Mission Folder: View Mission for 'MADScientists'

State	Illinois
Grade	6th
Mission Challenge	Environment
Method	Scientific Inquiry using Scientific Practices
Students	Anjali Shah (scientistdancer11) Sanskriti Aggarwal (Scientist2017) Diya Kannan (astronut) Meera Dullur (MeowNerd)

Team Collaboration

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.

See attached file Team Collaboration_MADScientists

Uploaded Files:

- [View] **Team Collaboration** (By: MeowNerd, 03/03/2018, .pdf)
  Describes our Team Collaboration process, response to questions under "Team Collaboration"
- [View] **Team collaboration-what we did during every meeting** (By: MeowNerd, 03/03/2018, .pdf)
  This is a document that says what we did every meeting, our homework, etc.

Scientific Inquiry

Problem Statement

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

See attached file Scientific Inquiry_MADScientists.
Our team used Google docs to respond to all the question in this section and saved all responses in the same pdf attached.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts). Use multiple types of resources and do not limit yourself to only websites.

See attached file Scientific Inquiry_MADScientists

(3) Describe what you learned in your research.

See attached file Scientific Inquiry_MADScientists

Hypothesis

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

See attached file Scientific Inquiry_MADScientists

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

See attached file Scientific Inquiry_MADScientists

(6) When you developed your hypothesis how did you know it could be tested AND could be proven false by testing?

See attached file Scientific Inquiry_MADScientists

Experimental Design

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

See attached file Scientific Inquiry_MADScientists

(8) Identify the control group and the constants in your experiment.

See attached file Scientific Inquiry_MADScientists

(9) What was your experimental process? Include each of the steps in your experiment. Include all safety precautions used by your team as step one.

See attached file Scientific Inquiry_MADScientists

Data Collection and Analysis

(10) Present the data you collected and observed in your testing. The use of data tables, charts, and/or graph is encouraged.

See attached file Scientific Inquiry_MADScientists

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

See attached file Scientific Inquiry_MADScientists

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

See attached file Scientific Inquiry_MADScientists

Drawing Conclusions

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

See attached file Scientific Inquiry_MADScientists

Uploaded Files:

- [View] **Scientific Inquiry Process** (By: MeowNerd, 03/03/2018, .pdf)
  Describes responses to all questions in the "Scientific Inquiry Process'
- [View] **Scientific Inquiry Pictures** (By: MeowNerd, 03/03/2018, .pdf)
  Contains pictures with description of our Scientific Inquiry Process

Community Benefit

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

See Attached file_Community Benefit

Uploaded Files:

- [View] **Newspaper Coverage_Mayor Presentation** (By: astronut, 02/24/2018, .docx)
  This is a newspaper article that appeared in the local newspaper regarding our presentation to the Mayor of Naperville.
- [View] **Community Benefit** (By: MeowNerd, 03/03/2018, .pdf)
  Contains response to the question on Benefit to Community
- [View] **Pictures** (By: MeowNerd, 03/03/2018, .pdf)
  Shows pictures of all the presentations and community benefit initiatives
- [View] **Press release** (By: MeowNerd, 03/03/2018, .JPG)
  Screenshot of the Press release of our presentation to the Mayor

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which include humans)? If yes, team must complete and attach an IRB approval form.

No

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.

No

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community

Our team, MADScientists chose the problem of finding natural alternatives to artificial fertilizer, hoping to reduce the phosphorus runoff into rivers and drinking water. We set up an experiment to investigate whether phosphorus runoff will be less in natural fertilizers than artificial fertilizers. Our experiment tested five different fertilizers: 4 natural (cow manure, goat and sheep dung, coconut peat moss) and 1 artificial fertilizer, using a control tray with no fertilizer and duplicated trays. Over 15 weeks of grass growth, we compared the phosphorus runoff, grass and soil quality.

We compared averages and trend data using statistical methods, using a shared online Google platform, including tools such as Google Sheets. We also used HACH 8-90 (a phosphate tester), RGB testing to test greenness of grass and a scientific approach to test indicators of our soil and grass quality.

Our data analysis determined that sheep dung may also lead to lower phosphorus runoff, and goat dung produced the most phosphorus runoff. The phosphorus runoff of the rest of the fertilizers was similar to the artificial fertilizer. The grass and soil quality of the natural fertilizers were also comparable to that of the artificial fertilizers. From our data, we can conclude that sheep dung, coconut peat moss, and cow manure good alternatives to artificial fertilizers. The use of these natural alternatives from the existing phosphorus cycle will reduce the contribution of phosphorus coming from artificial fertilizers, preserving marine life by reducing algal blooms.

Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed in time and deadlines were met.

Our Team and how we worked:
We are the MADScientists : **M**eera(MeowNerd), **A**njali(scientistdancer11), **D**iya(astronut), **S**iya(Scientist2017).We are four curious 6th grade girls who love science. We worked on our science experiment by dividing and rotating our responsibilities. For example, if one team member logged what we did that week, then the next week another member would do it. We also rotated between who would check and respond to our experts via our group email: (madscientists2017@gmail.com). Our team worked well together because we were all very engaged in this project. We all made sure to follow a strict timeline and get the job finished. All of us wanted to make a difference in our community and this was a very good opportunity to do so.

What we have in common:
Three out of the four of us go to the same school. One commonality we found was that we all love science and we work together very well, though some of our interests are different. Siya plays many sports and plays three instruments. Meera is a singer, and plays the piano, and plays badminton. Anjali does Indian classical dance, tennis, and also plays the piano. Diya sings, plays the violin, enjoys math, and figure skates. We were all very excited about starting a science project together. We have a lot of fun each meeting as we have common interests and make each other laugh.

Weekly Work Plan:
Up until 2 weeks ago, our team held weekly meetings. Some of these meetings were four hours long, dedicated solely to working on one topic. When we got serious about working on our mission folder, we had more frequent meetings.

Research and Experimentation:
Once we settled on our community problem, we all started researching natural and artificial fertilizers. Each week, we assigned different areas of research to each team member. The following week, we were tasked with presenting our research to each other. While creating our experimental design, each of us took turns drawing and setting up the experiment. While one person watered the plants (it was at her house), two of us logged what we did in the meeting, and one person recorded grass height measurements every week.

Roles:
Each week, when we met, we assigned roles to each other. One of us took notes, one of us kept the team on track, bringing us back to topic in case we were distracted. Another team member kept track of the agenda for the day, and she made sure we accomplished the tasks in the meeting. Yet another team member recorded what we did during each meeting, and our homework for the week. Every week, this shifted amongst the four of us, and we each got a chance to do each task.

We prepared our Powerpoint slides together. We each got 10-11 slides to create and present. We presented to the Naperville officials, who were interested in what we had to say.

Time Management:

Because of our schoolwork and other activities, managing our time during our meetings was essential. Each week, we would assign ourselves homework that would be due the following meeting. We were very organized, and followed a strict format. For the first portion of our meeting, we would discuss our research, and do some extra reading. For the next portion, we would be doing some hands-on activities with the experiment. Finally, for the last portion, we would be analyzing our grass measurements and our phosphorus readings and making some theories.

Collaboration using Technology:

We used Google Docs as our main collaboration tool. We made many different documents with all our research, and in the end, we compiled them together to get a clearer picture. We also used WhatsApp for scheduling meeting times. We also worked well together by assigning things to each person to accomplish by the end of the meeting. If it didn't get done, it became homework. In addition, if someone didn't understand something or wasn't at the meeting, the other team members would help them out or fill them in on what happened while they were gone. For example, one of our `team members was good at using Google Sheets, and double-checked all our calculations. She also showed the other team members how to graph with Google Sheets.

When we were first trying to identify our problem, we assigned each person a different problem to research. Then every meeting we reviewed everyone's research. We then eliminated problems. With our experiment, we would set everything up together. The deadline for finishing our homework was the next meeting.

When one team member had to miss a meeting, we could also communicate with that person using Google Docs and other collaboration tools. We had a document that said what we did for every meeting and the homework.

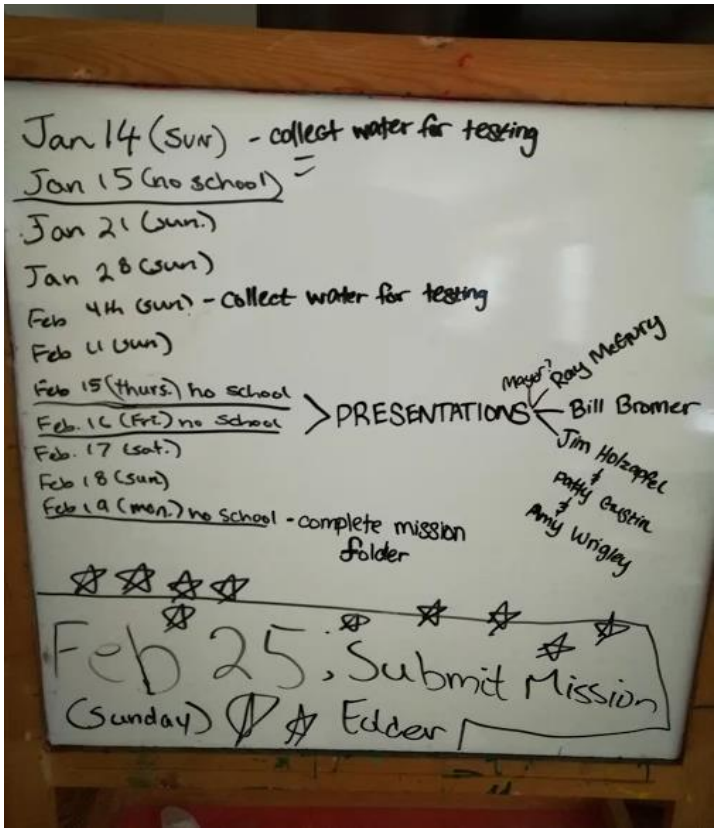
Date	**M**eera (MeowNerd)	**A**njali (scientistdancer11)	**D**iya (astronut)	**S**iya (Scientist2017)
May 14 (our first meeting)	Wrote everything in Team Collaboration and helped with the interview document.			(Wasn't on the team yet)
May 21	Reviewed all the stuff we got from interviews. Narrowed down the broad problems.			
May 31	Reviewed everything we found out from our research. Rated problems.			
June 20	Shared research. Wrote in Team Collaboration. Researched Water Pollution.	Shared Research. Narrowed down Problems. Researched Water Pollution, Water Purification, and Smoking.	Shared research. Assigned problems. Researched Soil Pollution and Natural Fertilizers.	Shared research. Narrowed down Problems. Researched Soil Pollution and Natural Fertilizers.
July 4	Shared Research. Researched Water Pollution.		Shared Research. Researched Natural Fertilizers	
August 9	Finalized Problem. Contacted Naperville City Councilwoman; Patty Gustin to talk to her about Fertilizers			
August 16	Interviewed Mrs. Patty Gustin and asked her questions. Researched about phosphorus.		Interviewed Mrs. Patty Gustin and asked her questions. Sent an email to Mr. Jim Holzapfel.	Interviewed Mrs. Patty Gustin and asked her questions. Researched about phosphorus.
August 29	Interviewed Mr. Jim Holzapfel and asked him questions. Found expert on algae.			
September 10	Presented research to the team advisor and others	Presented algae and phosphorus research to team mentor. Discussed what our specific problem is. Talked to parents about Oct. 5 and 6th.	(absent)	Presented algae research to our team mentor. We also got very close to finalizing our problem.
September 17	Helped assign homework	(absent)	Assigned homework	

September 28	Interviewed Ms. Somya Srinivasan, a Scientist in Biotechnology, who has a master's degree in biotechnology			
October 5	Took a tour to see the water treatment plant.			
October 12	Helped team advisor explain to the other parents where we are in the project. We also explained to them our plan and what our problem is.			
October 15	Shared research on **sheep** manure fertilizer	Shared research on **goat** manure fertilizer	Shared research on **cow** manure fertilizer	Shared research on **coconut peat moss** fertilizer
October 20	Shared homework and thought up questions to ask	Shared Homework and Researched fertilizer proportions. Wrote down things we needed for our experiment. Brought materials.	Shared homework - research fertilizers, send emails- and discussed. Brought materials for experiment.	Shared Homework and Researched fertilizer proportions. Wrote down things we needed for our experiment. Brought materials.
October 26	Interviewed Professor in Life Sciences; Dr. Bromer. Supplied team with materials.			
October 29	Put Soil in trays. Got measurements for fertilizers. Figured out how many grass seeds to put in a tray and how often we need to water grass. Put information on experiment document.			
November 2	Bought supplies for the experiment, and helped set it up. Added Fertilizers into soil by measuring.			
November 9 (*phone meeting)*	Helped find problems in our experiment	Discussed observations of experiment. Helped to find and solve problems in our experiment. Checked observations sheet.	Watered the plants over the week and observed the trays. Helped group find flaws in the experiment.	We discussed about Diya's observations on the experiment, and we found many problems in our experiment.
November 19	Wrote in team collaboration.	Replaced bottles. Found volumes, radiuses, and	Replaced bottles for our experiment	Replaced the bottles from our experiment

		heights of all bottles. Put on Google Spreadsheet.		
December 11	Sent a thank you email to Mr. McGury	Interviewed Mr. Ray McGury, the executive director of the Naperville Park District. Explained to him where we were and asked him about the grass and what we should look out for.	Interviewed Mr. Ray McGury, the executive director of the Naperville Park District to ask him about the grass and what we should look out for.	Interviewed Ray Mcgury; the executive director of naperville park district
December 14	Updated team collaboration.	Took bottles of phosphorus water to Dr. Bromer. Learned how to test them for phosphorus by ourselves. Sent thank you email to Dr. Bromer.	Took filled bottles to Dr. Bromer and got an experience to test the water for phosphorus ourselves.	Took bottles of phosphorus water to Dr. Bromer. Learned how to test them for phosphorus by ourselves. Sent thank you email to Dr. Bromer.
December 17	We did a phone interview with Mr. Upendra, Environmental Engineer, who is a water reclamation espert in Indiana. He gave us more information on what we were researching, PAO (Phosphorus Accumulating Organisms)			
December 24	Worked on the team collaboration section of the mission folder	Worked on sections of Mission Folder.	(absent)	(absent)
January 7	Wrote some of team collaboration. Wrote timeline on chalkboard	Fixed dates. Wrote timeline. Researched artificial fertilizers and goat manure to find out if there are any health concerns.	Fixed dates and made a timeline for our presentations and how we will get things done	Fixed dates and made a timeline for our presentations and how we will get things done
January 15	Shared research about sheep dung,	Shared research about goat dung. Interviewed Carl	Got started on our ***real*** Mission Folder and we	Worked on the ***real*** Mission Folder. Also

	and cut grass. Also asked Mr. Carl Gorra, Park Operations manager in Naperville city, a few questions.	Gorra, an expert on grass from the Naperville park district. We also worked on the Mission Folder. We also created final documents for each Mission Folder components.	created final drafts for each component of the Folder. Also shared research about cow dung. Carl Gorra came over to my house and tested the grass.	created final draft docs for each of the components. Started our Mission Folder! Also met Mr. Gorra, a grass specialist who works in Park District, came to view our grass and the healthiness of it.
January 21	Recorded measurements for the A trays. Also did the averages of trays 1A, 2A, and 3A	Measured grass for the A trays. Also calculated and recorded averages for trays 1A, 2A, 3A, 4A, 5A, and 6A.	Recorded measurements for the B trays. Did averages for all the B trays.	Measured grass for B trays and averaged some B trays.
January 28	Made the RGB graph	(Absent)	Made the calculations for the volume/phosphorus	Helped the calculating the RGB graph
February 4	Measured grass and soil quality. Also worked on speech and presentation			
February 9	Helped edit speech document and presentation slides	Updated spreadsheet for the Grass Length Averages. Also worked on presentation and speech.	Helped edit the speech document and fix up the presentation	Finished putting the first draft in the presentation
February 11	We worked on our conclusion statements and practiced our speech (which was assigned for homework)			(absent)
February 13	Continued data analysis, practiced speech, tweaked slides			

February 14	Presented to the Naperville Water Department and Councilwoman Patty Gustin			
February 15	Presented to Dr. Bromer, Dr. Sloan and Ms. Spesia, Professors and Dean at the University of St. Francis	(Absent)	Presented to the University of St. Francis	
February 16	Presented to Park District, Mayor of Naperville, Councilwoman Patty Gustin & Executive Director of Parks, Mr. McGury.	(Absent)	Presented to Park District, Mayor of Naperville, Councilwoman Patty Gustin ,and a Naperville reporter	
February 19 - March 2	WORKED ON MISSION FOLDER	WORKED ON MISSION FOLDER	WORKED ON MISSION FOLDER	WORKED ON MISSION FOLDER


Jan 14 (SUN) - collect water for testing
Jan 15 (no school)
Jan 21 (Sun.)
Jan 28 (Sun)
Feb 4th (Sun) - Collect water for testing
Feb 11 (Sun)
Feb 15 (thurs.) no school
Feb. 16 (Fri.) no school
Feb. 17 (sat.)
Feb 18 (Sun)
Feb 19 (mon.) no school - complete mission folder
PRESENTATIONS
Mayor Ray McElroy
Bill Bromer
Jim Holzapfel
Patty Gerstin
Amy Wrigley
Feb 25, Submit Mission Folder
(Sunday)

Team Collaboration Sheet

Date	Members present	Members absent	what we did	The Next Meeting	Homework
5/14/17	Present: M, A, D	Siya	we made a interview outline document.	5/21/17	Interview 6 people about problems they have found in the society.
5/21/17	Present: M, A, D, S	Nobody	we narrowed down some of the really broad problems	5/31/17	Research about the 3 problems given to you. Be ready to present next meeting.
5/31/17	Present: M, A, D, S	Nobody	we shared our research for each of our 3 problems and rated them.	6/20/17	Narrow down and investigate your problem. Also be open to any new problems to find and look at some mission folders from past teams by june 14th.

6/20/17	Present: M,A,D,S	Nobody	we shared our research for each of our problems. we narrowed it down to water purification, pollution, and natural fertilizers. we are now researching water purification, soil pollution, water pollution, and natural fertilizers.	7/4/17	Meera: research water pollution Siya: natural fertilizer and soil pollution Diya: soil pollution and natural fertilizers Anjali: water pollution and water purification and research smoking again
7/4/17	Present; M,A,D,S	Absent: Nobody	we shared our research	7/18/17	Meera: research water pollution more thoroughly Siya: natural fertilizers Diya: natural fertilizers Anjali: same as Meera
7/18/17	Canceled	Canceled	Canceled	8/9/17	Canceled

8/9/17	M,A,D,S	Nobody	we finalized our problem and we contacted Councilwoman Patty Gustin to talk to her about natural fertilizers	8/16/17	Look into smaller problems for Natural Fertilizers and check email inbox regularly.
8/16/17	M,A,D,S	Nobody	we interviewed Councilwoman Patty Gustin and asked her some questions she told us to contact Jim Holzapfel; head of the water department.	8/27/16	Look up naperville.il.us and do a search for phosphorus. Diya: send an email to Jim Holzapfel.
8/29/17	M,A,D,S	Nobody	we interviewed Mr. Jim Holzapfel; head of the Naperville water department and he told us many things about phosphorus	9/10/17	Find an expert on algae. If you don't find anyone, do some research on your own. Also research more on phosphorus

9/10/17	M,A,s	Diya	we discussed and reviewed our homework which was to research about algae and phosphorus. we presented the information to our team leader. And we discussed what our specific problem is.	9/17/17	Talk to expert on algae, and taking the phosphorus and talk to parents about Oct. 5 and 6th.
9/17/17	M,D,S	Anjali	we read an article that our team mentor sent us and got very confused, but we figured it out and then we assigned homework.	9/28/17	Talk to a botanist (if you can) Answer this question: "Are there any species that absorb phosphorus but won't become an invasive species." And "are there any species of algae that grows slower than others." as well as "which fertilizer has the least amount of fertilizer runoff and will make your lawn grow
9/28/17	M, A, D, S	Nobody	we interviewed	10/5/17	No homework!!

			Mrs. Soumya Thirumalai Srinivasa Research .Scientist in Clinical Genomics		
10/12/17	M,A,D,S	No one	Two of the parents came over and we discussed what our problem would be. We also explained to the parents where we are now.	10/15/17	Everybody: Check the MADS email whenever you can. Research the fertilizers
10/15/17	M,A,D,S	No one	we shared our research about fertilizers and made an outline about our experiment	10/20/17 8:30 at anjali's house	Make a sketch of our experiment. Meera: find out where to find sheep and goat poop Anjali and Siya: talk to golf clubs about grass Diya: send email to mr Holzapfel and amy
10/20/17	M,A,D,S	No one	we shared our homework and we discussed.	Thursday 10/26/17, 4:00 P.M.	write down questions to ask the professor in Life Sciences; Dr. Bromer and finalize our experiment outline. How much of goat dung and sheep dung should we use? Find and

					research a proportion. write down in table in what we need for the experiment. Anjali: Bring 12 trays and 4 Chafer Dish Stands Siya: email Amy about experimental design. what artificial fertilizer is on golf fields. Diya: Bring tall fescues, potting soil, coconut peat moss and cow dung
10/2617, 4:00 P.M.	M,A,D,S	Nobody	Interview with Dr. Bromer; Professor of Life Sciences.		Meera: Go to Home Depot and get the artificial fertilizer. Anjali: Bring materials listed on Shopping List Siya: Bring materials listed on Shopping List Diya: Bring materials listed on Shopping List.
10/29/17	M,A,D,S	Nobody	we put the soil in the trays and set up our experiment. we also got measurements for the	11/2/17, 4:15 P.M.	Find how much grass seeds to put in one tray. Also, research how much you have to water the grass. Put on

			fertilizers.		what we need for experiment.
11/2/17	M,A,D,S	none	we added the fertilizers into the trays by measuring.	11/9/17	Diya: water plants and observe the experiment
11/9/17 (phone meeting)	M, A, D	Siya	we discussed about Diya's observations on the experiment, and we found many problems in our experiment.	11/11/17	Check observations sheet once per day. Also, write down questions and answers that the judges may ask us in what we need for the Experiment doc.
11/19/17	MADS	Nobody	we replaced the bottles from our experiment	11/26/17	All: summarize problem identification. on mission folder Doc. Meera: Team collaboration Anjali: Also, find volumes and calculate bottles. Rewrite volume drawings of bottles and put on Google Spreadsheet. Share with everyone. Diya: Start Hypothesis Siya: Start Problem Statement
12/11/17	M,A,D,S	none	we interviewed Ray Mcgury; the executive		Meera: send a thank you email

			director of naperville park district		
12/14/17	M,A,D,S	none	we took our bottles to Dr. Bromer and tested them for phosphorus	12/17/17	Meera: update team collaboration Anjali: Send a thank you email to Dr. Bromer Diya: Continue with the experiment Siya: make a table with the phosphorus results
12/17/17	M,D	Anjali and Siya	we asked Environmental Engineer, Mr. Upendra questions about PAOs	12/24/17	Research more about the harmful effect of artificial fertilizers, and log it in the mission folder Also look into the 7th grade folder to see how to measure the greenness of the grass
12/24/17	M, A	Diya and Siya	we worked on the Mission Folder	12/31/17	Edit your section of the Mission Folder. Make sure to separate it into paragraphs and look at the 7th grade mission folder. Everyone: Finish their sections of Mission Folder write about the phosphorus in your

					explanations. Siya: Do problem statement
12/31/17	Canceled	Canceled	Canceled	Canceled	Canceled`
1/7/18	M, A, D, S	None	we fixed dates for everything	1/15/18	Research your fertilizer and artificial and see if you can find more info about health reasons, etc.
1/15/18	M, A, D, S,	Nobody	we interviewed Carl Gorra; Park District Operations Manager. we worked on the Mission Folder and created final draft docs for each of the components.	1/21/17	Finish team Collaboration. Everyone do their part of each meeting. Anjali: Experimental Design
1/21/17	M,A,D,S	Nobody	we worked on the Mission Folder and measured the grass.		Anjali: Create a Google Spreadsheet. Need 1 Column for trays and 1 row for dates. write averages for every date. Everyone (Anjali too if have time): work on Google Slide presentation, and scientific inquiry sources.

1/28/17	M, D, S	Anjali	Worked on Radii for bottle drawings		Work on Presentation
2/4/18	M, A, D, S	Nobody	Worked on Mission Folder Presentation and Speech		Diya: Work on graph for averages/total of samples of phosphorus. Meera: Add pictures into presentation Siya and Anjali : Elaborate on all slides! Everyone: Update speech and write down first name initials for each statement you are saying for each slide. Remember to color code and put in MADS order.
2/9/17	M, A, D, S	Nobody	we worked on the presentation and speech docs.		Anjali: Update Grass Length Averages spreadsheet. Answer question: "Which grass grew the fastest each week?" Support with evidence. Siya: Grass Density Graph

					Diya: Phosphorus Meera: RGB tests graph Everyone: work on presentation
2/11/18	M,A,D	siya	we looked over the presentation and found results		Meera and Anjali: Upload pictures to Google Drive in Ecybermission Folder and put them in presentation. and add them to the presentation.: Everyone: Elaborate on presentation. Then, finish conclusion slides.
2/19/18	M,D,S	Anjali	we worked for five hours straight on the mission folder	2/24/18	Meera: Do Scientific Inquiry numbers 1-4 Anjali: finish community benefit, experimental process , and numbers 5, 6, and 9 on scientific inquiry Diya: Finish #s 10-12 Siya: finish numbers 7 and 13 on scientific inquiry and do team collaboration Everyone: Do your part of the table in team collaboration if you haven't

					already finished it.
2/24/18	M, A, D	Siya	we worked on the Mission Folder		work on the mission folder as much as you can
3/2/18	M,, D,S	none	we worked on the mission folder and almost finalized everything		Do a bit of everything.
3/3/18	M,D	Anjali and Siya	we basically finalized all the pictures and uploaded everything		Look over every section and make sure everything is ok.

Scientific Inquiry

Problem Statement:

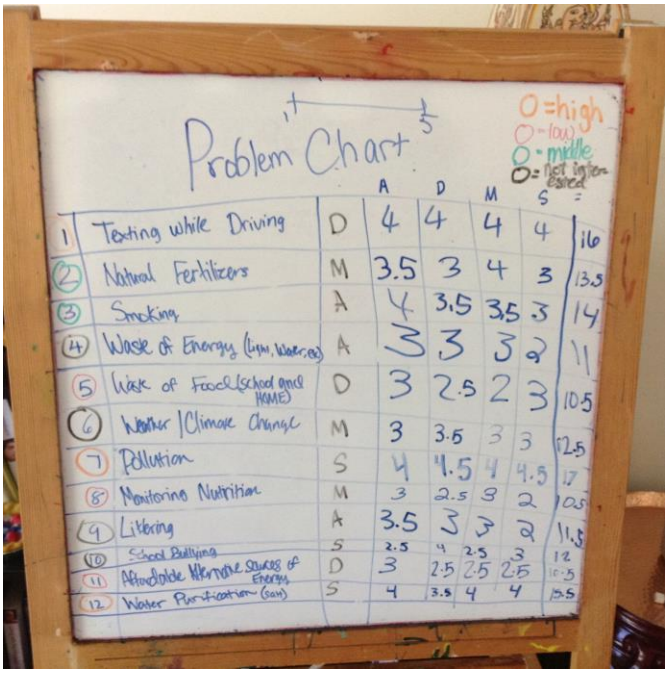
Question 1: What problem in your community did your team investigate? Why is this problem important to your community?

Answer:

We decided to investigate the problem of large amounts of phosphorus that comes from fertilizer runoff getting into rivers. 40% of the phosphorus comes from artificial fertilizers. 40% come from wastewater and 20% come from other sources. This phosphorus causes devastating algal bloom that kills many fish and causes dead zones. Dead zones are sites that have too much phosphorus and not enough oxygen which kills sea life and causes problems for the ecosystem. We found in our research that 40% of the phosphorus runoff is caused by artificial fertilizers, which people commonly use to fertilize their lawns and farms. We wanted to investigate natural alternatives to artificial fertilizers in order to tackle this problem. To try and solve this problem, we compared natural fertilizers to artificial fertilizers.

The city of Naperville was issued an ordinance by the Federal EPA (the Environmental Protection Agency) to reduce the amount of phosphorus in the rivers. There is a big cost to the city to clean up the phosphorus: Naperville spent $200,000 cleaning up a small portion of a pond in Hunter's Woods Park. This phosphorus was caused by the neighborhood lawns. This problem is all across Illinois, and other states bordering the Mississippi River as well as other places around the world.

Figure 1:



Our first meeting as a team was on May 14, 2017. The first step towards this project was to write an interview outline to see what people classified as problems in our community. We then each interviewed 6 people in our society for homework. We ended up with 16 prominent problems, listed in the chart below.

Our team then came up with a variety of problems and documented them, as seen in Table 1. We took the overlapping data into consideration and ordered it based on popularity. Once we took the sixteen most prominent problems that people in our society told us about, we each took four topics and researched them. During each meeting, we eliminated problems from our possibility list based on our research and the feasibility of finding a solution to the problem in the limited time we had. Once we had our top 12, we decided to rate them from 1-4, as seen in Figure 1. As you can see in the picture, each of us rated the 12 topics. In the end, we

took the top 5 and did extra research on them. Our top 5 topics were texting while driving, water pollution, smoking, natural fertilizers, and water/climate change. After more research and further elimination, we finally arrived to the general topic of artificial fertilizers.

Problems that we researched

Table 1: Problem chart and frequency

Problem	Some ways to solve it	How many people mentioned it?
Smoking- keep away from kids	● More education on the adverse side-effects of smoking ● Ban smoking in public places. Done in many places already - require legislation for that	4
Weather and Climate change		1
Pollution	● People should make and use more electric cars ● Find clean energy alternatives	1
Waste of Energy	A device/sensor should be made that checks to make sure all of your lights are turned off.	1
Waste of Food	Redistribute unused food	1
There aren't enough ways to find out how much nutrition you need.	Make some sort of chart or app that monitors your food consumption.	1
Alternate sources of energy are not cheap.	If you make people use less traditional energy, the money that is saved can be used toward buying alternative sources of energy	2
Littering		1
School Bullying		1
Texting and Driving with Phones	Create an alarm that senses when you take your arm off the steering wheel.	1
There aren't enough natural fertilizers		1

School Lunches are thrown away too much	Extend the lunch time or make it more appetizing.	1
Food/Water purification		1
Hot Car Deaths		1
Homelessness		2
Stray Animals	Make more shelters	1

We wanted to focus on a specific problem with artificial fertilizers in our community. So, next, we looked online on the Naperville city website, (naperville.il.us) for officials who were interested in this topic. We found councilwoman Mrs. Patty Gustin, who had an environmental background.

We sent an email to her, and requested a phone interview. We managed to have a phone interview with her, with prepared questions to ask her about the use of artificial fertilizers. She told us about this problem and recommended us to the head of the Naperville Water Department; Mr. Jim Holzapfel. They both showed us that phosphorus runoff was a legitimate problem in our society and that artificial fertilizers contributed to this. We finally arrived at the problem of phosphorus getting into Naperville's waters and causing algae growth.

Further research in this problem (see link to the article below) made it clear how important this problem was to our community. We read about the federal ordinance that Naperville was given. This article explained to us how prominent of a problem this really was, and if we didn't try to solve it quickly, there would be an issue. The article is linked below. http://www.chicagotribune.com/suburbs/naperville-sun/news/ct-nvs-naperville-water-treatment-phosphorus-st-0424-20160423-story.html

As we started to progress in our experiment, we received a newsletter from the Naperville Park District Executive Director, Mr. Ray McGury to Naperville's residents to inform us that Naperville is going green. It talked about how the Naperville parks were switching to organic herbicides and pesticides. We had an interview with Mr. McGury and this inspired us to expand our study to examine the soil and grass quality as well.

Question 2: List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts). Use multiple types of resources and do not limit yourself to only websites.

Answer:

- Marie Iannotti (2017). Is Manure Safe to Use in Your Vegetable Garden. Retrieved from website: https://www.thespruce.com/is-manure-safe-to-use-in-your-vegetable-garden-1402192

- Nikki Tilley (last updated 6 Jan 2018). *cow manure Fertilizer: Learn the Benefits of Cow Manure Compost*. Retrieved from the website: https://www.gardeningknowhow.com/composting/manures/cow-manure-compost.htm

- Black Gold (Oct 10, 2016). *Peat Moss: Nature's Gift to Gardeners.* Retrieved from the website: http://blackgold.bz/peat-moss-for-gardens/

- Lauren Wise (September 21, 2017). *What are the benefits of peat moss?* Retrieved from the website: https://www.gardenguides.com/123985-benefits-peat-moss.html

- Tessa Zundel (January 18, 2018). *Chicken vs. Goat Manure: Which is Best?* Retrieved from the website: http://www.hobbyfarms.com/chicken-vs-goat-manure-which-is-best/

- Bob Perini (July 6, 2015). *Purification Technology.* Retrieved from the website: https://www.drinkmorewater.com/water-purification-methods

- David Nield (November 13, 2015). *This New Robot Eats Water Pollution and Produces Electricity as It Swims.* Retrieved from the Website: http://www.sciencealert.com/this-new-robot-eats-water-pollution-and-produces-electricity-as-it-swims

- Lisa Zyga (April 11, 2016). *Microbots can Clean up Polluted Water.* Retrieved from the Website: https://phys.org/news/2016-04-microbots-polluted.html

- Bonnie L. Grant (May 28, 2015). *Fertilizer for Lawns - What Type of Lawn Fertilizer to Use.* Retrieved from the Website: https://www.gardeningknowhow.com/lawn-care/lgen/type-of-lawn-fertilizers.htm

- Brett Martin (March 21, 2017). *The Quick and Easy Guide to Fertilizing your Lawn.* Retrieved from the Website: https://www.popularmechanics.com/home/lawn-garden/how-to/g237/the-quick-and-easy-guide-to-fertilizing-your-lawn/

- N. Srikanth, Devesh Tewari, and A.K.Mangal, *The Science of Plant Life (Vriksha Ayurveda) in Archaic Literature: An Insight on Botanical, Agricultural and Horticultural Aspects of Ancient India, World Journal of Pharmacy and Pharmaceutical Sciences. Volume 4, Issue 6, April 2015, pg 388-40*

- Savitha Bhat , Ashok, , Acharya Rabinarayan, Ravishankar, *Importance of Kunapajala (Traditional Liquid Organic Manure) of Vrikshayurveda in Medicinal Plant Cultivation, GJRMI, Volume 1, Issue 7, July 2012, pg 272-274)*

- R.S.Deshmukh, N.A.Patil, and T.D.Nikam, *Influence of kunapajala treatment from vrikshayurveda on leaves of tomato (lycopersicon esculentum I. Cv. Selection 22) and it's comparison with conventional farming and organic farming. Journal of Pharmacy. Volume 2 Issue 5, Sept-Oct 2012, pg 55-63*

- R.D.Harmel, D.R.Smith, R.L.Haney, and M.Dozier, *Nitrogen and phosphorus runoff from cropland and pasture fields fertilized with poultry litter. Journal of Soil and Water Conservation. 2009, 64(6) : 400-412*

- https://phys.org/news/2008-07-swine-fertilizer.html

- https://phys.org/news/2010-09-phosphorus-runoff-farming.html

Question 3: Describe what you learned in your research.

Answer:

First, we researched algae and phosphorus and took notes based on our research. We also researched artificial and natural fertilizers.

Every meeting, we would each do research as homework and share it during the next meeting. We would write down problems and facts.

Algae:

Algae actually takes up 70% of our oxygen during the day. We focused on a certain kind of algae: cyanobacteria ("blue-green algae"). Cyanobacteria is multiplying and leads to many problems. We found an article about many health concerns caused by this type of algae. In addition, phosphorus runoff and climate change causes algal blooms in the waters. Extreme storms add to the increase of cyanobacteria as well.

Phosphorus:

Phosphorus isn't a bad element alone. It is a mineral needed in your body. Too much or too little phosphorus in your body can cause you to have medical problems. In nature, phosphorus is never in its elemental form. It is usually found in numerous compound forms, such as the phosphate ion, located in water, soil and sediments. Animals absorb phosphates by eating plants or other plant-eating animals. Phosphorus in soil can end up in waterways and eventually oceans. Algal blooms are unpleasant to swim in and can be a health hazard to humans. Studies show that the more phosphorus there is, the more algae there is in the water.

Artificial Fertilizer:

Advantages:

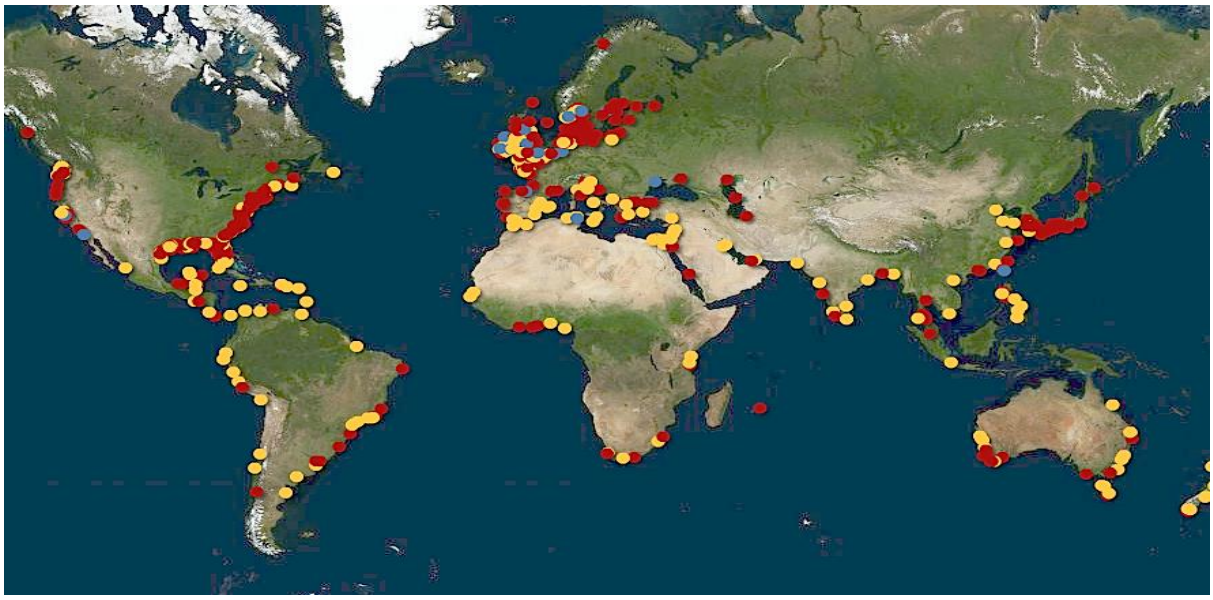
Nutrients are readily available in chemical fertilizers. The packages have an easy-to-read ratio in the back to make sure the plants are fertilized correctly. The ratios on the back of the packets are highly analyzed to make sure that only the nutrients needed are given. Artificial fertilizers act faster than organic fertilizers. Organic fertilizers also make a bad stench, so people don't want to buy them. They go for odorless chemical fertilizers. Artificial fertilizers are inexpensive as well.

Disadvantages:

One problem is that chemicals such as zinc, lead, cadmium, etc., in the artificial fertilizers can harm the plant, the soil, or even us. These chemicals in artificial fertilizers eventually sink into the ground water, contaminating the water we drink. Also, artificial fertilizers destroy critical soil microorganisms. Some inorganic nitrogen fertilizers break down into nitrates and travel easily through the soil. Since it is water-soluble and can remain in groundwater for decades, the addition of more nitrogen over the years has an a cumulative effect. Also, plants affected with inorganic fertilizers can change people's nervous system and weaken it. Groundwater contamination from artificial fertilizers and pesticides have been linked to gastric cancer, goitre, birth malformations, and hypertension, and testicular cancer. Artificial fertilizers are used the most in the USA, China, and Japan. Also, phosphate and potash-based

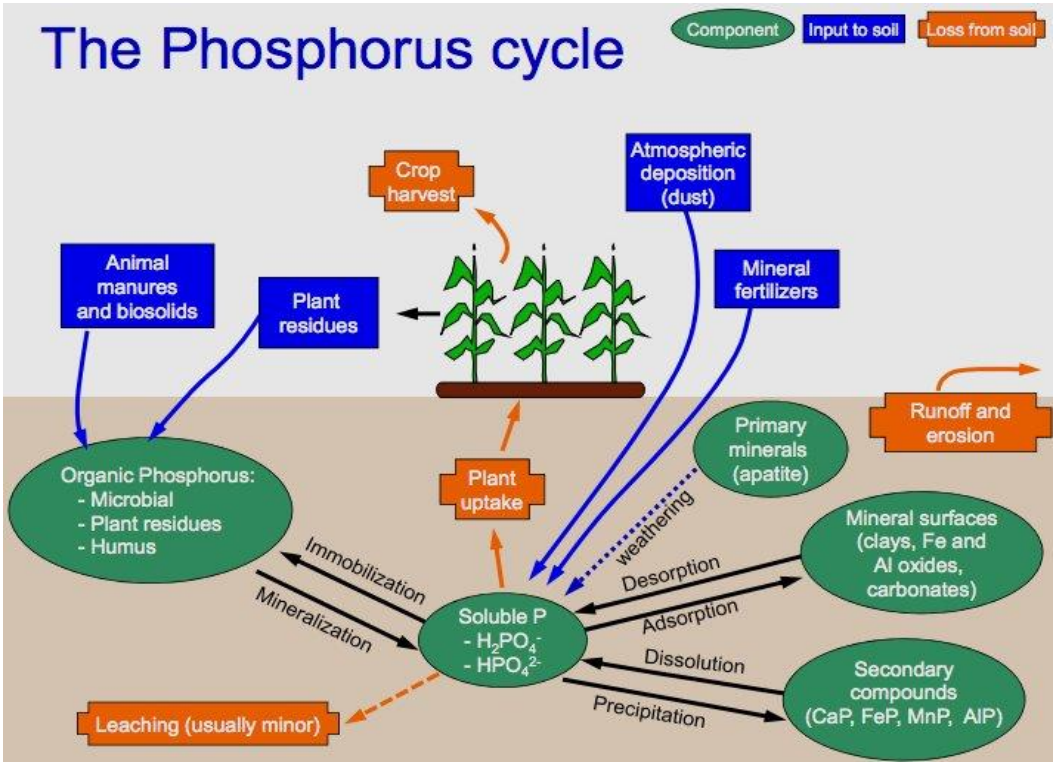
fertilizers causes greenhouse gas emissions. In the picture below, all the red spots are where there are dead zones. (see Picture 2)

Picture 2: Artificial fertilizer use and contamination. Image from en.wikipedia.org



Natural Fertilizers: Figure 3 Phosphorus Cycle: Image from https://en.wikipedia.org/wiki/Phosphorus_cycle

Figure 3 shows that natural fertilizers are part of the phosphorus cycle, and they will not cause problems. However, artificial fertilizers add more phosphorus into the system which adds a net increase in the amount of phosphorus in the cycle, which leads to more in runoff waters.



Advantages:

Organic fertilizers are environmentally friendly. In addition, they improve the structure of the soil and increase its ability to hold water and nutrients. There's little to no risk of any chemicals that can be harmful to plants. As it is expensive in packages, you can make your own organic fertilizer by composting. You can also find inexpensive sources such as local dairy farms that may sell composted manure. They contain many minerals that benefit the plankton growth. They contain protein, fat, and fiber, and can be used for food for many organisms. When using it, you can recycle the waste product rather than putting it in the trash. Even if it is expensive, you can get it cheaper at farms that may sell composted manure.

Disadvantages:

The plants grown using natural fertilizers take a lot more time to get the growth people want. The microorganisms in the natural fertilizer only work in warm weather so you only can use natural fertilizers at certain times. Some natural fertilizers have to be decomposed, causing their action to be slower than other fertilizers. Also, they increase the risk of infections, because the manure may not be composted beforehand. Finally, natural fertilizers need high transportation and labor costs.

Information that we got from our interviews with experts

We talked to a Naperville councilwoman Mrs. Patty Gustin, and she presented to us a new problem that fell into the big category of artificial fertilizers. This was very beneficial to us because we wanted to know about problems that are around our community that we didn't think about before. The problem is that lots of phosphorus was ending up in the Naperville rivers, and some of our drinking water was getting contaminated. She told us that this was because of the heavy amount of artificial fertilizers used in the lawns. She told us that the surface runoff water from these lawns went into the river. These fertilizers are full of phosphorus and other chemicals that aren't good for you. She also told us that artificial fertilizer needs to be replenished, and that's something we need to keep in mind during our experiment. Mrs. Patty Gustin then recommended that we meet with the head of the Naperville Water Department, Mr. Jim Holzapfel.

We contacted Mr. Holzapfel through email and figured out a time to meet with him in his office. When we met with Mr. Holzapfel, we told him our problem and explained to him where we are so far in our experiment, as seen in Figure 4. He told us some more steps we should take and explained to us more in depth about the problem in Naperville. He showed us a picture of a place in the Gulf of Mexico called "The Black Zone" where the plants and the marine life is dying because of all the algae and phosphorus in the water.

Figure 4: With Director of Water Department of Naperville city

Mr. Holzapfel introduced us to Amy Wrigley, the Operations manager at the Water Reclamation Center. We talked to her about our experiment and she validated our experimental design and told us more about phosphorus runoff. Mr. Holzapfel and Ms. Wrigley gave us tour of the Naperville Water Reclamation Center. We found that another 40% of the phosphorus in the river is from the wastewater treatment plant. We then tried to find an algae expert and researched about phosphorus and algae. We then presented our research to our team advisor and discussed it. We then did lots of research and answered 3 essential questions, "Are there any species that absorb phosphorus and algae but are not an invasive species?", "Are there any species of algae that grow slower than others?", and "Which fertilizer has the least amount of fertilizer runoff and will make your lawn grow?" We took notes on these questions and researched them. Mr. Holzapfel also gave us a helpful source: naperville.il.us/waterrates. Here is a brief summary of the article:

The phosphorus tax will expire once funds collected are equal to 50% of the cost of improvements. In 2017, the DuPage Water Commission wholesale water rate increased from $3.63 to $3.65, which is a big change for one year. As part of the new permit to operate the Springbrook Water Reclamation Center, the City must remove more phosphorus than it currently does from the water it treats. This will have positive environmental impacts for local and national waterways, as excess phosphorus in water can cause "dead zones" where no aquatic life can survive. These phosphorus improvements must begin in 2025. Rates today are not covering the utility's cost of providing service to customers.

We then interviewed a genetic scientist, Mrs. Soumya Tirumalai Srinivasa, research scientist in Clinical Genomics. We explained to her our problem and asked her some questions about what we should do. We then created a group email account so we could send messages to experts. We also continued to research about our fertilizers. We then shared our research about our fertilizers and we made an outline of our experiment. We then planned a meeting with Dr. Bromer, a professor in Life Sciences, at the University of St. Francis. We thought of some questions to ask him at our meeting. We then wanted someone to talk to about our experimental design so we emailed Ms. Wrigley, an executive specials operator,explained to her where we were so far.

Organic fertilizers are vital for the ecosystem because it provides a recycling system for the nutrients and the organic waste. (N. Srikanth, Devesh Tewari, and A.K.Mangal, *The Science of Plant Life (Vriksha Ayurveda) in Archaic Literature: An Insight on Botanical, Agricultural and Horticultural Aspects of Ancient India, World Journal of Pharmacy and Pharmaceutical Sciences. Volume 4, Issue 6, pg 388-404*)

Through our research we have found that chemical fertilizers are harmful to health and especially to these groups of people, Pregnant women, infants, and nursing mothers. There are also medicinal plants with toxic materials that are harm people after transferring through fertilizer runoff and wastewater. (Savitha Bhat , Ashok, Acharya Rabinarayan, Ravishankar, *Importance of Kunapajala (Traditional Liquid Organic Manure) of Vrikshayurveda in Medicinal Plant Cultivation, GJRMI, Volume 1, Issue 7, July 2012, pg 272-274)*

Artificial fertilizers are petroleum derivatives. We think that this could possibly be a cause to global warming because we know that petroleum usually has a hand in climate change.

We also know that artificial fertilizers can cause groundwater contamination. If the groundwater from artificial fertilizers get contaminated, than it could cause many problems for us and our community.

Table 2 shows the different natural fertilizers we found around the world, and the research we did. We looked at some natural fertilizers alternatives to artificial fertilizers because we found in our research that natural fertilizers were better than artificial.

Research for Fertilizers (Table 2):

Fertilizer	Type (chemical, organic, etc)	Some information	Where it is used
Nitrogen Fertilizer	Organic	➢ Nitrogen is essential to plants ➢ Lack of N and chlorophyll means the plant will not utilize sunlight ➢ Involved in photosynthesis ➢ Directly responsible for increasing protein level in plants	USA
Ammonium Nitrate	inorganic	● A grainy textured fertilizer ● It helps release the needed nitrogen to the soil for it to live ● Best used for citrus and pasture lands ● 33% of the fertilizer is nitrogen	In many countries, it is restricted
Ammonium Sulfate	Inorganic	❖ A fertilizer created from the waste of (coal) coke ovens. ❖ It forms when sulfuric acid is used to remove ammonia from the coal that is used to make coke. ❖ It is a salt. ❖ It contains 21% nitrogen. ❖ It is a solid material	USA and Britain.
Anhydrous ammonia	organic	★ It can be hazardous ★ Compressed gas ★ Smell is really pungent ★ High relationship to water	USA
Urea	inorganic	❑ Less corrosive than other fertilizers ❑ The plant will die if you don't mix it	USA

		in the soil well	
Calcium Nitrate	Inorganic	● Less effective than other nitrogen fertilizers b/c leaching. ● It contains 16% in nitrogen form. ● Used in fruit and vegetable crops. ● It provides calcium for soils.	Norway
Diammonium Phosphate	inorganic	● Used in areas with not a lot of phosphorus ● Over 46% of the chemicals get into the soil ● Also puts 18% nitrate too ● Used in liquid form	Used around the whole world
Monoammonium phosphate	Organic	• It is a phosphorus fertilizer • Gives more phosphorus than Di-ammonium phosphate • 48% phosphorus • Less than 11% of nitrogen. • Low level of ammonia. • It lessens the risk of damage to new seeds.	Not found
Phosphorus	organic or inorganic	❖ Phosphorus loss due to erosion is common ❖ Less soluble than nitrate ❖ Can easily be transported by runoff ❖ Can also lead to algae growth, often in freshwater streams/lakes/estuaries	USA
Superphosphate	inorganic	❑ Made by reaction that takes place when rock phosphate (phosphorus) is treated by sulfuric acid ❑ Common synthetic phosphorus fertilizer ❑ Comes in single super phosphate and triple super phosphate ❑ Single super phosphate has 20% phosphorus, and has a lot of sulfur and calcium ❑ Triple super phosphate has 48% phosphorus, but less sulfur and calcium.	India US Morocco Russia Norway Canada Israel
Cow Manure	Organic	● If you use fresh cow manure, you	All over the

	and Natural	might end up with a stinky garden and grass popping up in your flowerbed. ● If you use composted cow manure, you may have a thriving backyard. ● Cow manure generally doesn't have as much available nitrogen as chemical fertilizers, but it works well even though it is slow. ● High ammonia levels may burn the plant, and it may contain excess salt.	world
Goat Dung	Organic	➔ Easy to collect and is not messy. ➔ Can be composted and used as mulch. ➔ Doesn't attract insects and also doesn't burn the plants. ➔ Also it has a bunch of nutrients that are good for the soil. ➔ There's not a lot of nitrogen in it but if you mix it with urine, the nitrogen content increases. Benefits: ★ Higher than other fertilizers in nitrogen - around 22 pounds in 1 ton of fertilizer. ★ Promotes healthier plant growth. ★ Doesn't burn plants. ★ High amounts of NPK (Nitrogen, Phosphorus, Potassium) in fertilizer. ★ Doesn't smell Concerns: ★ Fresh goat manure may contain pathogens that could cause people to be sick. Experts suggest you should always use well-composted manure when you are using it, especially for crops. ★ Since goats eat lots of grass and hay, the fertilizer may contain weed seeds that could damage your garden	All over the world
Sheep Dung	Organic	➢ Referred to as cold manure because of low nitrogen content ➢ Good edition to a garden ➢ Low odor ➢ Can be used to topdress gardens ➢ Apparently really good for plants	

		➢ Composting sheep manure has vital plant nutrients ➢ Is a natural slow release fertilizer ➢ Can be found in farms ➢ High in potassium and phosphorus ➢ You don't really need to compost it before using it ➢ It can be used in lawns	
Coconut Peat and Clover Moss	Organic and natural	➔ Good to use for new plants/grass ➔ Keeps the seedlings moist ➔ Speeds up process of germination ➔ These effects only work when you make a mixture of coconut peat and clover moss ➔ Some people use coconut coir (instead of peat) but it takes up 30% of the natural water	

We also used this article (titled, *Kunapajala*) that we got from Doctor Shantha Srisailan, who is a Scientist in Siddha Research Institute in India, to find out about natural fertilizers used in India. This article also highlights the effect of artificial fertilizers on health and ecosystem.

How our research led to our problem statement and research:

Based on our research, we found that there is too much phosphorus in the rivers, increased by the use of artificial fertilizers. This leads to algal blooms, depleting oxygen and causing problems in the ecosystem. Naperville is specifically facing problems in both its ponds and the river run-off. Although there is research to show that organic fertilizers may lead to phosphorus runoff, they are already a part of the phosphorus cycle, so if we reduce artificial fertilizer use (which are not a part of the phosphorus cycle), the total amount of phosphorus runoff will decrease in the rivers.

The benefits of organic fertilizers on environment, health, and ecosystem were evident through our research. Our research also showed that cow manure, goat dung, and sheep dung were the most popular animal-based organic fertilizers, and coconut peat moss was the most popular plant-based organic fertilizer used around the world. So we decided to compare these organic fertilizers with the most commonly used artificial fertilizer in Naperville city, which was the Vigoro fertilizer and examine how they each affect the phosphorus runoff, the quality and density of grass and the soil quality. We grew grass in the trays that contained these fertilizers and tested all of this. We also spoke to local golf course managers to find out what the most common grass used in Naperville was, which was tall fescue grass.

Hypothesis

Question 4: State your hypothesis. Describe how your hypothesis could help investigate your problem.

Answer: Based on our review of research, we came up with four hypotheses statements:

Hypothesis 1: Using natural fertilizers will have less phosphorus in the water runoff as opposed to using artificial fertilizers.
This hypothesis will help investigate our problem of phosphorus runoff. By testing phosphorus runoff periodically from the soil trays, which has both these types of fertilizers, we can see if artificial fertilizer leads to more phosphorus runoff than from our four natural fertilizers.

Hypothesis 2: Natural fertilizers will produce healthier grass, as opposed to the artificial fertilizers.
This hypothesis can help investigate our problem by examining grass health in the trays with organic fertilizer and comparing it to grass health in the tray with artificial fertilizer. We examined grass health by determining the height of the grass, and color of the grass. We also examined the root health, by finding the color and length of the roots.

Hypothesis 3: We believe that artificial fertilizers will produce grass that is denser than grass that natural fertilizers produce.
This hypothesis will help investigate our problem by determining grass density in the trays with natural fertilizers, and studying the difference in the grass density of artificial fertilizers and natural fertilizers. We studied this by cutting a square inch of soil out of each tray and counting every blade of grass on the square. We made sure not to cut a piece with too much grass or too less grass.

Hypothesis 4: Natural fertilizers will make the soil healthier than that of artificial fertilizers.
This hypothesis can help investigate our problem by examining soil health in the trays with organic fertilizer and comparing it to soil health in the tray with artificial fertilizer. We examined soil health by determining how moist, dry and/or crumbly the soil was. People who believe in trying to make the world a better place and making their lawns healthy will definitely use natural fertilizers if this hypothesis is supported.

Question 5: Identify the independent variables and the dependent variables in your hypothesis.

Answer:
For our experiment, the independent variables were the different types of fertilizers that we used. These were:

1. Cow Manure
2. Goat Dung
3. Coconut Peat Moss
4. Sheep Dung
5. Artificial Fertilizer

The dependent variables were:

- The amount of phosphorus runoff in the water

- The grass quality as determined by grass height, grass color, root length, root color
- The soil quality as determined by moisture, dryness, crumbliness.
- The grass density

Question 6: When you developed your hypothesis how did you know it could be tested AND could be proven false by testing?

Answer:

When we developed our phosphorus hypothesis #1, we knew that it could be tested and proven by testing. If the testing of the phosphorus runoff from the trays of grass containing the natural fertilizers would produce less phosphorus than the artificial fertilizers tray, then our hypothesis could be supported. If not, it would be refuted. We sent our water to the Naperville Water Department to test for phosphorus. Using this data, we would be able to validate our hypothesis. We also collected data for 12 weeks, with testing the run-off water every 3 weeks, a sufficient amount of time for fertilizers to sink into the soil and for grass to grow.

Our second hypothesis was about the grass quality. When we developed it, we knew that it could be tested and proven false by testing, because if our hypothesis was proven false, the artificial fertilizer would have healthier and greener grass than natural fertilizers. We knew we could test it because when Mr. Carl Gorra (Park District Operations Manager) came over, he told us that we could test by doing a few tests such as the length of the grass, how green it is, length and color of the roots. We also did an RGB (Red, Green, Blue) test to see how green the grass is across the trays. If these tests across the trays are compared and the grass quality in the artificial fertilizers are higher than most of the natural fertilizers, then our hypothesis will be supported.

When we developed our density hypothesis #3, we knew that it could be tested and proven by testing. If the testing of the density from the tray of grass containing the natural fertilizers would produce a lower number of blades per square inch from the tray of grass containing artificial fertilizers, then our hypothesis could be supported, if not, it would be refuted. We knew we could do this, because when Mr. Gorra come over, he told us the method. We took one square inch from the tray and counted the grass blades. We made sure that the area we chose wasn't too dense, or too sparse. Each square inch had a medium density.

Our fourth hypothesis was that the natural fertilizers will make the soil healthier than that of artificial fertilizers. We knew that it could be tested and proven false by testing because Mr. Gorra came to our house and told us how to test soil quality. He said to cut a 1 inch square from the tray and look at the texture of the soil. If the soil was moist, this meant that the soil quality was better than something dry. We created a table with all of our results. If the soil health of the artificial fertilizers is less than the soil health of the natural fertilizers, then our hypothesis will be supported.

Experimental Design

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

Answer:

- Goat manure
- Sheep manure
- Cow manure
- Coconut peat moss
- Artificial fertilizer.
- Chafer Dish Stands
- Trays for fertilizer
- Potting Soil
- Grass Stands
- Calculators
- The Internet
- Google Docs
- Google Slides
- Google Sheets
- Water
- Tables
- Bottles
- Rulers

Question 8: Identify the control group and the constants in your experiment.

Answer:
Our control group were the two trays that had no fertilizer in them.

The controlled variables were:

- The amount of water we used to water our plants
- The days we watered our plants
- The amount of soil put in trays
- The amount of sunlight each tray got
- Grass seeds (number)
- The grass type (Tall Fescue grass)
- The temperature in the room
- Size of trays
- Number of holes for water
- Soil brand
- Bottles - fresh, bought (to avoid smells, contamination)
- Bottles - size
- Tulle fabric
- Bottles given to us for testing
- Testing
    - Same lab - Naperville Water Department
    - Same person - expert in water testing
- the days of growth.

Question 9: What was your experimental process? Include each of the steps in your experiment. Include all safety precautions used by your team as step one.

Answer:

1) Safety Precautions:

We made sure to use gloves whenever were using any of the materials because we didn't want any of us to get sick from of the fertilizers, phosphorus, or soil. We also took precautions when using sharp objects. We didn't use gloves or safety goggles at the science lab at the University of St. Francis because we had Dr. Bromer's permission, since we were not using any harmful chemicals. We also followed the instructions on the artificial fertilizer bag. It told us not to touch the fertilizer with our bare hands, and we made sure to use gloves and only to touch the bag. (see attached pictures for all stages of our experiment)

2) The first thing we did was to design our experiment. We decided to use aluminium chafer dishes to raise the trays and collect water. We originally wanted to use 6 aluminum trays for each of the 4 organic fertilizers, 1 artificial fertilizer and 1 control, but, we decided to have a backup row of each, in case some problem occurred with any of the trays.
3) We poked 10 holes with a safety pin into one corner of aluminium trays (for each of 12 trays) and we set the trays on the chafer dish stands. Then we put bottles underneath each tray, making sure each bottle is aligned under the holes of the trays. We used canning jars to collect the runoff water under the trays. We labeled the aluminum trays and bottles 1A and 1B, to 6A, 6B and noted down what each number-letter combination stood for. For example, 1A and 1B were both trays with cow manure. We then put tulle fabric over the bottles because we wanted a soil filter over our bottles.
4) The next thing that we did was to collect the different fertilizers, soil, and grass seeds. We had to buy the coconut peat moss and cow manure online. Our research said that cow manure should not be used fresh from the source, and that it had to be used as manure, otherwise it would burn the plants. To get our goat and sheep dung, we went to a nearby farm before it closed for the season and picked up sheep and goat dung with permission from the owners at 7 A. M. in the morning, before they cleaned the pens! The experience was a memorable one, and we'll never forget it.
5) To grow the grass, we wanted to use an indoor space where we could get direct sunlight since it was winter in Illinois. We also wanted to ensure that the trays would remain undisturbed during the whole experiment. This led us to choose our team member, Diya (Astronut)'s, sunroom for setting up our experiment.
6) We first added soil in the trays and made sure that the soil we bought from the store did not have any added fertilizer, and the soil quantity was about the same in all the trays. We used the same type of soil in all the trays.
7) We then mixed the organic fertilizers into the trays. Before we mixed, we calculated the correct amount of each type of the organic fertilizer that went into each tray as per the recommended amount from our research (see Table 3 below for our calculations). There were some really small amounts of fertilizer needed (especially the artificial fertilizer). We got access to a lab in our school and measured it using a very small scale. With the coconut peat moss, it came as a brick. We had to cut ⅙ of the block and did this by

cutting ⅓ of the block and cutting that in half. We then soaked the cut brick in warm water and let it sit for 10 minutes. Then we mixed all the organic fertilizers into the soil. With goat dung, we were a little short of the required amount and had to make another trip in the freezing weather to get more of the dung from the farm.

Table 3: Amounts of fertilizer used in each tray:

How we calculated the amount of fertilizer we need for each square foot aluminium tray of soil:
Sheep poop: **1 pound per 200 square feet** **Convert pounds to ounces : 16 ounces for 200 square ft** **Divide both by 200** 0.08 ounces per 1 square foot
Cow manure: **40 pounds per 100 sq ft** **Convert pounds to ounces: 640 pounds per 100 sq ft** **Divide both by 100** 6.4 ounces per 1 square foot
Goat Poop: **250-500 pounds per 1,000 square feet.** **Convert pounds to ounces: 4000-8000 ounces per 1000 square ft** **Divide both by 1000** 4-8 ounces per 1 square foot
Coco peat: **Each one-third cubic foot brick of coco peat makes 4 quarts of planting material** **⅙ of the brick for one of our trays (as per the directions on the packet)**
Artificial Fertilizer: **2.8 pounds per 1000 square foot** **Convert to ounces : 44.8 ounces to 1000 square foot** **Divide by 1000** **0.0448 ounces per 1 square foot**

8) After that, we spread the grass seeds in the trays as per the instructions, measuring how much of the seeds we needed for a square foot (the size of the trays). We then watered the soil and began observing and noting what characteristics we saw from the trays each week. We wanted to make sure that it had the required amount of water, and all the trays had grass growing continuously. We planned to put the heights of all the grass trays once the grass started to grow. We deliberately overwatered the trays to ensure that water would fall in the bottles.
9) Four days after our planting, the grass started to grow in all the trays. We waited for the grass to grow well before we added the artificial fertilizer. This was when we got the idea

to start "mowing" the grass, to simulate a real lawn. Every week, during our weekly meeting we would measure the grass in centimeters, and cut the grass.

10) Once we saw lots of water collecting in our bottles, we decided to change our bottles. We poured the water into small plastic bottles, that were provided to us by one of our resources: Ms. Amy Wrigley from the Naperville Water Department. We also made sure to label these bottles with the same number-letter combinations as before (1A,1B, etc.). We then placed the bottles back in their original place under the trays. We had a regular schedule to measure the phosphorus runoff which was every three weeks. We originally thought we would test every two weeks, but we found out that some of the fertilizers may be slow release for phosphorus. So, we decided to test every three weeks to get five readings of phosphorus before our mission folder was due.
11) We also measured the volume of the water in each bottle by placing the bottles on a paper, and drawing a circle around the bottle to find the radius. Then we used the formula; πr^2 x h, where 'r' is the radius (which we calculated by halving the diameter that we drew) and h is the height of the bottle (which we measured in cm.).
12) We then took some of our bottles of phosphorus runoff to The University of St. Francis, where the Professor in Life Sciences, Dr. Bromer, showed us how to test phosphorus. We also actually tested the phosphorus runoff ourselves! We all enjoyed testing the phosphorus because we found the chemical that we added to our samples of water interesting. We used a device called a Hach 890 to aid us in our testing. We used the bottles that he had provided us.
13) As we were progressing in our experiment, with measuring the grass height, trimming the grass, and testing phosphorus runoff, we saw an article from the Executive director of the Naperville Park District, Mr. Ray McGury on the green initiatives in Naperville Parks. We reached out to him and interviewed him and his team. He introduced us to Mr. Gorra; the parks operation manager of Naperville, who offered to come over and help us test our soil and grass quality. He asked us to wait until mid-February to ensure that there is enough time for the grass to grow.
14) Meanwhile, we were trying to research on what was being used to remove the excess phosphorus from the water in other places and we then interviewed an Environmental Engineer, Mr. Upendra, who informed us about PAOs or Phosphorus Absorbing Organisms. We were interested in pursuing this, but, realized that it was a complicated process to grow these organisms. So, we decided to continue our experiment.
15) We continued to test phosphorus runoff every three weeks and charted all our data: phosphorus (phosphate) levels in milligrams per liter and the grass height. To safely measure the grass height, we took an average height blade of grass from each quadrant of the tray and found the average of them, each week.
16) Then, during mid-February, Mr. Gorra came over and showed us different techniques for testing soil and grass quality. We used this method, which is described in the steps below.
17) We then created a graph with the grass length averages (which we measure each week) for each tray, the grass density, and the phosphorus content. We kept on updating this. We measured the grass trays and got the average of each tray by measuring a average sized piece from each quadrant and recording it. We then got an average to put it in a table which we had started at the beginning of this experiment.
18) To test soil quality, we cut a square inch piece of soil from each of the trays and observed the soil features. We made a variety of many different tables on the attributes we

measured which was how crumbly the soil is, and moisture content or how dry it was. This tip from Mr. Gorra really helped us extend our learning of the inside of our plants and how they affected quality of the plant.

19) To test grass quality, we measured grass height weekly. We also cut a square inch piece of soil from each of the trays and counted the number of grass blades per square inch to calculate the density of soil in each of the trays. We also measured the height of the roots by picking the longest and shortest roots and averaging them out. We also observed the color of the roots - the more white they were, the healthier they were. These tips were also from Mr. Gorra, and they really added to our data and our understanding of the quality of grass.
20) We also did an RGB (red, green, and blue).We did this test on Microsoft Paint and took the total red, green, and blue of each tray. The lower the total, the greener the grass, and the more healthy the grass. We then made a graph with this.
21) We tabulated all our data above and created graphs to see how each of the trays differed from each other (see Data Collection and Analysis).
22) We presented our findings and conclusions to the Mayor of Naperville, Park Executive Director and other officials and the Water Department. We also presented to the professors at the University of St. Francis. We got their feedback and incorporated their suggestions into our analysis and conclusions.
23) We added the second round of artificial fertilizer, as per the recommendation and did one last phosphorus testing in the run-off water (test 5).
24) We added this test results to our data tables and calculated averages.

Data Collection and Analysis

Question 10: Present the data you collected and observed in your testing. The use of data tables, charts, and/or graph is encouraged.

1. We tested the phosphorus content in water that seeped into the bottles under each tray every three weeks. The last column shows the average over the five testing dates.

Table 4: Phosphorus milligrams per liter over time

Tray	Test 1: 12/3	Test 2: 12/24	Test 3: 1/14	Test 4: 2/4	Test 5: 2/26	Average milligrams per liter
Cow manure 1A	0.3	0.25	0.32	1.98	5.12	1.59
Cow manure 1B	0.21	0.34	0.38	1.91	4.99	1.57
Goat Dung 2A	0.91	0.77	1.01	2.18	5.41	2.06
Goat Dung 2B	1.1	0.98	1.07	7.89	5.67	3.34
Coconut Peat Moss 3A	0.61	0.45	0.58	2	5.25	1.78
Coconut Peat Moss 3B	0.34	0.32	0.41	2.09	5.15	1.66
Sheep Dung 4A	0.25	0.34	0.28	2.85	0.17	0.78

Sheep Dung 4B	0.81	0.35	0.57	2.09	0.13	0.79
Artificial Fertilizer 5A	0.22	0.24	0.25	2.32	3.52	1.31
Artificial Fertilizer 5B	0.24	0.28	0.27	2.24	1.16	0.84
Control 6A	0.22	0.75	0.28	7.82	5.67	2.95
Control 6B	0.25	0.35	2.35	N/A	5.09	2.01

Table 4 shows the phosphorus runoff in milligrams per liter. This is the number we get when we test the water for phosphorus. The five testing dates are shown and the average milligrams per liter is what the average of the amounts over the 5 dates (for each of the 12 trays) were. For example, we averaged out the 5 tests for 1A. As you can see above, 2B and 6A have the highest, and all the fertilizers in our fourth test produced much higher results than the rest. In our fifth test, goat dung and sheep dung went down while the rest of the fertilizers shot up. 6B didn't have enough water during our fourth test, so, it could not be tested.

Table 5: Phosphorus milligrams per liter over time - average of A and B

Tray	12/3	12/24	1/14	2/4	2/26
Cow 1	0.26	0.295	0.35	1.945	5.06
Goat 2	1.01	0.875	1.04	5.035	5.54
Coconut Peat Moss 3	0.48	0.385	0.495	2.045	5.20
Sheep 4	0.53	0.345	0.425	2.47	0.15
Artificial 5	0.23	0.26	0.26	2.28	2.34
Control 6	0.24	0.55	1.315	3.91	5.38

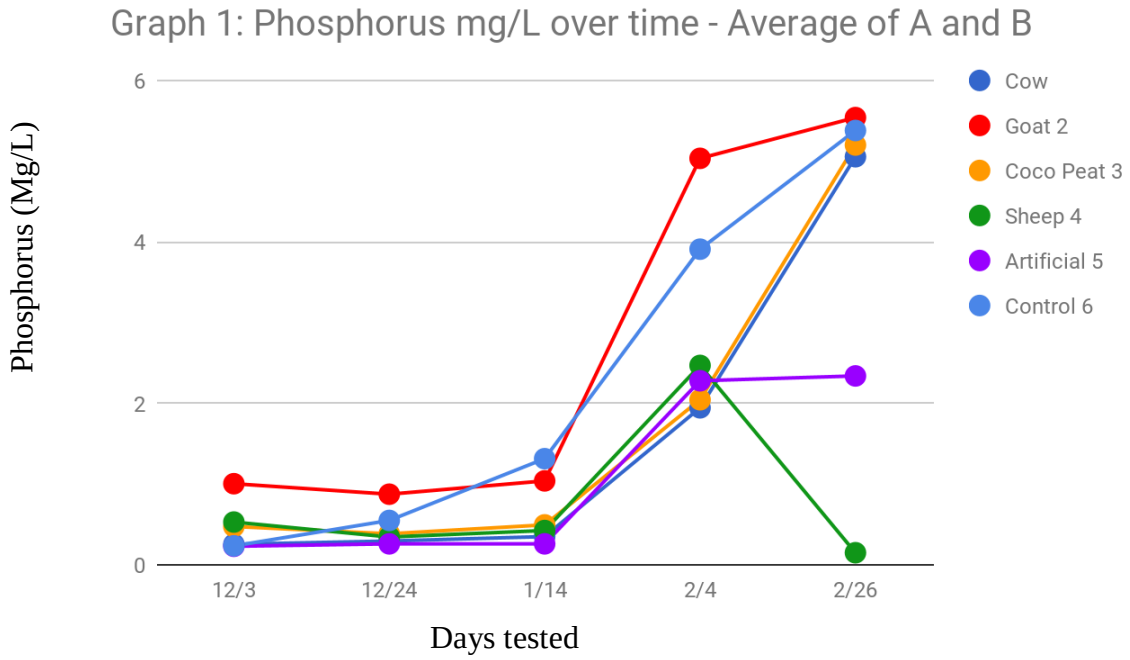


Table 5 and Graph 1 above show the phosphorus in milligrams per liter over time, and the average of A and B trays for each type of fertilizer. We used a line graph because we thought it would be the easiest way to see the trends over time. We also got to see the difference in the fertilizers over the time period we tested. Some trends we found were that goat dung was always above the other fertilizers since the beginning. In the first four readings, the clusters were all together except for the control and goat trays. For the fifth test, however, goat dung, control, coconut peat moss, and cow manure were all clustered together, while artificial fertilizer had a very slight increase and sheep dung had a sudden drop.

Table 6: Phosphorus runoff in milligrams over time:

	12/3	12/24	1/14	2/4	2/26	Average phosphorus in milligrams
Cow Manure 1A	0.10	0.08	0.06	0.12	0.50	0.17
Cow Manure 1B	0.002	0.13	0.09	0.06	0.49	0.15
Goat Dung 2A	0.29	0.27	0.19	0.21	0.43	0.28
Goat Dung 2B	0.70	0.06	0.26	1.32	0.72	0.61
Coconut Peat Moss 3A	0.10	0.08	0.04	0.45	1.08	0.35
Coconut Peat Moss 3B	0.003	0.07	0.08	0.13	0.30	0.12
Sheep Dung 4A	0.12	0.09	0.03	0.08	0.02	0.07
Sheep Dung 4B	0.12	0.15	0.06	0.04	0.01	0.08
Artificial Fertilizer 5A	0.03	0.06	0.04	0.11	0.76	0.20

Artificial Fertilizer 5B	0.03	0.09	0.01	0.03	0.11	0.05
Control 6A	0.12	0.05	0.03	0.23	0.17	0.12
Control 6B	0.14	0.15	0.35		0.45	0.27

Table 6 shows the total amount of phosphorus release over time. We calculated this by first calculating the volume. We placed the bottles on paper, then we drew circles around the bottom of our bottles. After that we calculated the diameter/radius by measuring it with a ruler. For our first test, we had different bottles, with different sizes, but after that we switched to the same brand bottle, so the radius would be same all across. Then, we marked where the water level is with a red Sharpie marker, and we measured the height in centimeters. Then we applied $\pi r^2 h$ to find our volume in cc (cubic centimeters) or ml (milliliters). Then, we had to change our volume from milliliters to liters, because our phosphorus results come in milligrams per liter. We did this by dividing our number (in milliliters) by 1000. Then, to find the total phosphorus that came out, in milligrams (because our results come in milligrams per liter, we need to find what it is in milligrams), we multiplied the volume in liters with the phosphorus milligrams per liter. We did this for each volume and phosphorus reading, so we had 12 in total (for 12 trays). Then, we had 5 testings. The graph and table above show the five dates. For 6B, we did not have enough water so we could not test. We tested this because we wanted to know the total amount of phosphorus coming out of the trays, because this is what is getting into the rivers. However, the milligrams per liter prove more useful.

Table 7: Total Phosphorus in milligrams over time - Average of Trays A and B

	12/3/17	12/24/17	1/14/18	2/4/18	2/26/18
Cow	0.05	0.10	0.07	0.09	0.50
Goat	0.49	0.16	0.23	0.77	0.57
Coconut Peat Moss	0.05	0.08	0.06	0.29	0.69
Sheep	0.12	0.12	0.05	0.06	0.02
Artificial	0.03	0.07	0.03	0.07	0.44
Control	0.13	0.10	0.19	0.23	0.31

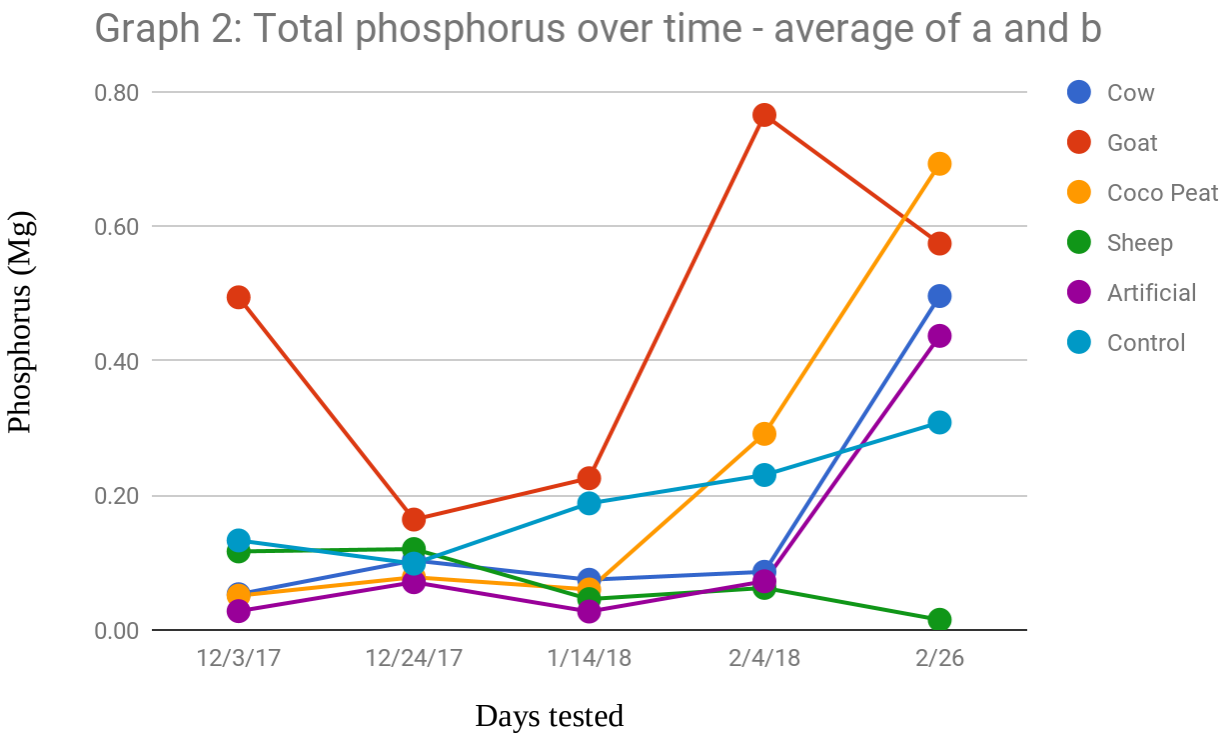
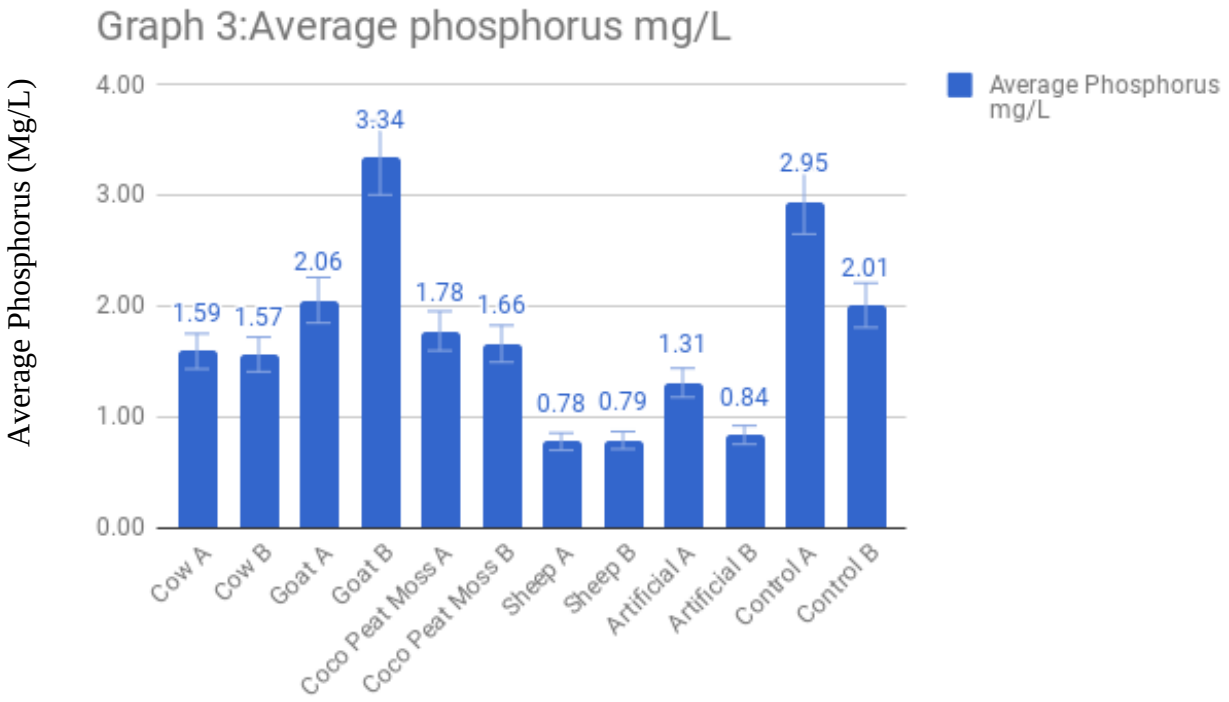
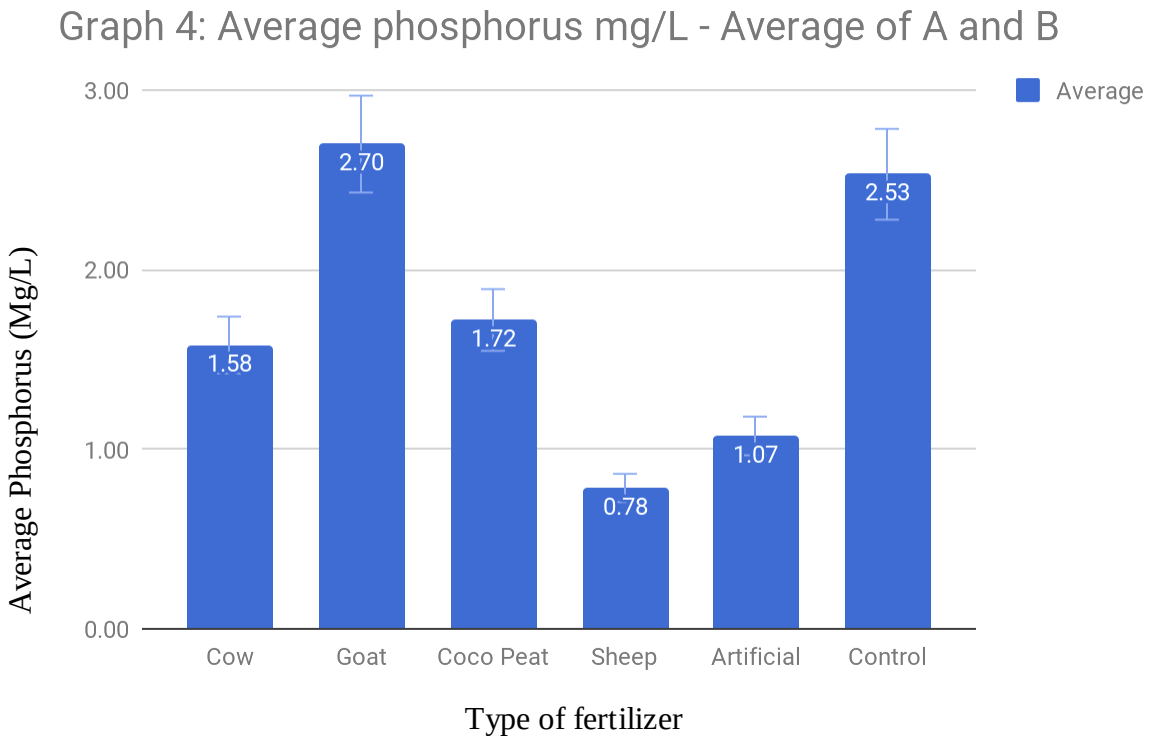


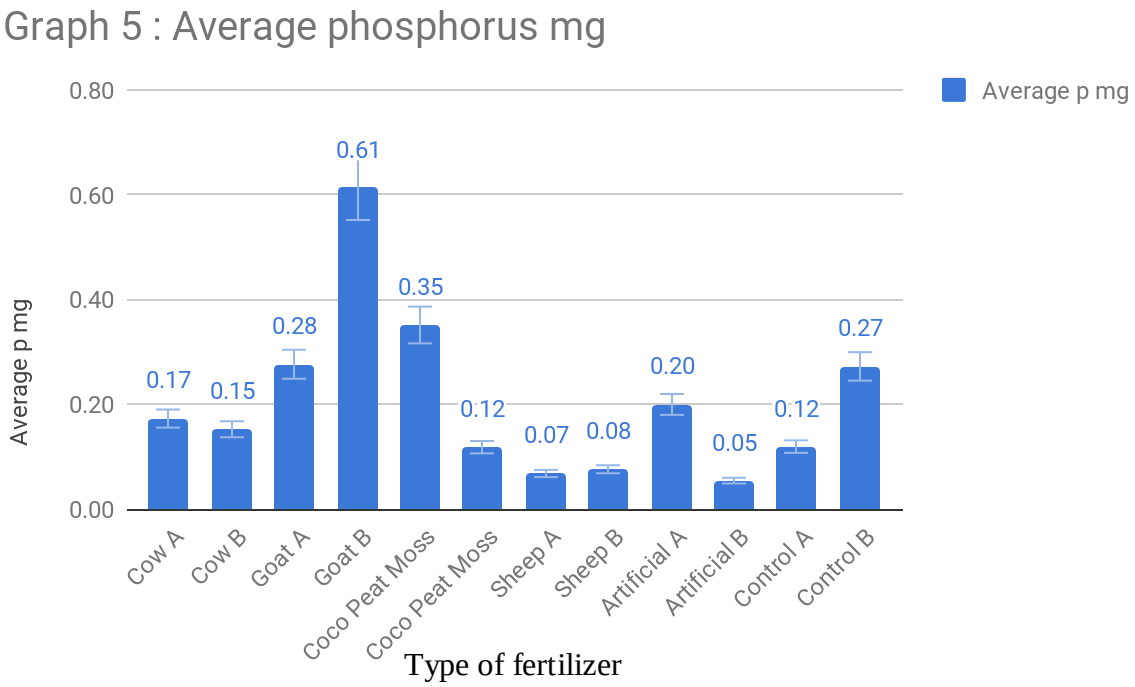
Table 7 and Graph 2 above show the total phosphorus in milligrams. We took the same steps as before, in Graph 1. However, this time, we took the average of 1A and 1B and put it together as Cow, as seen above in the graph. We did the same for all the trays. We then graphed it, and chose to do a line graph again because it shows the data in the best way possible. In the second and third reading, all six trays are close to each other, until the fourth and fifth readings, where everything either dramatically spikes up or drops down. Surprisingly, goat dung reduced in the fifth test, and coconut peat moss was the highest.



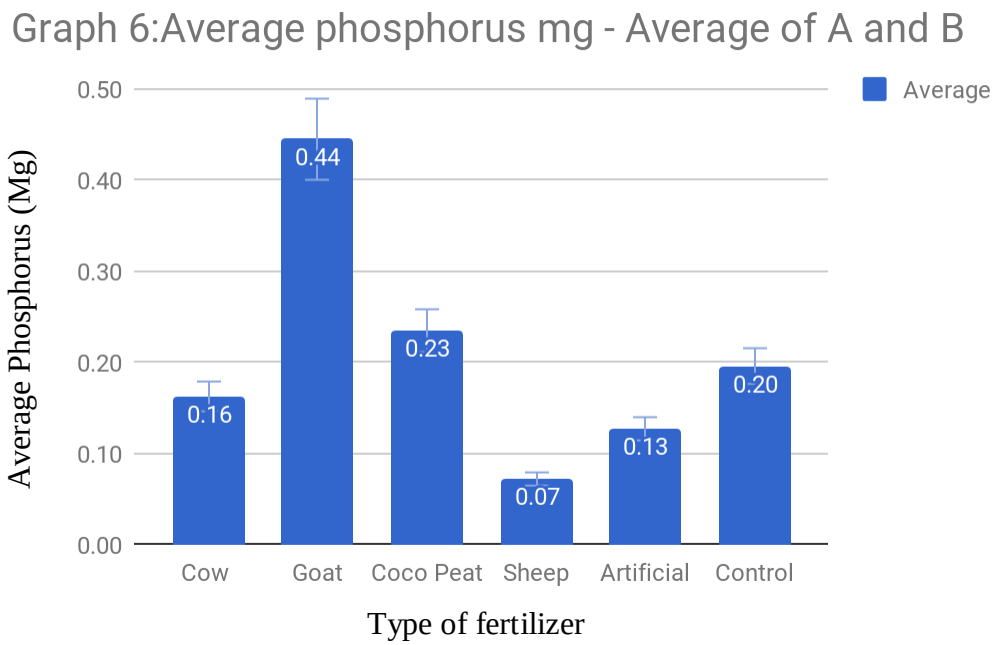
Graph 3 shows the average phosphorus in milligrams per liter. Basically how we did this was we took all five test dates for each tray and averaged them out. The average phosphorus was least in sheep dung tray and the most in the goat dung.



Graph 4 was made by using Graph 3 and averaging A and B. Goat dung had the highest phosphorus average, and control is following close behind. Sheep dung has the lowest phosphorus runoff. The rest of them are comparable.



Graph 5 is the graph of all the total phosphorus values. We averaged them out (from the 5 tests) and graphed alone. The highest bar on the graph belongs to Goat dung, and the next highest is coconut peat moss. The two lowest bars belong to artificial fertilizer and sheep dung. The rest of the values are comparable.



This Graph 6 above was made using the values from the last graph. We averaged A and B out and made a new graph of it. Again, goat dung has the most phosphorus milligrams per liter, and sheep dung as the least. The rest of the trays have about the same amount of phosphorus in milligrams per liter with only a slight difference of 0.07 milligrams.

Table 8 - Percent Difference from Control and Artificial Fertilizer in milligrams per liter:

	Average Phosphorus milligrams per liter	Average of A and B	Percent Difference from control	Percent Difference from Artificial fertilizer
Cow A	1.59	1.58	-36.26	47.11
Cow B	1.57			
Goat A	2.06	2.70	8.87	151.30
Goat B	3.34			
Coco Peat Moss A	1.78	1.72	-30.62	60.15
Coco Peat Moss B	1.66			
Sheep A	0.78	0.78	-68.37	-27.00
Sheep B	0.79			
Artificial A	1.31	1.07	-56.68	0
Artificial B	0.84			
Control A	2.95	2.48	0.00	130.82

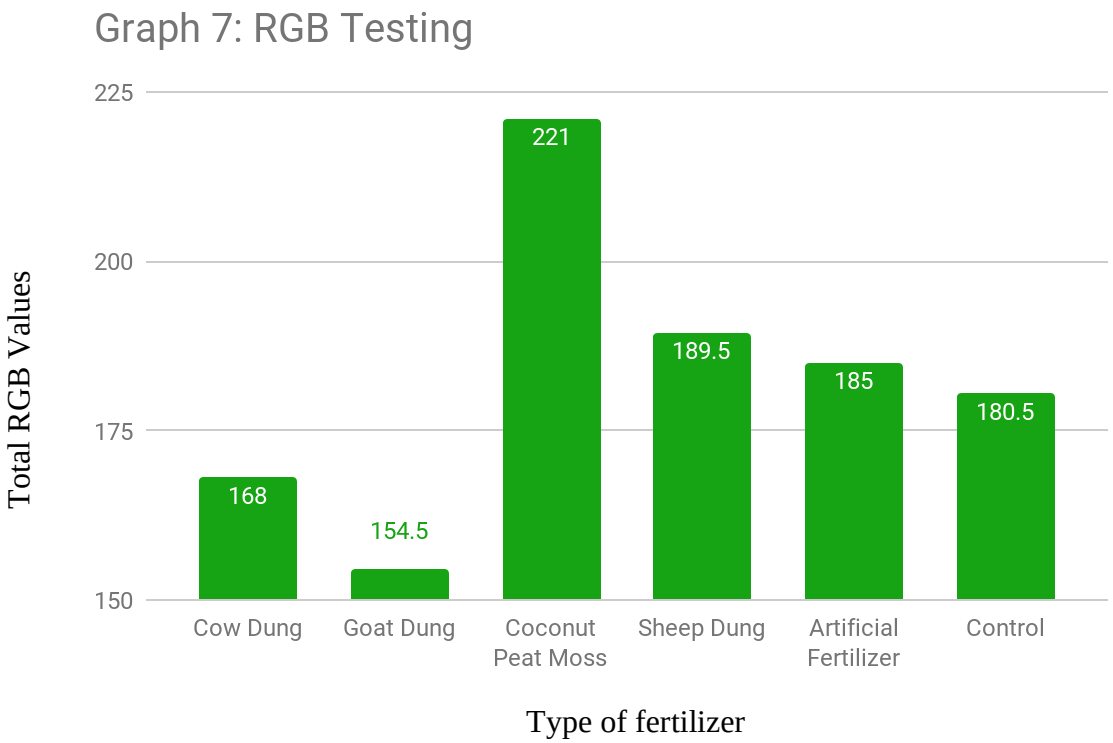
Control B	2.01			

This table shows Percent Difference from our control trays and our artificial fertilizer trays. We did this to see how much the trays differed from both the control and from the artificial fertilizer. Our first step was calculating the average phosphorus in milligrams per liter, which one of the graphs show above. The next step was to take the average of A and B. Then, we calculated the percent difference from control. This data tells us that all of the natural fertilizers except for sheep dung are higher than than the artificial fertilizer tray.

Table 9 - Percent Difference from Control and Artificial Fertilizer in milligrams:

	Average	Average of A and B	Control	Artificial Fertilizer
1A	0.17	0.16	-16.92	28.01
1B	0.15			
2A	0.28	0.44	127.02	249.78
2B	0.61			
3A	0.35	0.23	19.84	84.65
3B	0.12			
4A	0.07	0.07	-63.20	-43.30
4B	0.08			
5A	0.20	0.13	-35.10	0
5B	0.05			
6A	0.12	0.20	0	54.07
6B	0.27			

In Table 9, we did the same things as above, except this is the total phosphorus that came out. The control has the highest phosphorus results except for goat dung, and artificial fertilizer has the lowest phosphorus, except for sheep dung.



To find out how healthy the grass was, we cut a sample of the trays and took a picture of it. We then looked at the color of the grass, and used microsoft paint to do an RGB (red, green, blue) test. Once we found the red, green, and blue of each fertilizer tray, we took the totals of the numbers and made this graph (Graph 7). The lower the value, the greener the grass. We wanted to see how much each fertilizer is by itself, so we averaged each fertilizer A and B tray. As you can see, goat dung has the greenest grass which means it has the healthiest grass. Coconut peat moss has the highest total RGB thus having the lightest grass. We used a bar graph because we thought it was the easiest way to store our data. Coconut peat moss has the highest value, and the most yellow grass. Goat dung has the least value, and the greenest grass. The rest of them are comparable, except for cow dung, which is also very low.

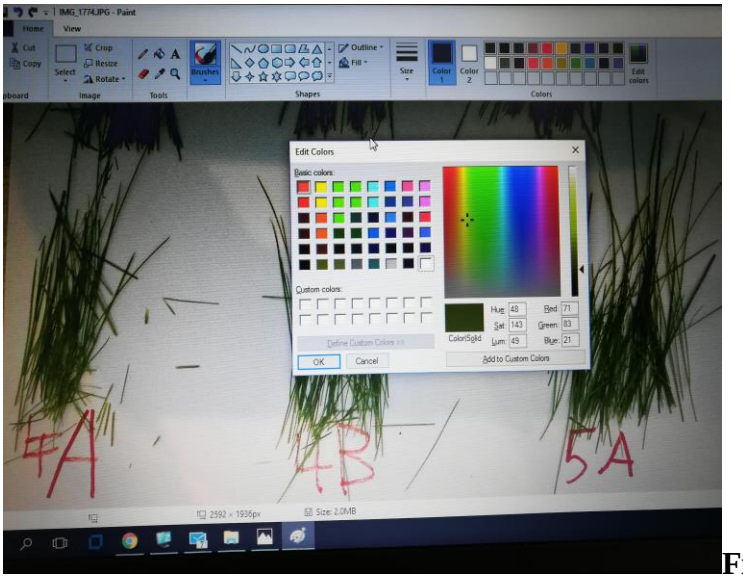
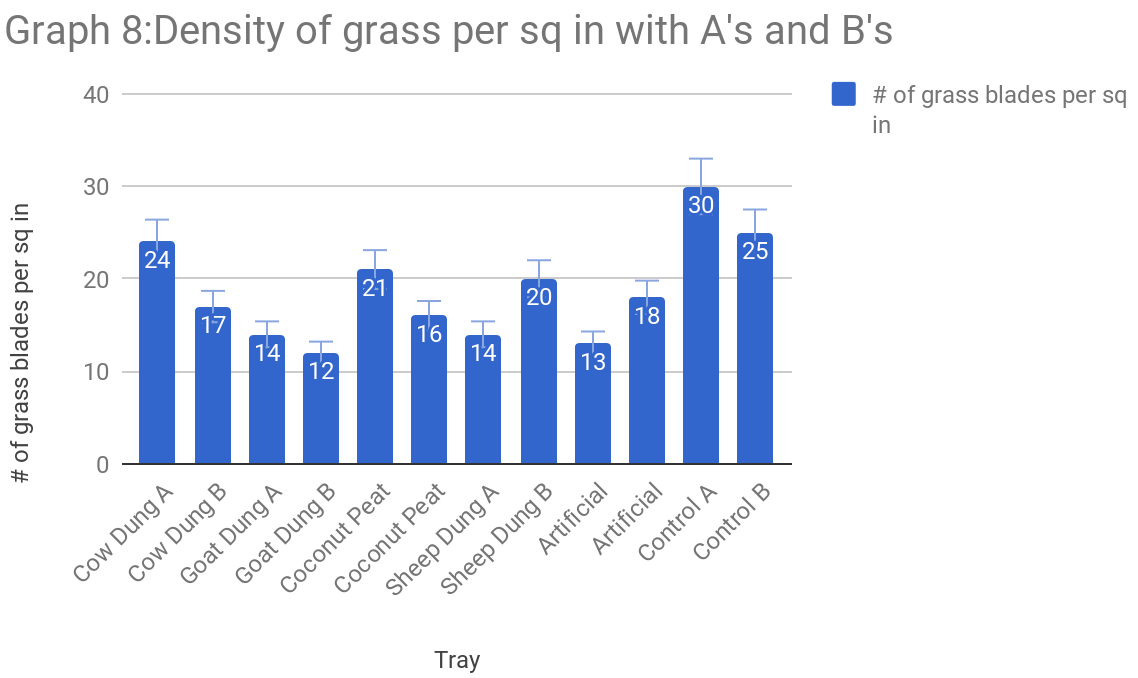
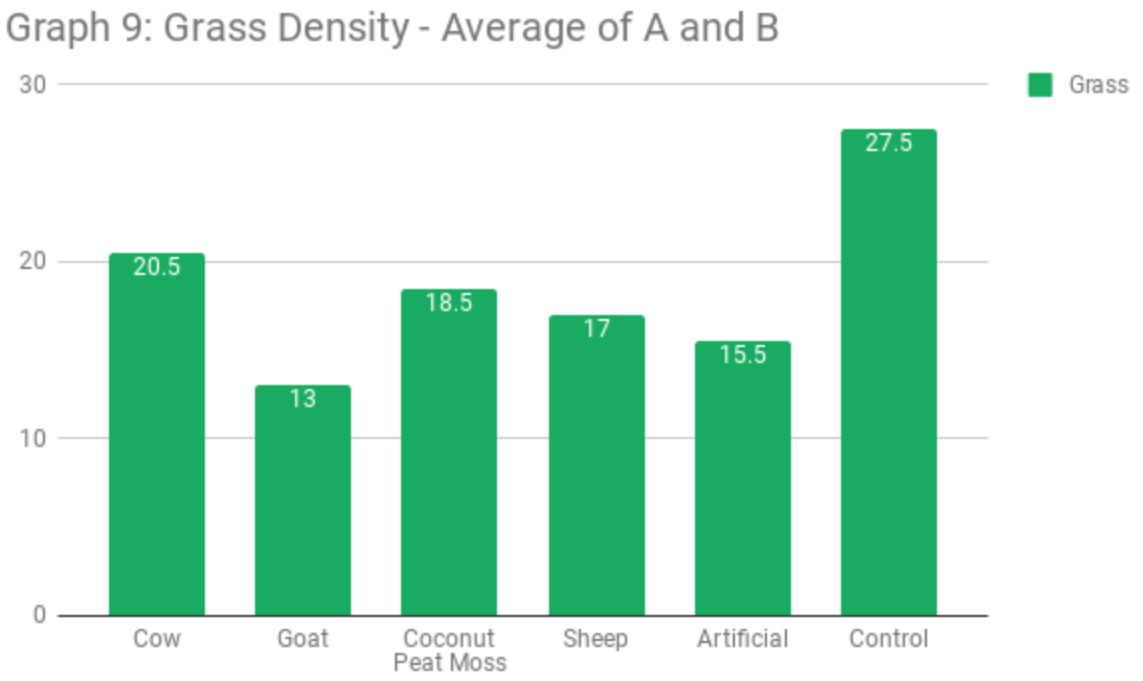


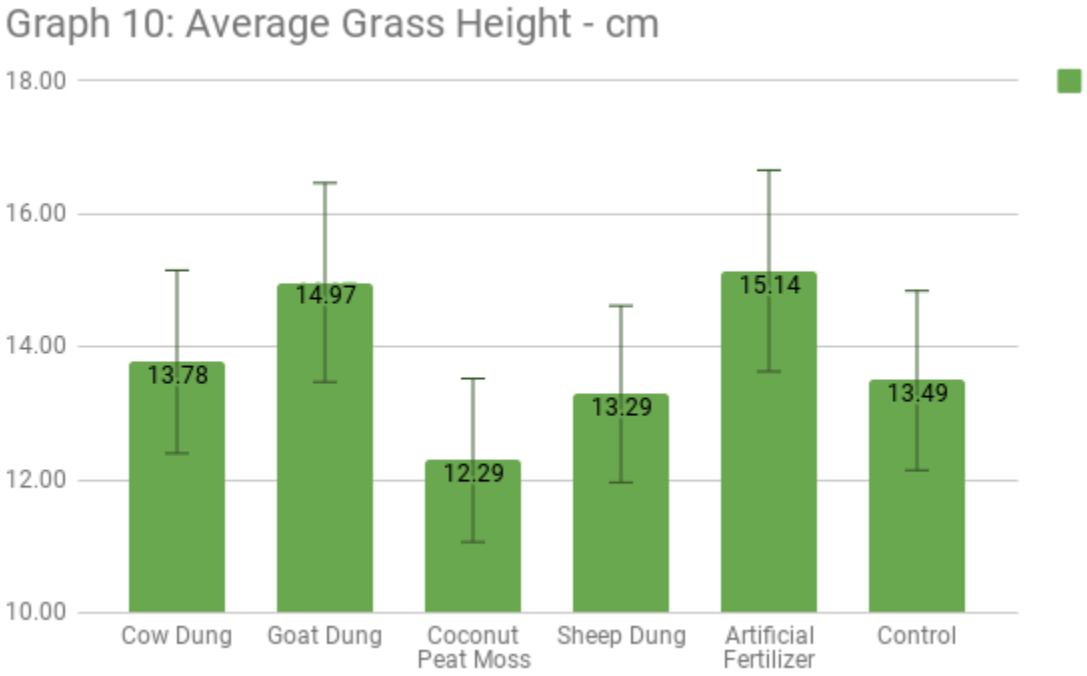
Figure 5: RGB test for grass



Graph 8 shows the density of grass. Control has an unusually high density, and Goat Dung had a low density. All the other trays had comparable density.

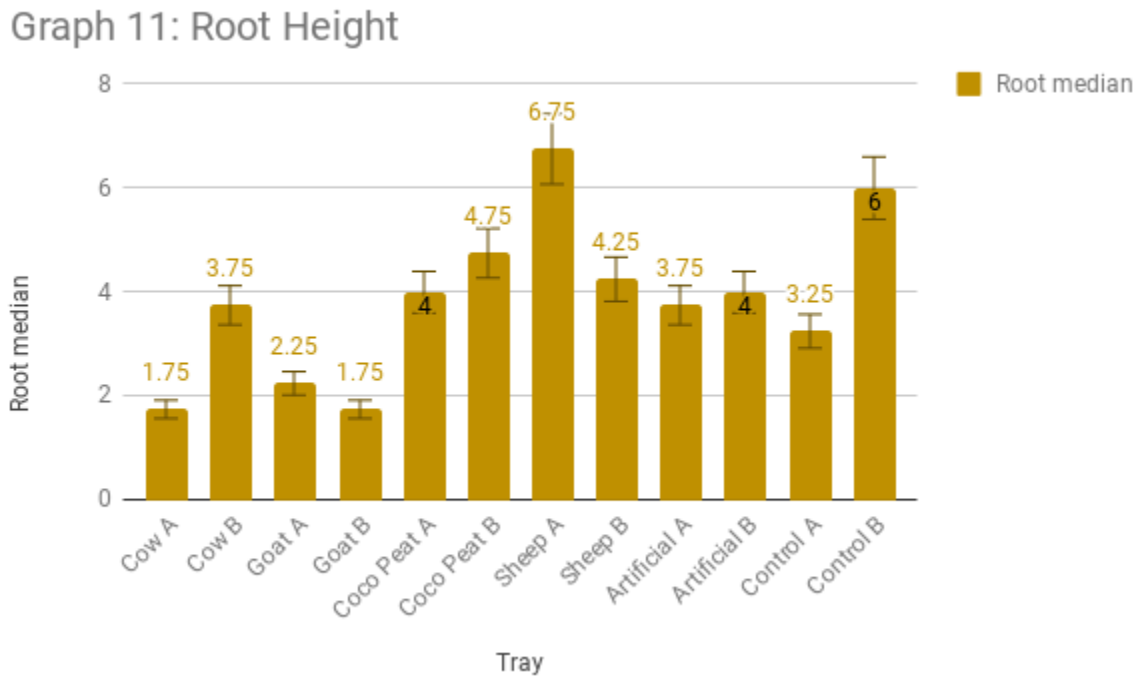


We averaged A and B from Graph 8 to for Graph 9. For example, 1A and 1B were averaged to Cow Manure. Goat has a really low density, and Control has a very high density. The rest of them are comparable.

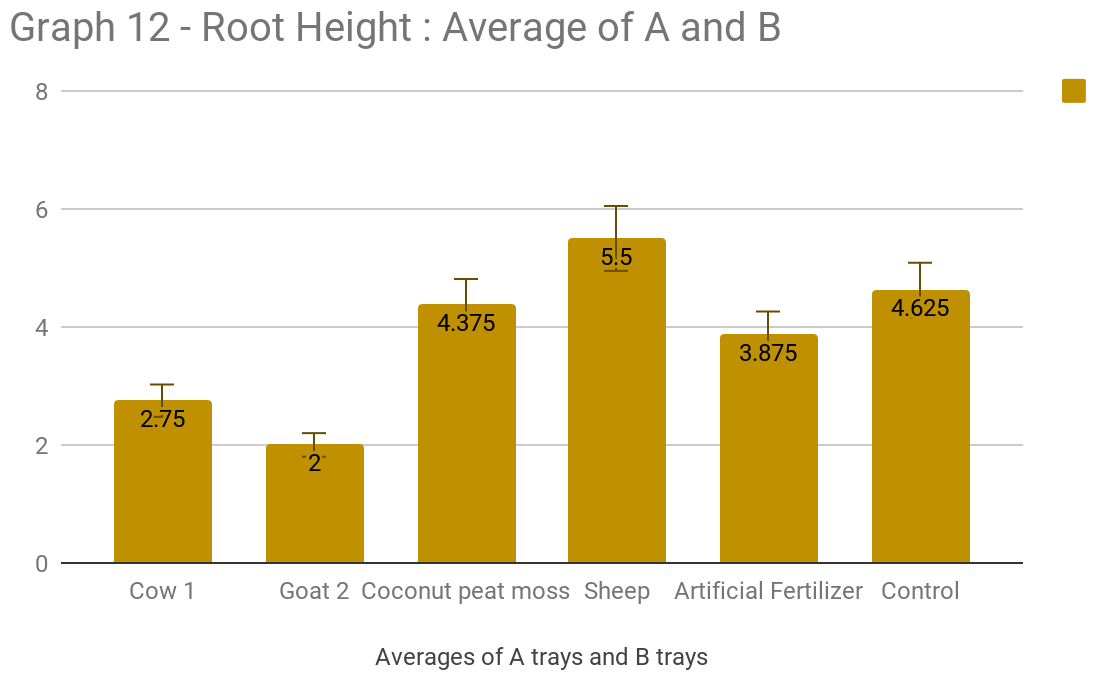


Graph 10 shows the grass height. We also "mowed the lawn". Cutting the grass to the same length gave surprising results as the grass grew taller each week. As you can see in the graph

above, our plant based fertilizer (coconut peat moss) had the shortest grass and our artificial fertilizer had the tallest grass.



Graph 11 shows the root height Root height (in cms) was comparable across all the trays. Goat dung trays had the smallest roots. Sheep dung had the longest roots.



We made Graph 12 by averaging the A and B values from Graph 11. These are the root height results. The highest and lowest roots only had a difference of 3.5 centimeters. We interpreted this

as all the fertilizers being mostly the same in root height. Again, sheep had the longest and goat had the shortest roots.

Table 10: Root color test results

Tray	Root Color
1A - Cow	white
1B - Cow	white
2A - Goat	white
2B - Goat	white
3A - Coconut Peat Moss	white
3B - Coconut Peat Moss	yellow-white
4A - Sheep	white
4B - Sheep	white
5A - Artificial	white
5B - Artificial	white
6A - Control	white
6B - Control	yellow-white

Table 10 is the color of the roots. As seen in the data, most of the roots have the same healthy white color while two trays, one tray with coconut peat moss and one tray with the control had yellowish-white roots.

Table 11 - Dryness of the soil test results:

Tray:	Dryness:
1A - cow manure	dry
1B - cow manure	more dry than moist
2A -Goat Dung	moist
2B - Goat Dung	moist
3A - Coconut Peat Moss	really moist
3B- Coconut Peat Moss	really moist
4A - Sheep Dung	dry
4B- Sheep Dung	moist

5A- Artificial Fertilizer	dry
5B- Artificial Fertilizer	moist
6A- Control	dry
6B - Control	dry

Table 11 shows the soil quality of each tray. When Mr. Gorra, the Naperville Parks Operations Manager, came over to our house to give us tips on measuring soil quality, he told us to record the dryness and crumbliness of the soil. As you can see, coconut peat moss was very moist, and this is because it retains a lot of water (as our research told us). While the control trays were really dry, there was no significant difference among all the other trays.

Table 12 - Test results of crumbliness of the soil:

Tray	Crumbliness
1A - Cow	None
1B - Cow	None
2A - Goat	None
2B - Goat	Crumbly
3A - Coconut Peat Moss	None
3B - Coconut Peat Moss	None
4A- Sheep	None
4B- Sheep	Crumbly
5A- Artificial	None
5B- Artificial	None

6A- Control	Crumbly
6B- Control	Crumbly

Table 12 shows if the soil was crumbly or not.
However, crumbly does not necessarily mean dry. 2B was very crumbly, yet it was moist, too. This test was surprising to us, and added to our data. We also learnt that crumbly meant good, so we changed our thoughts and posed questions, like *Why are the trays so different??*

These were some general trends we noted in all our data:

- ➢ Our grass health and soil health were comparable across all our trays, except for coconut peat moss, which had bad soil and grass health
- ➢ Phosphorus levels varied across all the trays, with sheep dung having the lowest. The phosphorus levels in coconut peat moss, cow manure, and the artificial fertilizer were comparable in every test.
- ➢ Cow Manure was always medium for the grass quality tests, but it was about the same as artificial fertilizer with the phosphorus except for the fifth test where it was above artificial.
- ➢ Goat Dung was always high in phosphorus
- ➢ Coconut peat moss was always very moist, and had the lightest and shortest grass. It also had bad grass and soil health.
- ➢ Sheep dung always released the least amount of water. Sheep dung also showed decreased phosphorus runoff in our last test.
- ➢ Artificial Fertilizer always had one of the least for phosphorus
- ➢ Control trays were always dry

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

We had four hypotheses in our experiment, and we tested each one through different variables.

Our first hypothesis was that using natural fertilizers will have less phosphorus in the water runoff as opposed to using artificial fertilizers. Our data supports this hypothesis for one natural fertilizer: sheep dung, but the data from coconut peat moss, cow manure and goat dung refutes our hypothesis. For the first three tests, cow manure and sheep dung were comparably close to artificial fertilizer. We studied the phosphorus runoff every 3 weeks, we had 5 tests in all. We calculated phosphorus in milligrams per liter and the total phosphorus in milligrams. Our graph that shows the average phosphorus in milligrams per liter shows us that the artificial fertilizer had one of the least amount of phosphorus. The artificial fertilizer had the least phosphorus in all the trays with the exception of sheep dung. Our graph that shows the average

phosphorus in milligrams (the total phosphorus) also refutes our hypothesis. Artificial fertilizer had the least phosphorus in all of our graphs except for sheep dung. Therefore, this hypothesis was refuted for all of our variables except for sheep dung.

Our second hypothesis was that natural fertilizers will make grass healthier than the artificial fertilizers. Our data refutes the hypothesis. The grass health was comparable between the two types of fertilizers. We know this is true based the data we collected for grass health indicators, which were the grass height, the color of the grass, the root height, and the root color. There was only a three cm difference between the tallest grass (artificial fertilizer) and the shortest grass (coconut peat moss), and there was no big difference in the color of grass in all the fertilizers, with the exception of coconut peat moss, which was yellow. Our coconut peat moss trays were very yellow, and thus very unhealthy. We think that coconut peat moss required much less water because the soil was very moist.

Our third hypothesis was that we believe that artificial fertilizers will produce grass that is denser than grass that natural fertilizers produce. This hypothesis was refuted because the artificial fertilizer did not produce grass that was denser than the natural fertilizers. The density of grass in our artificial and natural fertilizer trays were comparable to each other. Our control tray had the most density, and at first, we thought this was a mistake. So, we tested it again, and got the same results. As seen in Tables 14 and 15 and Graphs 8 and 9, the grass density is similar across 5 of the 6 trays.

Our fourth hypothesis was that natural fertilizers will make the soil healthier than that of artificial fertilizers. Our data refutes our hypothesis because there was no significant difference between the soil health indicators in the trays with artificial fertilizer and all the natural fertilizer trays. We know this because our data on soil health indicators: moisture level in the soil and crumbliness or dryness in the soil were comparable across the trays of natural and artificial.

Question 12: Explain any sources of error and how these could have affected your results.

Answer: Here are some of the sources of error of our experiment:

1. One source of error in our project was the artificial fertilizer because of how we applied it. We used granules, while typically, in all golf courses and many lawns, they are sprayed on the grass directly.
2. Another source of error could be the way we set up our experiment. We tested the water run-off at the bottom of each tray. If someone gets their lawn fertilized and it rains that same day, all of that phosphorus from the fertilizer goes straight to the river. In the lawns, the run-off water is from the top of the soil and not from under the soil. This could be reflecting on the run-off phosphorus levels from the trays.
3. Another source of error was that our water was being controlled. In our research we did learn that fertilizers like coconut peat moss absorbs a lot of the water. Still we watered all of the trays the same to keep this constant. This may have caused too much moisture in trays 3A and 3B (Coconut Peat Moss). This may have influenced our results. Trays 3A and 3B had the yellowest grass, and the shortest grass growth. This didn't simulate a real life situation, because our research showed that this fertilizer was used in drier areas.

4. The Control trays likely had some source of error, because they always showed a high level of phosphorus runoff. We are unsure of the reason behind this, but it is possible that there was contamination somewhere. We can treat these values as outliers.
5. Another source of error was our time. Even though 12 weeks was a sufficient amount of time for fertilizers to sink into the soil and for grass to grow, it might not have been enough time for all the phosphorus to be released in the groundwater/runoff; especially by the slow-release fertilizers. This was not really our fault, but if we could have started earlier, we may have had enough time. The results in phosphorus releases may change over time if we continue testing.
6. We also had some soil in the bottles of collected water, even though we covered each bottle with a tulle fabric and secured it with a tight elastic band. The soil may have contaminated the water and may be a source of error.
7. We used tap water to water our plants. We later learned that Naperville water has a small amount of phosphorus (0.163mg/L) which may influence our phosphorus runoff levels.
8. Finally, we grew the grass indoors due to the winter weather in Illinois. This did not simulate the real environment for an outdoor grass growth. This may have influenced how the plants grew and the phosphorus was absorbed.

Drawing Conclusions

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

Answer:

Conclusion

We know now that sheep dung, coconut peat moss and cow manure are reasonable alternatives to artificial fertilizers. Using sheep dung may actually lead to lower phosphorus runoff because the total average was lower than the artificial fertilizer. The grass and soil quality of the natural fertilizers were also about the same as the grass and soil quality of the artificial fertilizers, making all of them great alternatives to consider.

Usefulness of our data

Our comprehensive data about soil and grass quality indicators, coupled with the phosphorus runoff tests make it useful for us to compare the four types of natural fertilizer against the artificial fertilizer.

There was one essential part of the phosphorus cycle that we kept in mind. All the phosphorus from the natural fertilizer is already part of the cycle, and is already in the soil. When it goes into the soil, some of it is taken up again by the plant. But the phosphorus from the artificial and mineral fertilizers is new, and goes into the groundwater and other water sources.

Natural fertilizers are also better than artificial fertilizers, though, because natural fertilizers don't need to be replenished, and artificial fertilizers do. This means that with repeated use of artificial fertilizers, there will be a long term increase in the amount of phosphorus released compared to natural fertilizers. Another thing is that all of the phosphorus in natural phosphorus is already a part of the phosphorus cycle. This means that the problem of increased phosphorus in runoff is due to added phosphorus that was not originally in the cycle, which

comes from artificial fertilizers. Thus, by using sheep dung, cow manure, or coconut peat moss, we can reduce the amount of phosphorus added to the phosphorus cycle while maintaining the same healthiness of grass and soil.

Another thing we learnt is that coconut peat moss is especially good for hot, dry places such as Arizona, because it can retain a lot of water. Dry places don't get so much water, and so the peat moss can provide water for the plant.

Modifications to our hypotheses or experimental design

We would most likely not make changes to our hypothesis, but we would change our experimental design. For example, we may water the trays based on need for water or soil dryness, instead of having a controlled system. Then, for example, we may give coconut peat moss less water. Another experimental design difference could be to test our hypothesis outdoors, closely simulating the lawn. We would also try to research how to test phosphorus runoff from the top of the trays, rather than have holes at the bottom, like we did. Finally, we would try to use a spray fertilizer for the artificial fertilizer, instead of using the granules.

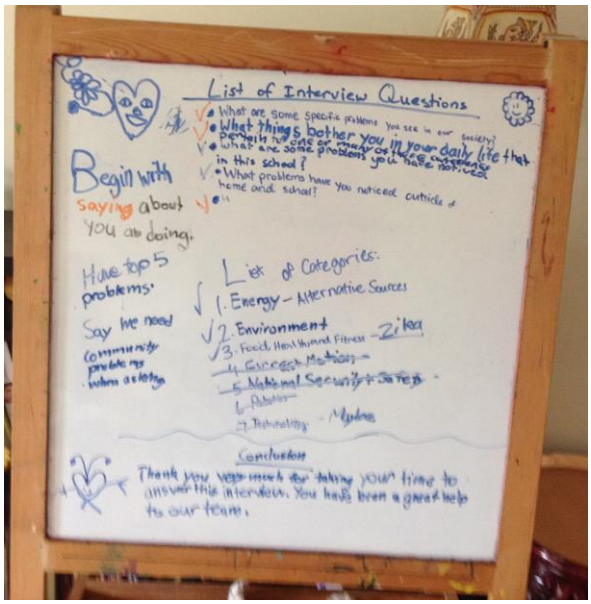
Further testing or retesting:

We would also try to test all our trays for a longer time to test slow-release and long-term release of phosphorus. We would also like to retest our control group, as our data seemed to be an outlier for this group.

To summarize: In conclusion, even though our hypothesis about the phosphorus runoff was refuted for three of the four natural fertilizers, we can still say that natural fertilizers are a reasonable alternative to artificial fertilizers use due to the facts that:

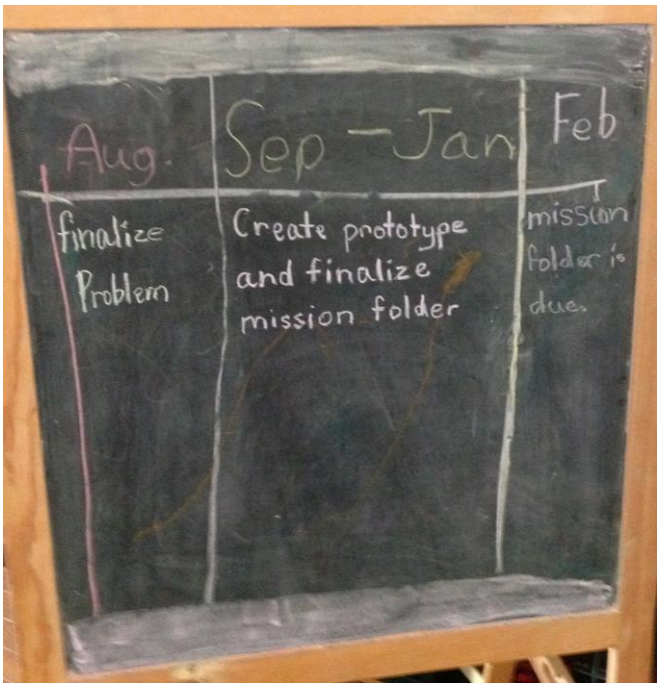
- ➔ Artificial fertilizers have to be replenished every eight weeks, while natural fertilizers do not need to be replenished.
- ➔ Natural fertilizers' soil and grass quality are comparable to those grown in artificial fertilizers
- ➔ Artificial fertilizers are a separate part of the phosphorus cycle
- ➔ Changing to natural fertilizers will reduce the 40% of phosphorus getting in the runoff water from artificial fertilizers

Pictures



Picture 1 is a picture of our Interview Outline. We created an interview in order to find out what prominent problems were in our society. We were assigned to interview 6 or more family, friends, and teachers/administrators at school. We also made a list of categories so the public could have a smaller range of topics to choose from.

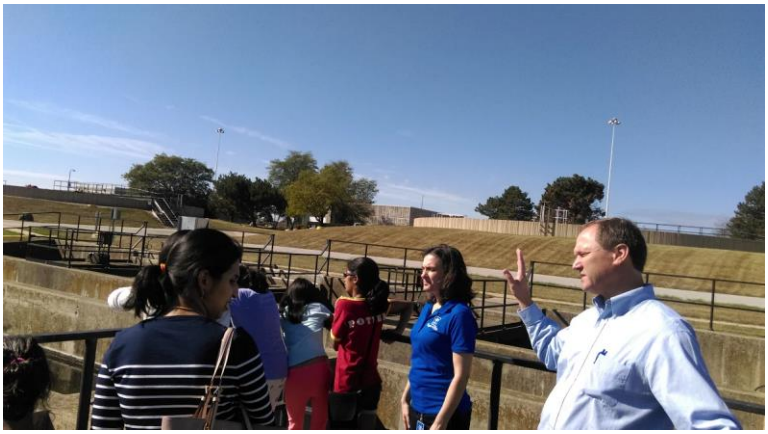
Picture 2 is our Problem Chart. As you can see, here are our top 12 problems. We each took up 3 problems and further researched them. We then rated them and took the average. The higher numbers, we considered were in the higher category, the numbers we considered were in the middle were in the middle category, etc. The problems with a very low rating, we rated them not interested. We then further eliminated our problems by researching and by interest. We then arrived to the general problem of natural fertilizers.



Picture 3 shows a very basic timeline that we made early on in our experiment. We wanted to create this since we did not want to procrastinate and wanted to be on an orderly schedule. We originally wanted to create a prototype for a device/invention to get rid of algae/phosphorus, but after a while, we decided to test phosphorus after the problem was brought to our attention.

Picture 4 (above) shows us in the beginning stages of our project, working together.

Picture 5 is a picture of our meeting with Mr. Holzapfel, Director of Public Utilities - Water Department of Naperville.



Picture 6 & 7 above show us on a tour of the wastewater treatment plant in the Springbrook water reclamation center, which Mr. Holzapfel and Ms. Wrigley took us on. We learned many things on the process in which they remove chemicals from the water.

Picture 8 is a picture of us putting the soil in our 12 trays, the first stage of our experiment. We marked an area of the tray to make sure all of them were filled to the same height. The soil we found had no artificial fertilizers so our experiment wouldn't contain more phosphorus.

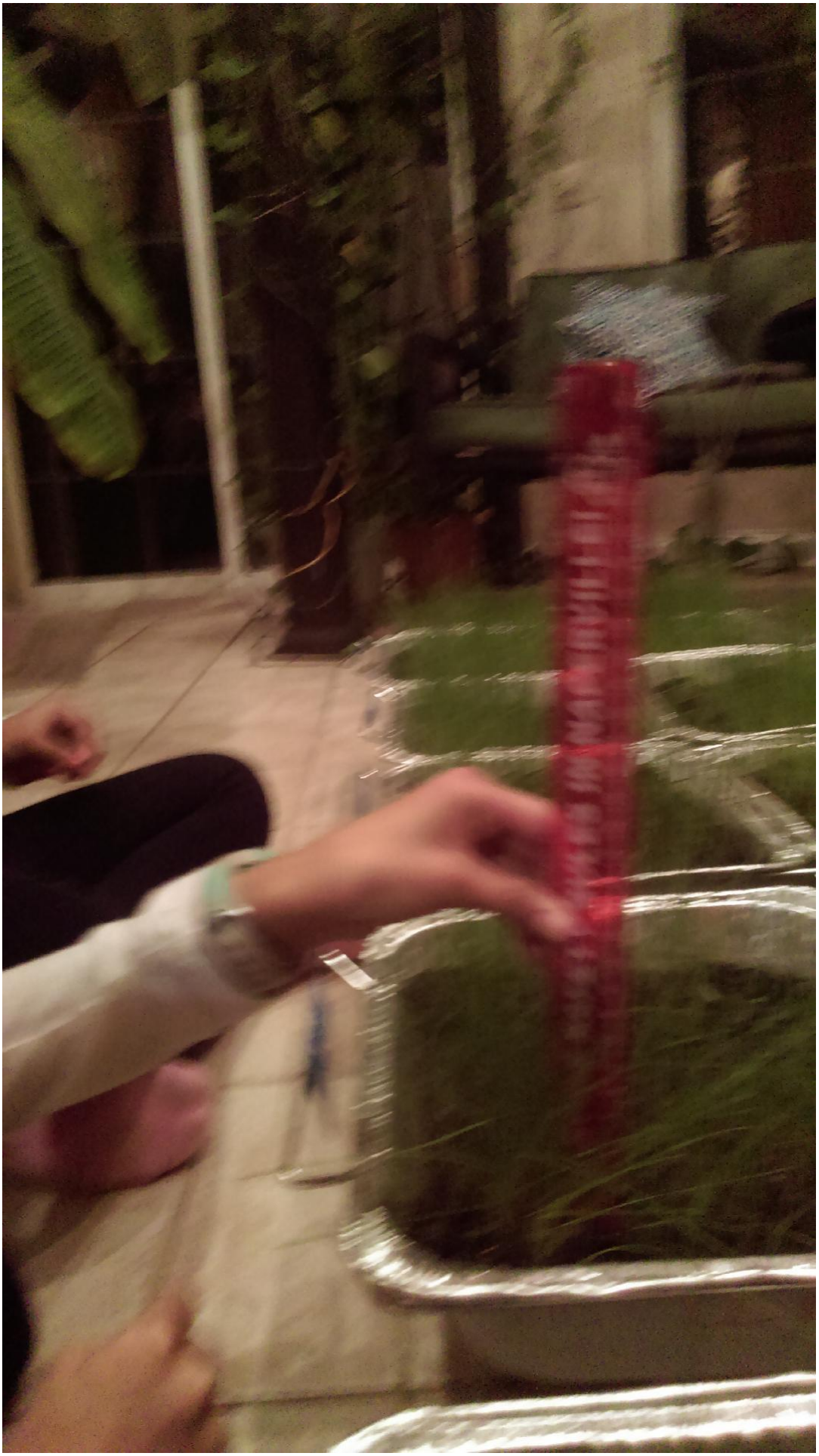
Pictures 9, 10, 11 & 12 above are two of our team members in the farm collecting fresh goat and sheep dung for our experiment. We had to get there at 7 A. M. in freezing cold weather, before they cleaned the pens.

Pictures 13 above is us mixing the animal based fertilizers (goat, sheep dung and cow manure) into the soil. The picture 14 on the right is us measuring the correct amount of the plant based fertilizer, coconut peat moss and using a scale, while one team mate was getting an exact $1/6^{th}$ of the brick by using a cheese grater.

Pictures 15 & 16 above show us covering the bottles that we used to collect the run-off water using tulle fabric and elastic bands to secure them over the bottles.

Picture 17 below shows all of us watering the trays for the first time, after we planted the grass seeds.

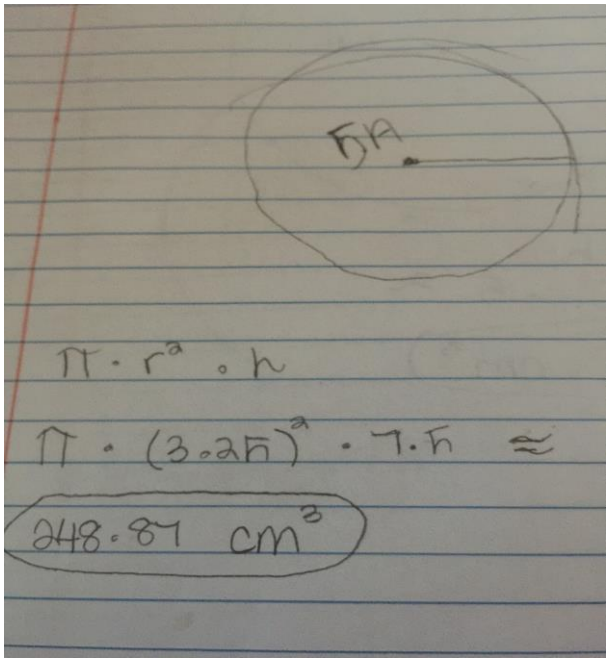
Our trays set-up. We used numbers on each bottle and the tray to identify the different independent variables: types of fertilizers.



Picture 24 above shows the Naperville Parks Director, Ray McGurry, and his co workers. We went to go and present to them our project after we received an email from him. He sent out an email to all Naperville residents about going green by switching to natural herbicides. This got us interested in meeting him. He has really exposed us to a lot of people, and opportunities to expand our project to the actual city of Naperville.

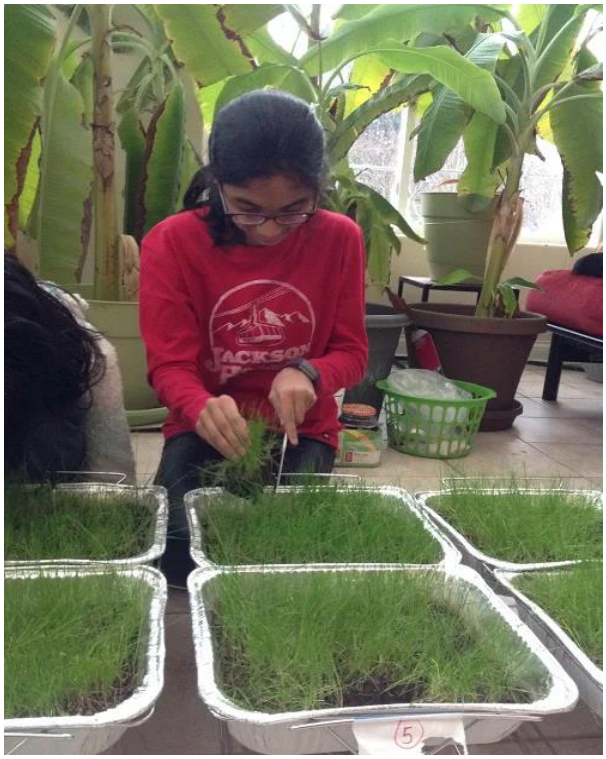
Our water run-off samples that we sent to the water department for testing phosphorus.

Picture 27 (below left) shows how we calculated the volume of the bottles.
Picture 28 (below right) shows how we laid out samples of every grass tray to use for the RGB tests.



Picture 29 (on the left) shows Mr. Gorra, grass specialist from the park district, over to help us test the soil and grass quality. He gave us many tips on how to

Picture 30 (bottom left) and 31 (bottom right) both show us measuring grass and soil quality. In 30, we are cutting a square inch of soil in each tray. We are looking at the crumbliness and dryness of the soil to measure soil quality. We are also looking at root color and root height in picture 31.



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District 203 Middle School Students Present Soil Research to Naperville Officials

NAPERVILLE, Ill. —On Wed., Feb. 14 and Fri., Feb. 16, a small group of District 203 middle school students presented the results of their original research to officials at the City of Naperville's Water Utility and to the Naperville Park District, respectively. Mayor Steve Chirico, City Councilwoman Patty Gustin and Park District Executive Director Ray McGury joined an audience of staff and parents who attended the Feb. 16 presentation.

-more-

The four sixth grade students, representing both Kennedy and Madison Junior High Schools, met in elementary school and shared a desire to conduct a scientific study of a real-world issue. After considering many different topics, they chose to study the problem of excessive phosphorus in ponds and streams, which leads to algal blooms that can harm marine life. Their experiment was to compare the effects of natural versus artificial fertilizers on the amount of phosphorus runoff.

With the assistance of Dr. Srimani Chakravarthi, one of their parents, the students began their research in May 2017. They consulted with several experts about how to test water, soil and grass, including Jim Holzapfel, Naperville Water and Wastewater Utility Director; Dr. Bill Bromer, a biology professor at the University of St. Francis; and Carl Gorra, Park Operations Manager (Central) at the Naperville Park District.

The students assembled trays of soil and grass and compared the effects of natural versus artificial fertilizers under carefully controlled conditions. The grass and soil quality were comparable across artificial and natural fertilizers. The phosphorus run-off levels were surprisingly low in the artificial fertilizer trays, and also, low in the tray that used cow manure as the natural fertilizer. One explanation may be that the artificial fertilizer may have been slow-release and needs to be studied over a longer period of time. The overall results suggested that cow manure may be a suitable alternative to artificial fertilizers.

The students plan to submit their research to a national competition and want to follow up with further study.

PHOTO CAPTION

Natural vs. Artificial Fertilizers
Students pose with City and Park District officials following their presentation on Friday, Feb. 16 at the Knoch Park Central Maintenance Facility. From left to right: Carl Gorra—Park Operations Manager (Central); student researchers Meera, Siya, and Diya; Councilwoman Patty Gustin, Mayor Steve Chirico, and Park District Executive Director Ray McGury. The fourth student researcher, Anjali, was not able to attend the presentation. Photo available here.

ADDITIONAL CONTACT:
Dr. Srimani Chakravarthi, team leader for the student researchers, srimanic@yahoo.com

# # #

About Naperville: *Located 28 miles west of Chicago, Naperville, Ill., is home to approximately 145,000 people. This vibrant, thriving City consistently ranks as a top community in the nation in which to live, raise children and retire. The City is home to acclaimed public and parochial schools, the best public library system in the country, an array of healthcare options and an exceptionally low crime rate. Naperville has ready access to a variety of public transportation, housing and employment options. The City's diversified employer base features high technology firms, retailers and factories, as well as small and home-based businesses. Residents also enjoy world-class parks, diverse worship options, the opportunity to serve on several City boards and commissions, a thriving downtown shopping and dining area, a renowned outdoor history museum known as Naper Settlement and an active civic community. For more information, please visit our website at www.naperville.il.us.*

About the Naperville Park District: *Created in 1966, the Naperville Park District is an independent, municipal agency serving the recreation needs of its residents. An Illinois Distinguished Agency since 1994, the District is one of only 1% of park districts across the country to be nationally accredited through the Commission for Accreditation of Park and Recreation Agencies (CAPRA). The Naperville Park District's mission is to provide recreation and park experiences that promote healthy lives, healthy minds and a healthy community. The District maintains and operates more than 2,400 acres with 137 parks and provides more than 1,500 recreational, arts and environmental programs and special events annually. Included within the District's operations are two championship golf courses, a multitude of playgrounds, trails, athletic courts and sports fields, Fort Hill Activity Center, Knoch Knolls Nature Center, two inline skating and skateboarding*

facilities, the Millennium Carillon, a paddle boat quarry, historic Centennial Beach, and the beautiful Riverwalk. For more information, please visit our website at www.napervilleparks.org.

Community Benefit

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

Answer:

Our experiments and data can benefit our community in the following ways:

Phosphorus from natural fertilizer is already part of the phosphorus cycle, and artificial fertilizers introduce more phosphorus to the cycle. Our experiment shows that some natural fertilizers decrease phosphorus runoff, and all of the natural fertilizers result in comparable grass quality. Using natural fertilizers such as sheep dung will most likely decrease the risk of "dead zones" caused by phosphorus runoff. Also, natural fertilizers can retain soil health. They also are an alternative to artificial fertilizers because they don't add to the phosphorus content and won't add to it because it is already part of the phosphorus cycle. Coconut peat moss is able to retain a large amount of water and is great for drought-stricken places. Sheep dung leads to the least amount phosphorus runoff and therefore, a good alternative for artificial fertilizers.

The city of Naperville was issued an ordinance by the federal EPA (the Environmental Protection Agency) to reduce the amount of phosphorus in Naperville's waters.
We were able to present our findings to several different people on several different dates to validate our study.

Our first presentation was to the Water Department on February 14, 2018 at the Naperville Water Department to Mr Holzapfel, the Director of Public Utilities for Water, Naperville City Councilwoman Mrs. Gustin, Technical Specialist, Ms. Amy Wrigley, who tested our phosphorus content, and the Water Compliance Officer.

Our second presentation was on February 15, 2018 at the University of St. Francis. We presented to Dr. Bromer and few of his colleagues, one of whom is an Associate Dean.
Our third presentation was on February 16, 2018. We presented to the Mayor of Naperville (Mayor Chirico), Mr. Ray McGury, the executive director of the Naperville Park District and his colleagues; Mr. Gorra and Mr. Finnegan. Mr. McGury told us that the Naperville Park District had to pay $200,000 to get rid of algae and phosphorus, for a small portion of a pond in Hunter's Woods Park. After we presented to the Mayor, he was very interested, so an article in the local newspapers: **Naperville Patch** and the **Chicago Tribune (Naperville Sun)** was published about our team. The article has been uploaded and here are the links to our articles.
http://www.chicagotribune.com/suburbs/naperville-sun/community/chi-ugc-article-district-203-middle-school-students-present-s-2018-02-21-story.html
https://patch.com/illinois/naperville/students-present-soil-research-naperville-officials

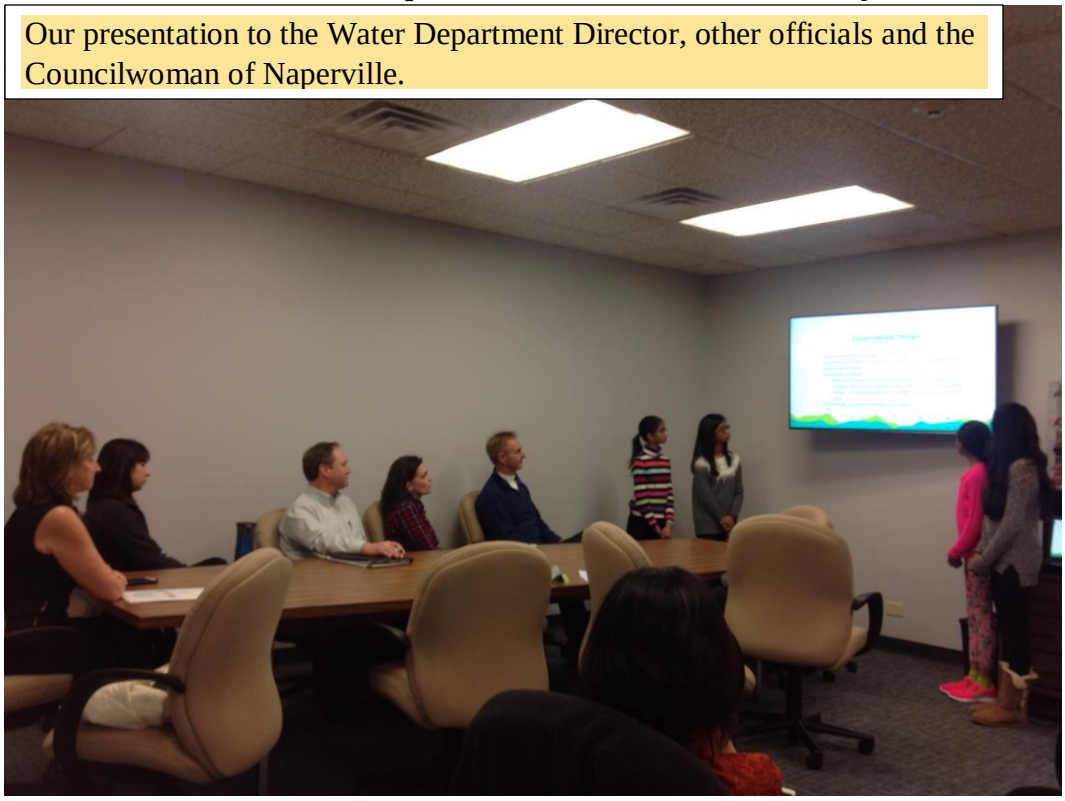
Our experiment will strengthen the already-green initiatives in Naperville. We have presented our research to many Naperville officials. They would like us to do a podcast and

attend a Naperville Parks board meeting to disseminate our research to the community. Hopefully, this will bring about awareness in the community about this problem. This problem can only be tackled by bringing awareness and educating people.

The Executive Director of Parks is very interested in supporting our findings and sharing them with the city residents. He has invited us to present at the Naperville Board Meeting and will put us on the agenda for their April meeting, during Earth Week initiatives. He has also invited us to develop a podcast of our study and share it with the residents in his monthly email. We plan to continue our study and participate in all these activities. We hope that the city will adopt these natural fertilizers in its green initiatives and help other cities do the same as well.

Pictures of our presentations in our community:

Our presentation to the Water Department Director, other officials and the Councilwoman of Naperville.



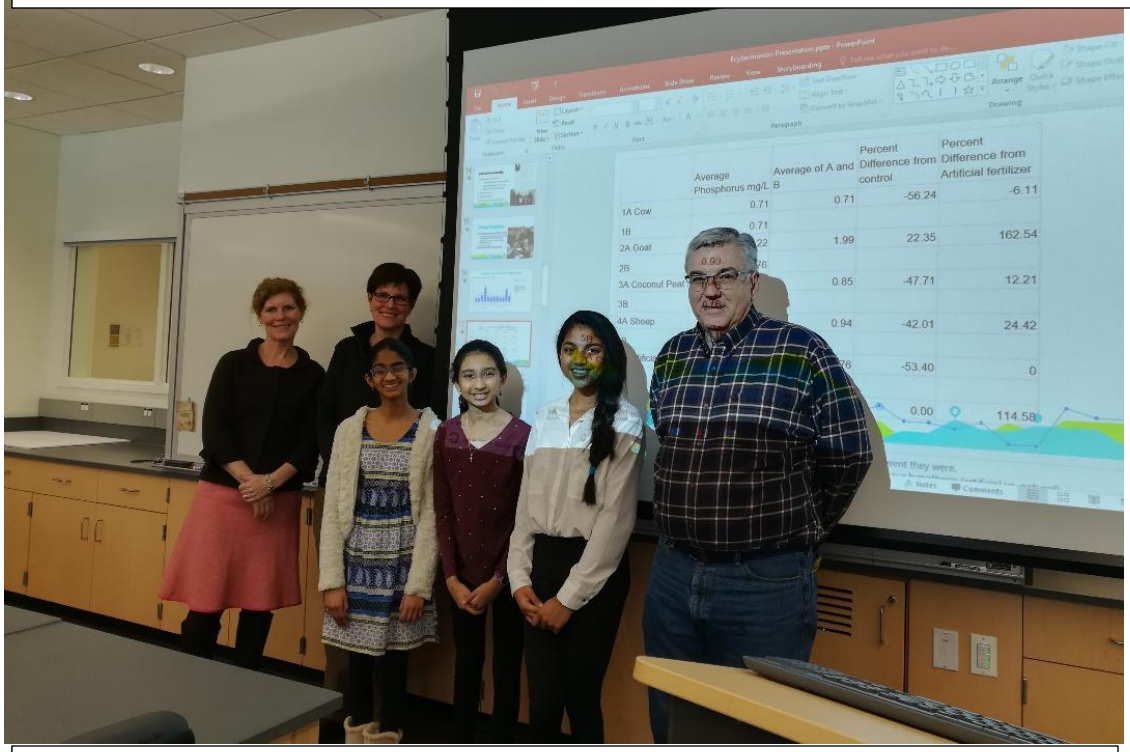
Presenting our data and finding to all.

With Mr. Holzapfel, Director of Water Department, Amy Wrigley, Operations Manager, Compliance Manager, other officials at the Water Reclamation Center and the Councilwoman of Naperville.

Our presentation to the Mayor, Executive Director of Parks, other officials and the Councilwoman of Naperville.

With Executive Director of Parks, Mr. McGury

With Professor of Life Sciences, Dr. Bromer, Dean, Dr. Sloan, and Ms. Tracy, College of Education.



Our presentation at the University of St. Francis, with Professor of Life Sciences, Dr. Broemer, Dean Dr. Sloan, and Ms. Tracy, College of Education.

From the community: District 203 Middle School Students Present Soil Research to Naperville Officials