Ready, Set, Grow!

New Mexico

Supercomputing Challenge

Final Report

April 3, 2019

1001

Los Lunas High School

Student:

Delsin Jaramillo

Teacher:

Anne Loveless

Mentors:

Abe Anderson

Creighton Edington

Table of Contents

Executive Summary

Algae are single-cellular, nonflowering, usually aquatic plants that grow in groups. When certain conditions are met, different cultures of algae grow. These conditions are the nutrients found in water and sunlight; the nutrients in the water determine the culture of algae grown. Algae have been found to have applications in the medical, agricultural, and energy fields. The reason algae hasn't been used more in our world is because algae is expensive to grow and monitor leading us to make little progress in implementing it in our society. To help solve this problem, I've created a program in NetLogo to analyze the growth of green algae and also use the program to find a fast and efficient way of growing algae by adding more nutrients in the nutrients solution. This program could have further applications in the field of algae as well as science. By improving the program and analyzing how algae grows and decays, I hoped to increase the efficiency of the

algae growth model. This could help stop the waste of materials and save money to conduct more experiments with algae.

Introduction

Algae to a lot of people are looked as something that grows in swamps or in their fish bowls, but with the growth of technology, we have been finding uses for it. Certain types of algae have been found to have applications in the agricultural, medical, and energy fields [1].

Algae have applications in the medical field by using the algae in chemotherapy. With normal chemotherapy, the chemo treatment is meant to stop the cell division of the cancer cells, but in the process it also stops other cells from dividing. This includes the patient's white blood cells, stomach lining, and more. Through genetic engineering the algae biomineralized silica (brown algae commonly found in fish tanks) is attached to the chemotherapy drugs which then attach itself only to the cancer cell and not touch any other cells [5].

Algae have uses in agriculture because algae are rich in nitrogen, and, when combined with compost, makes the compost rich with nutrients without having to alter the algae itself [6]. Algae can also be used as a biofuel because algae stores energy in the form of oil and could be easily converted for use in engines[3].

Algae have many applications and could be used more in our everyday lives, but the main reason we have not implemented algae more in these fields is because growing algae is difficult. One of the main problems in growing algae is the expense to grow and maintain it; the algae takes from three to six weeks to grow. Using algae as a biofuel is then a problem because it takes more energy to create the algae than the energy the algae outputs [4].

Method

The goal of this project is to find a better way of growing algae and indicating if the algae is healthy or is starting to decay. I grew algae (nannochloropis oculata) over a two week time period in a plate of 24, 3ml wells. Each well of algae was given different amounts of salt in its nutrients solution at a ratio of 1ml of algae to 1ml of the solution ratio in nine wells for every test. The algae with a set amount of salinity in the nutrients solution were placed in different columns and rows of the plate from each other due to the edge effect. The edge effect is the change in population or community structures that occur at the boundary of two or more habitats. The algae were placed on an orbital shaker and are shaken twice a day for 10 minutes at 80 rpms. An LED lamp was placed 30 cm above the algae with 27 LED lights at full spectrum to simulate sun light. Pictures of the algae were taken every day in the same spot with the same amount of lighting and a blank piece of copy paper under the algae. I used a Kyocera Dual Force Pro phone to take the pictures with the same setting for the amount of white light. The phone was set on a tissue box in the same area.

By creating a program in NetLogo, I was able to analyze the average pigment of the algae to indicate the growth or decay of algae over a period of time. The pictures were cropped out to the same size and ratio aspect. The different colors of green were found by using a color indicator to examine healthy and decaying algae and compare it to the patch colors in the program. In NetLogo each color was assigned a number up to the first number after the decimal point. To make it easier for the code to analyze current wells of algae, the turtles would walk over the patch similar to the pigment of green it is. Then the patch color is changed to a different color with a whole value. The monitors would then count the color patch and a different monitor would find the average color value. The color values were based on a scale of one to ten starting with lightest color of green to the darkest color of green on the scale in Figure 2.

After all the data was collected, the data was recorded in an Excel spreadsheet. Then I used the spreadsheet to find the average pigment color every day. The average pigment told how healthy the algae were overall in the experiment. Each testing period lasted two weeks (the life cycle of this algae).

Once a testing period was complete, I mixed all the algae together and calculated the base amount of salinity in the algae. I used the information I gained to select the next amount of salinity. Then I would make nutrient solutions that matched the new amount of salinity for the fresh algae to the salinity I selected to test. Every different nutrient solution was then tested three times to get an average pigment color overall and verify my results.

Code

```
ifelse (pcolor >= 1.4) and (pcolor <= 1.9)     ;;Black forest
  [set pcolor 33]
  [
   if pcolor >= 35.1   ;;asparagus green almost dead
   [ifelse pcolor >= 35.7  ;;green smoke
     [ifelse pcolor >= 40.7 ;;dark olive
     [ifelse pcolor >= 40.9 ;;dark green
     [ifelse pcolor >= 41 ;;Verdun green
     [ifelse pcolor >= 42.7  ;;highball green
```

```
[ifelse pcolor >=  51 ;;dark green
 [ifelse pcolor >= 52.1  ;;Verdun green
  [ifelse pcolor >= 52.7  ;;green kelp
   [ifelse pcolor >= 53.2  ;;dark olive
    [ifelse pcolor >= 55.5 ;; olive drab
     [ifelse pcolor >= 71 ;;black
      [set pcolor 31]
     [set pcolor 12]
     ]
     [set pcolor 26]
    ]
    [set pcolor 24]
   ]
   [set pcolor 22]
  ]
  [set pcolor 35]
  ]
  [set pcolor 14]
```

```
          ]
          [set pcolor 22]
         ]
        [set pcolor 35]
       ]
      [set pcolor 26]
      ]
        [set pcolor 18]
     ]
      [set pcolor 16]
   ]
   ]
  ]
```

The code above is run as the turtles walk over the patches; if the patch color value meets the requirements, the program keeps asking until the patch doesn't meet the requirements. Once it has stopped meeting the requirements, the patch color is changed to the corresponding color as shown in Figure 2.

The comments beside the “ifelse” statements show the colors the patches are.

Results

Key

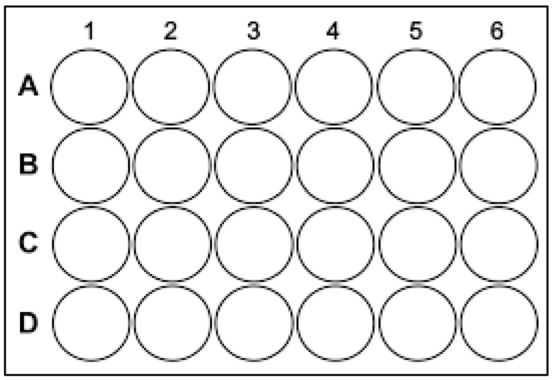


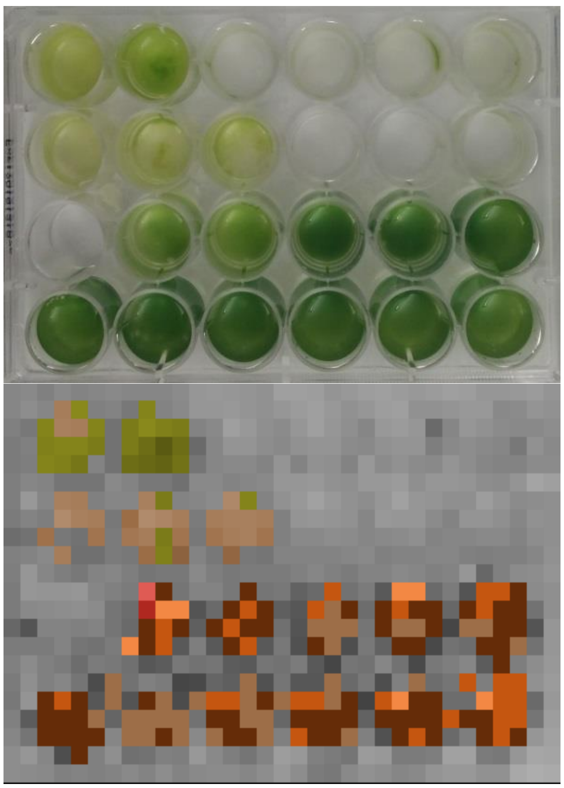
Figure 1. This is how the plate of wells was setup to identify different algae.

Color Chart			
Color values	**Color names**	**Colors**	**Corresponding Colors**
0-1.4	**Green smoke**		
1.5-2.4	**Asparagus green**		
2.5-3.4	**Highball green**		
3.5-4.4	**Olive drab**		
4.5-5.4	**Dark olive**		
5.5-6.4	**Green Kelp**		
6.5-7.4	**Verdun Green**		
7.5-8.4	**Dark Green**		
8.5-9.4	**Black forest**		
9.5-10.4	**Black**		

Figure2. This show how the different pigment colors of algae were identified in the program in NetLogo.

Images

Day 1



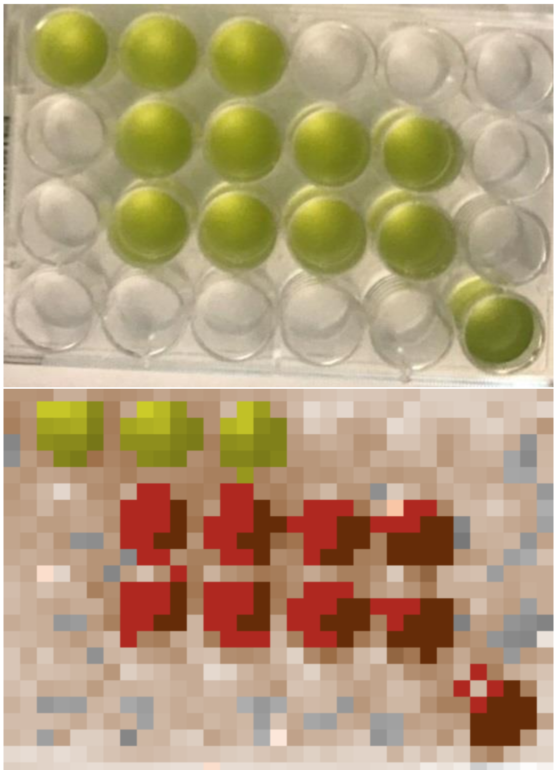
Day 14

Figure 3. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells C4, D2, and D6 have 16 PPT (parts per thousandth) of salt. Wells C6, D3, and D4 have 24 PPT of salt. Wells C5, D1, and D5 have 32 PPT of salt.

Day 1 Day 14

Figure 4. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells B2, B4, and C3 have 16 PPT of salt. Wells B3, C2, and C5 have 32 PPT of salt. Wells B5, C4, and D2 have 48 PPT of salt.

Day 1



Day 14

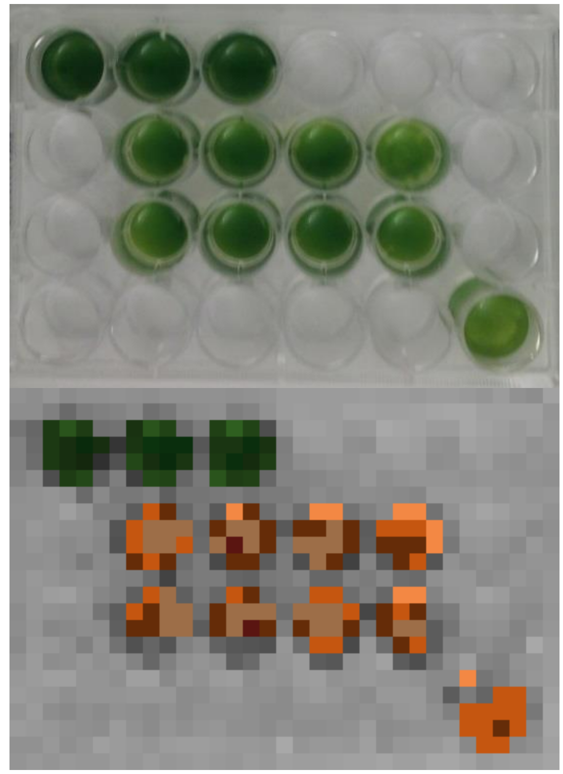


Figure 5. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells B2, B3, and B4 have 8 PPT of salt. Wells C2, C3, and C4 have 32 PPT of salt. Wells B5, C5, and D6 have 64 PPT of salt.

Day 1 **Day 14**

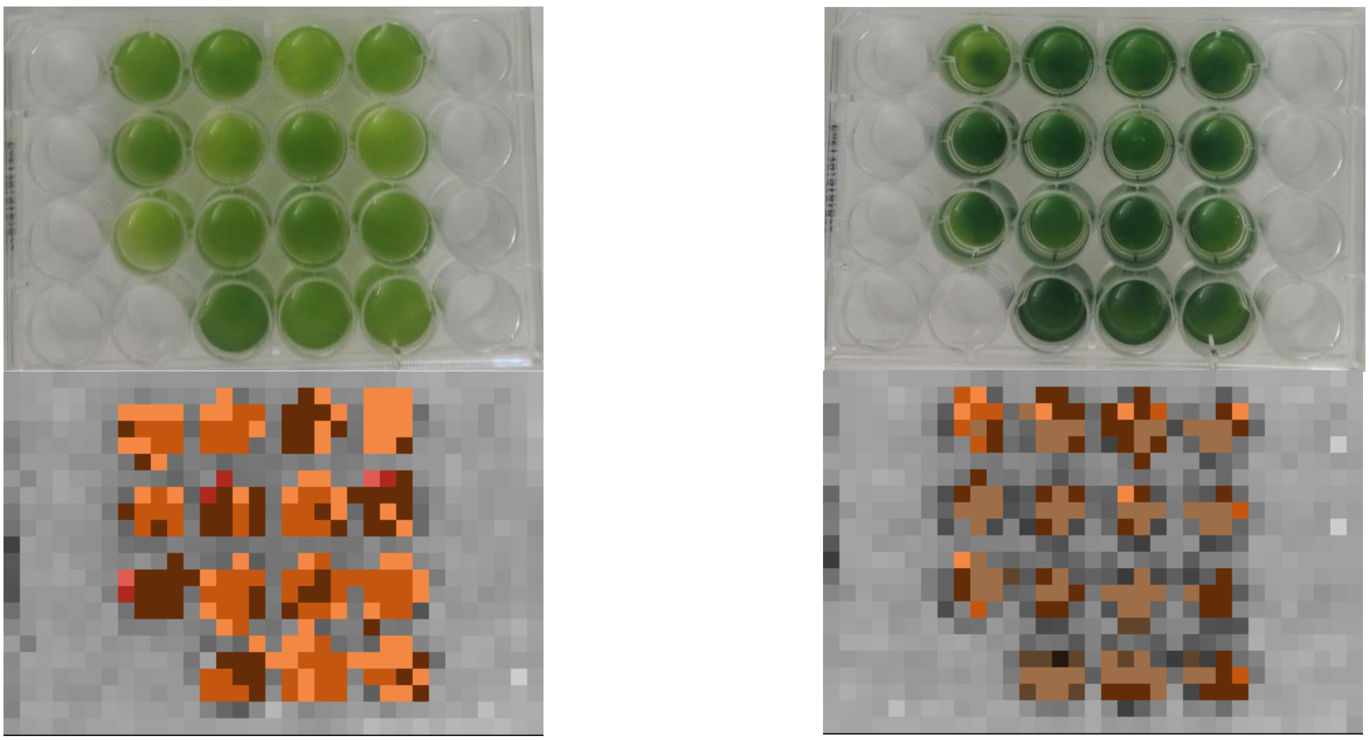


Figure 6. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells A4, B3, B5, and C2 have 8 PPT of salt. Wells A3, A5, B2, and C4 have 24 PPT of salt. Wells A2, B4, C3, and C5 have 64 PPT of salt.

Day 1 **Day 14**

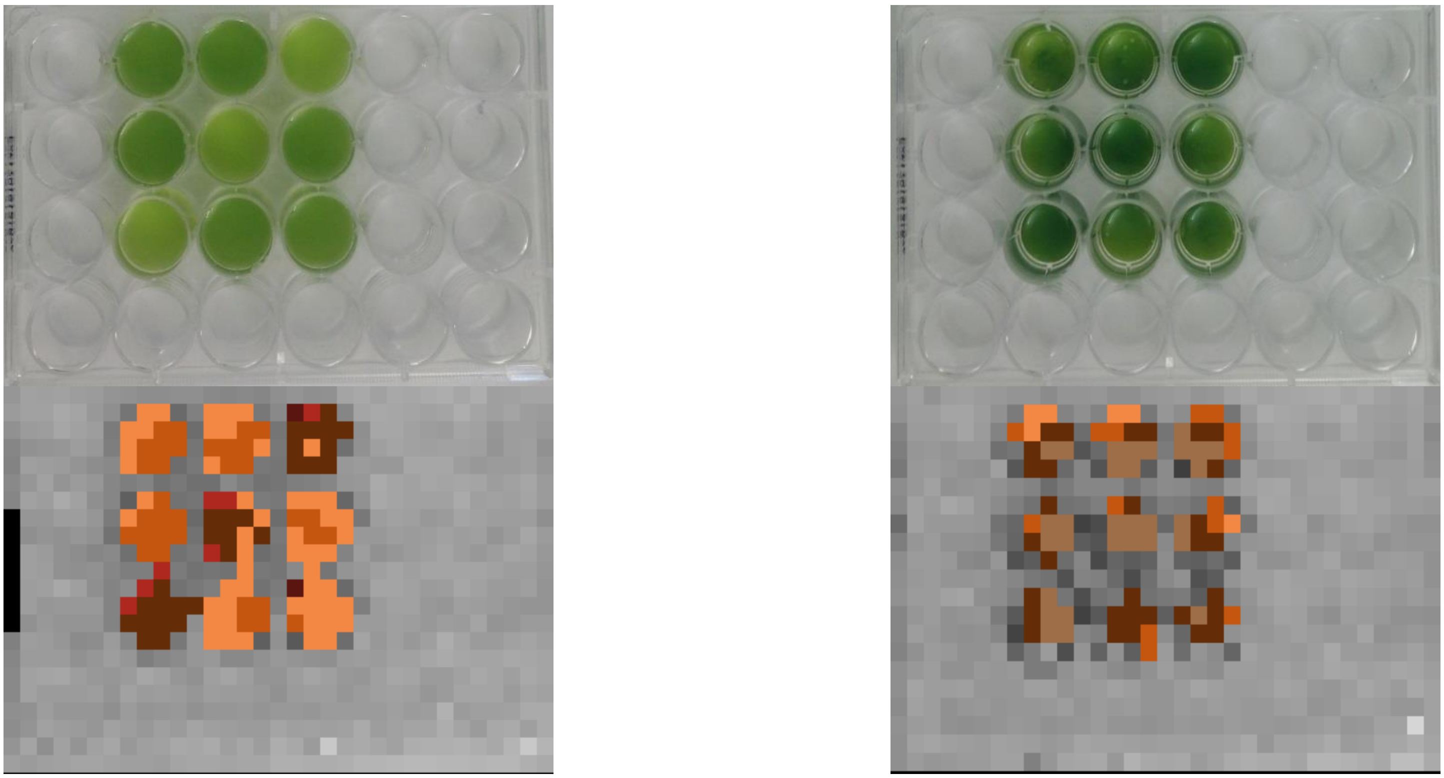


Figure 7. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells D5, C4, and C3 have 16 PPT of salt. Wells C5, D3, and D4 have 24 PPT of salt. Wells B4 and B5 have 48 PPT of salt.

Day 1 **Day 14**

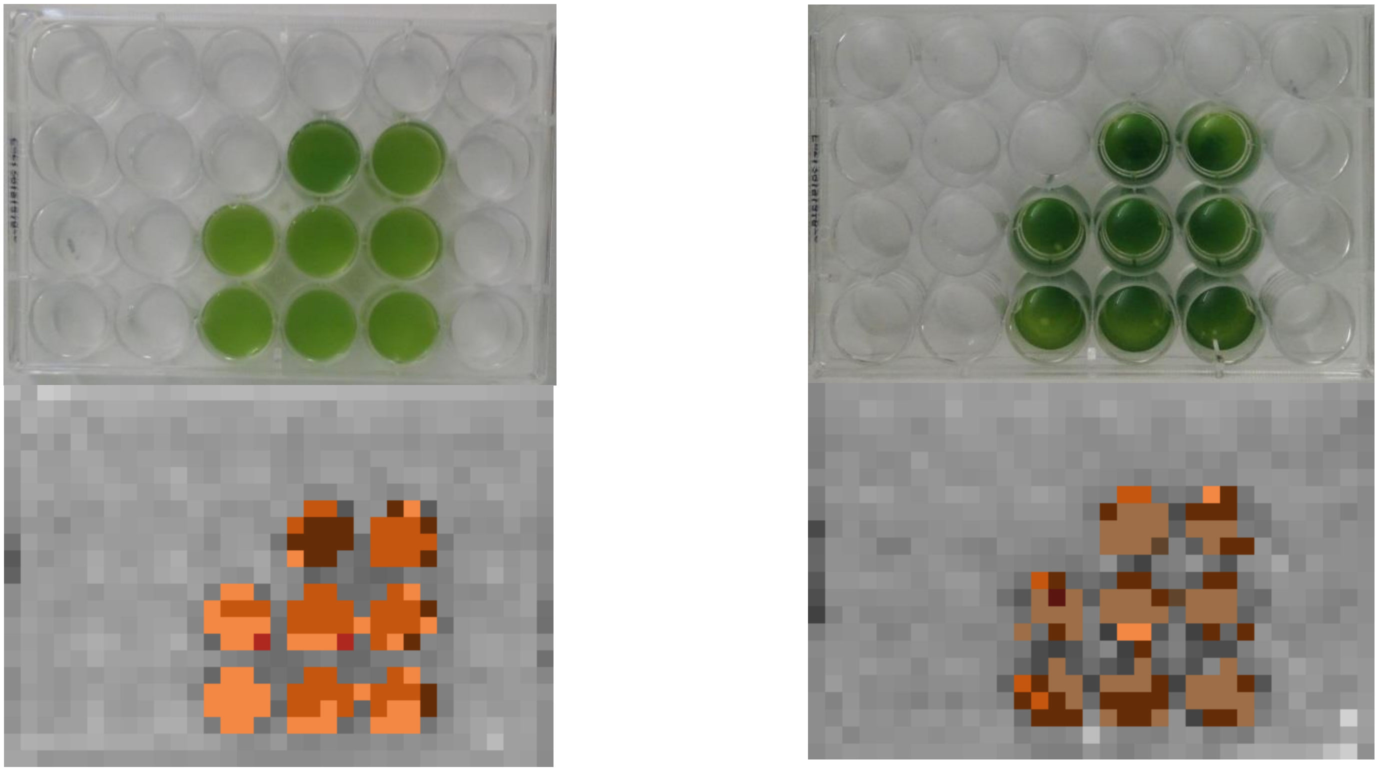
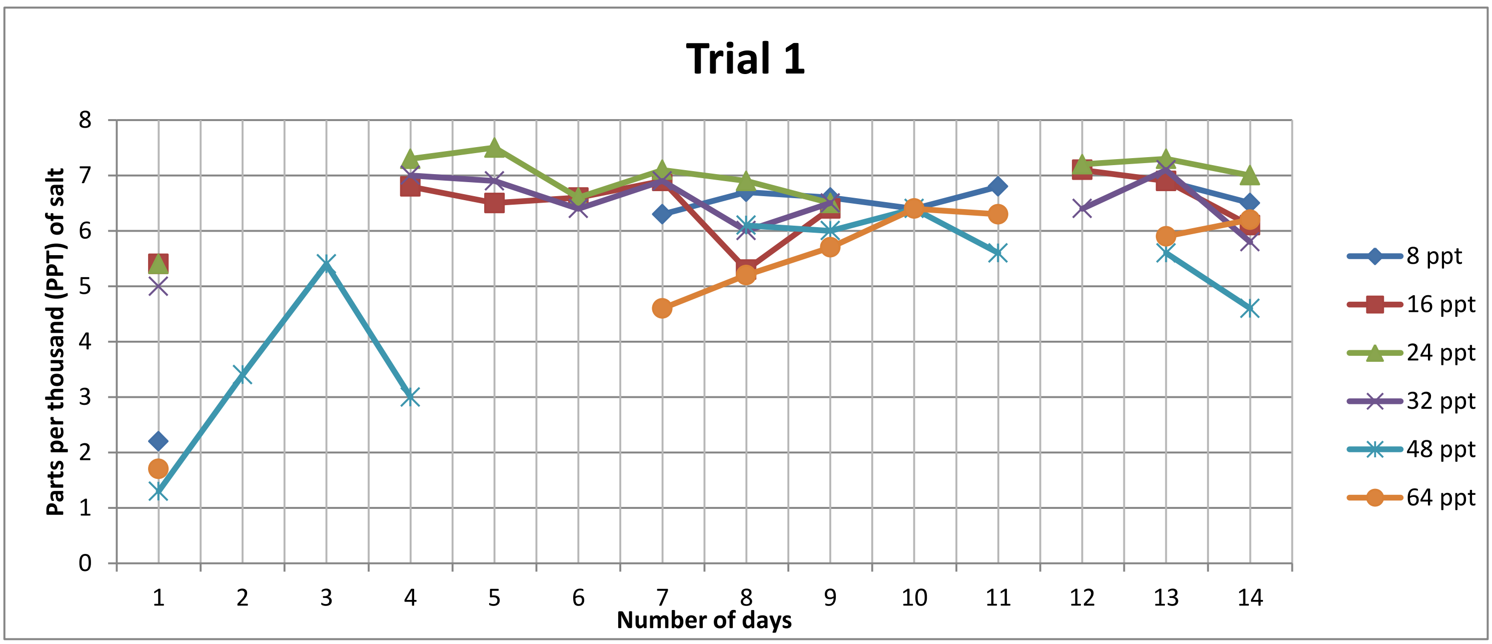
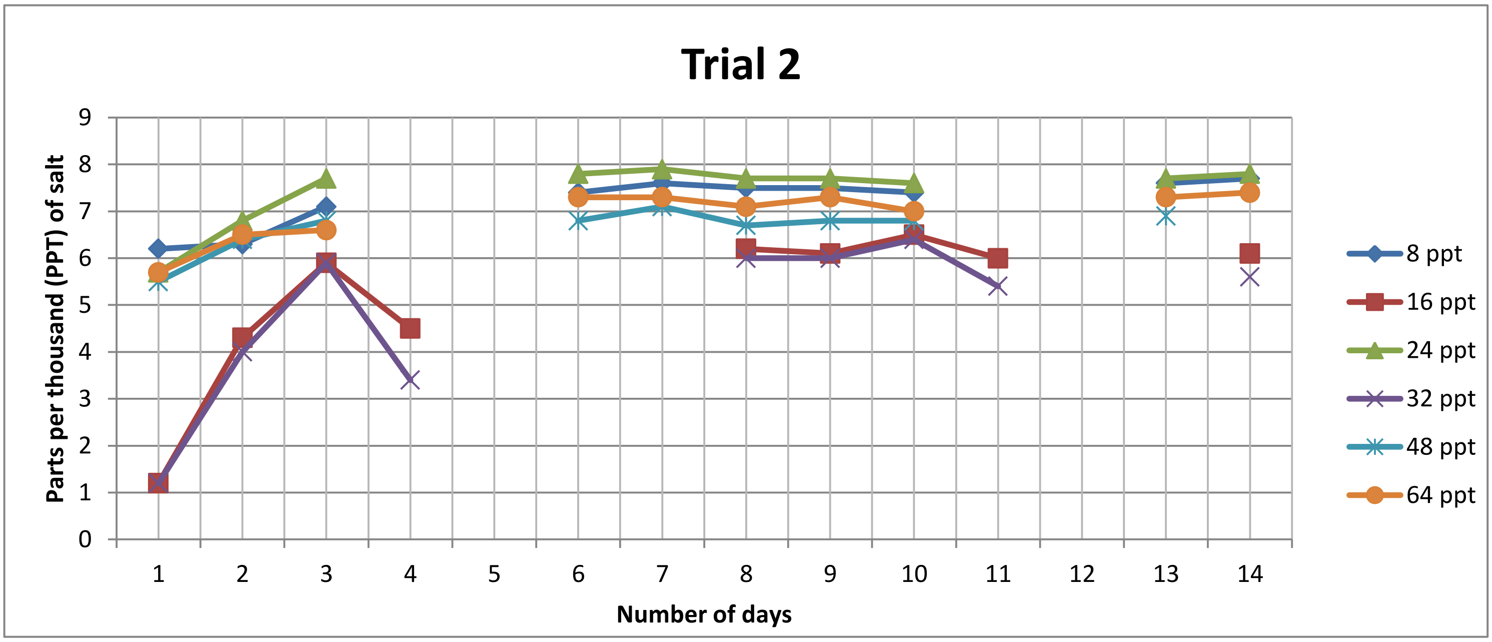


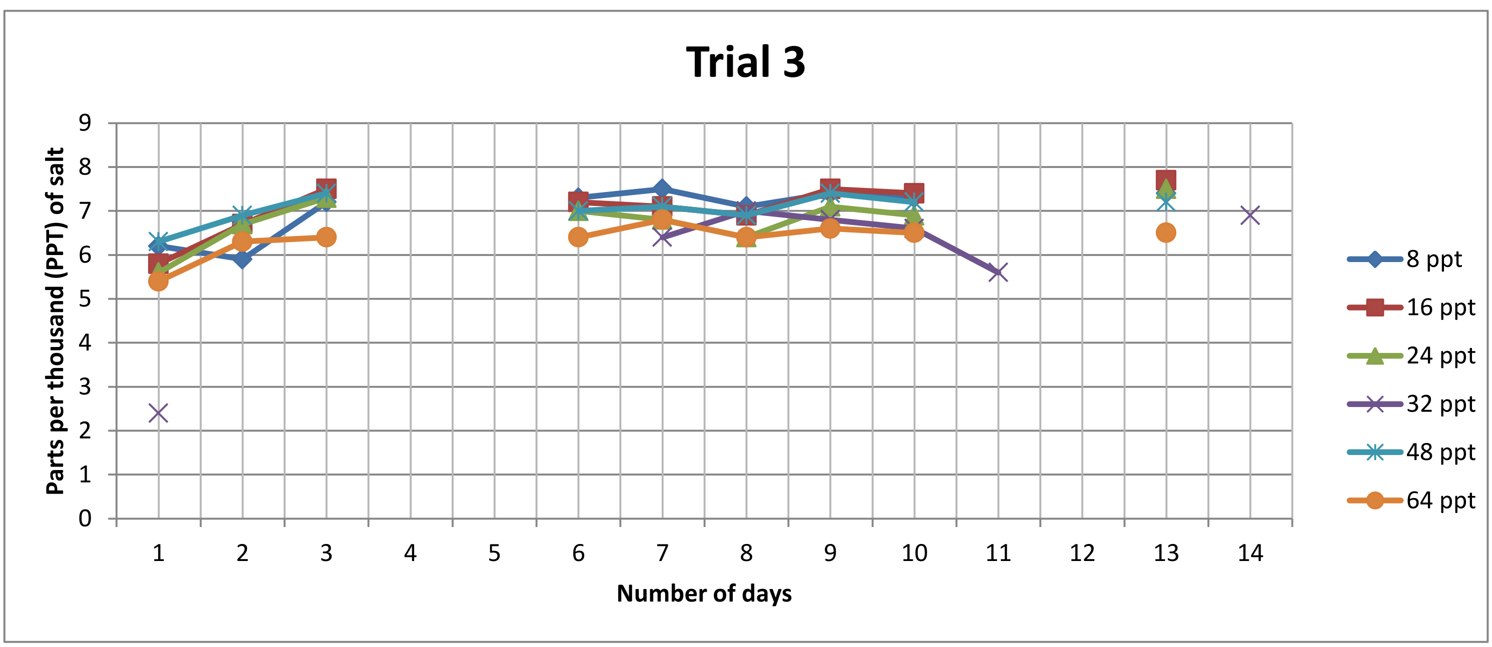
Figure 8. These pictures show the original pictures of the algae and the pictures of the algae after it has been analyzed. Wells C2, B3, and A4 have 8 PPT of salt. Wells B2, A3, and C4 have 48 PPT of salt. Wells A2, C3, and B4 have 64 PPT of salt.

Graphs

Figure 9. The graphs show all the data of the different algae's average pigment color. Some trails of algae were taken in separate months, but the data collected was compared over two weeks.




Trial 2
Parts per thousand (PPT) of salt
Number of days
8 ppt
16 ppt
24 ppt
32 ppt
48 ppt
64 ppt


Trial 3
Parts per thousand (PPT) of salt
Number of days
8 ppt
16 ppt
24 ppt
32 ppt
48 ppt
64 ppt

Average pigment table

	1st Trial	2nd Trial	3rd Trial	Average color value	Average pigment color
8ppt	6.1(Kelp Green)	7.2(Verdun Green)	7.1(Verdun Green)	6.8	Verdun Green
16ppt	6.4(Kelp Green)	5.2(Dark Olive)	7.1(Verdun Green)	6.2	Kelp Green
24ppt	7.1(Verdun Green)	7.4(Verdun Green)	6.8(Verdun Green)	7.1	Verdun Green
32ppt	6.4(Kelp Green)	4.9(Dark Olive)	6.0(Kelp Green)	5.8	Kelp Green
48ppt	4.7(Dark Olive)	6.6(Verdun Green)	7.0(Verdun Green)	6.1	Kelp Green
64ppt	5.2(Dark Olive)	6.9(Verdun Green)	6.5(Verdun Green)	6.2	Kelp Green

Figure 10. The chart shows the average pigment value and color of the algae in its trial and overall.

Conclusion

Overall the data in the graphs and average color table shows the most efficient amount of salt that could be used is 24 PPT of salt. By looking at the graphs in figure 9 shows algae with salt concentrations less than 24 PPT of salt didn't grow as fast as the other algae. On the last day of the trails, the algae seemed to decay more than the other algae. This could be because algae had less salt in the nutrients to maintain its growth and went under nitrogen starvation quickly [2].Algae given more than 24 PTT of salt seems to have kept the algae alive a lot longer as shown in the graphs in figure 9. On the last day of the trails, the algae with more salt in its concentration didn't decay as fast as the algae with less salt. The algae with the salt concentration of 24 PPT did have a constant growth that stayed similarly flattening out shown in the graphs in figure 9. On the last day of the trials, the algae didn't decay as fast as the rest of the algae, but the algae started to decay at a slower rate.

Significate Achievement

My significate achievement is how I've created a simple, but complex program to analyze the different pigment colors of green in algae. This could be used to ensure the full use of money in research in further applications of green algae in the future. Or this code could be expanded upon to how to monitor and indicate problems the algae has while growing, if the algae isn't getting enough sunlight or nutrients. I hope that NetLogo and other free computer programs have more applications in the field of science.

Acknowledgements

I would like to acknowledge the help of Anne Loveless and Creighton Edington in helping me improve upon my science fair project with the use of image analysis in NetLogo to analyze the algae. I would like to acknowledge my science teacher Abe Anderson who taught me how to analyze the algae and how to report on my results. Without their help by taking time out of their lives to help me do this competition, I would be lost in the direction I would have taken this project.

References

- [1]Nina Kalau, Economic Importance of Algae, Algae World News, July 3, 2017, http://news.algaeworld.org/2017/07/economic-importance-of-algae/
- [2]Hong-Po Dong, Ernest Williams, and Allen R. Place, Responses of Nannochloropsis oceanica IMET1 to Long-Term Nitrogen Starvation and Recovery, Plant Physiology, May 1, 2013, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3668043/
- [3]Michael Hannon, Javier Gimpel, and Stephen Mayfield, Biofuels from algae: challenges and potential, Biofuels, August 8, 2011, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3152439/
- [4]Marie-Luise Blue, Pros and Cons of Algae Biodiesel, Sciencing, April 25, 2017, https://sciencing.com/pros-cons-algae-biodiesel-6863.html

- [5]Bahman Delalat, Vonda C. Shepard, Soraya Rasi Ghaemi, Shasha Rao, Clive A. Prestidge, Gordon McPhee, Mary-Louise Rogers, Jacqueline F. Donoghue, Vinochani Pillay, Terrance G. Johns, Nils Kroger, and Nicolas H. Voelcker, Targeted drug delivery using genetically engineered diatom biosilica, November 10, 2015, https://www.nature.com/articles/ncomms9791
- [6]Jeremy Hsu, In New System, Algae Cleans Water, Then Transforms into Organic Fertilizer, May 7, 2010 https://www.popsci.com