Basil Plant Growth in the Aquatic Ecosystem model

By Drew Levine
Advisor Mauricio Gonzalez

(Photo by Drew Levine)

New York Harbor School
Marine Biology Research Program
New York
2017

Introduction

An A.E.M. or aquatic ecosystem model is an ecosystem contained in a small plastic box where organisms live and interact with each other. In this lab an A.E.M. was created and various organisms were added to produce a model that replicates the natural world. The importance of this lab is that by understanding the mechanism of the Aquatic model, we can better understand the natural aquatic system. In an A.E.M various organisms interact with each other in various ways, for example, some organisms benefit others by releasing waste product that is essential for other organisms while some organisms, such as the assassin snail, feed on each other for nutrients. The organisms added to the A.E.M. include, Assassin Snails, Blue Velvet Shrimp, Ghost Shrimp, Rams horn Snails, and Neon Tetra. For this experiment, an A.E.M was built with basil plants growing out of the top, using the A.E.M for water and essential nutrients. The A.E.M is very similar to the natural world, however in an A.E.M salts and nutrients cannot escape through diffusion and the amount of organisms is also limited. In this A.E.M, nitrifying bacteria (Nitrosomonas) was added to ensure that the Basil plants growing in the A.E.M would have nutrients that are essential for life. Other Organisms like fish, algae, snails, and shrimp are added to the A.E.M as well as the basil plants to replicate the interactions of organisms in the natural world. Because the ecosystem model built in this experiment replicates a natural environment, it will allow us to better understand the natural environment. The main purpose of this lab is to simply observe and discover the interactions between biotic factors as well as abiotic factors on organisms living in the A.E.M. A second major purpose of this lab is to

explore the growth of Sweet Basil growing in the A.E.M. If the A.E.M. can be maintained and understood, it can increase our knowledge of the natural world

Background Information

In an aquatic ecosystem model the levels of nutrients and chemicals must be carefully monitored in order to maintain a healthy system. Different abiotic factors of the environment in an A.E.M are monitored in order to maintain the organisms living in it like temperature, pH (potential hydrogen), electrical conductivity, ammonia(NH_3), as well as nutrients like Nitrites (NO_2) and Nitrates(NO_3). Keeping the abiotic factors at healthy levels in the A.E.M is vital in for a healthy ecosystem model (as shown in Figures A and B). These factors interact with each other as well which is another reason it is very important to maintain the levels of pH, E.C., ammonia and nutrient salts. Biotic factors as well as abiotic factors are also measured in this lab. Ammonia was added to the A.E.M as a food source for Nitrifying bacteria to kick start the nitrification process that occurs in nitrifying bacteria. Nitrification is the natural process that Nitrosomonas uses to convert ammonia into essential nutrients that other organisms will use. According to the E.P.A's Water Distribution System Issue Paper of 2002, "Nitrification is a microbial process by which reduced nitrogen compounds (primarily ammonia) are sequentially oxidized to nitrite and nitrate". It is these nitrates and nitrites that are crucial for plant growth. The abiotic factors measured in this lab are observed throughout the whole process of the experiment in order to discover the change of these factors as well as the interactions with the organisms. Some organisms are very sensitive to these factors like

plants, through observing the growth of the basil plants in centimeters, the overall health of the ecosystem will be shown.

Hypothesis

I predict the Basil plants to grow at a constant rate of 0.125cm every 24 hours while growing in the A.E.M. I also predict that over time the two Assassin sails (Clea helena), living in the A.E.M. will consume other snails in the system.

Materials

Item	Quantity	Purpose
Container	1	Enclosure for Organisms in the A.E.M
Netpots	2	Hold the Basil Plants on top of the A.E.M
Lid	1	Protects A.E.M from outside factors
Basil Plants/Basil Seeds	2	Plants used in A.E.M
Gravel	200mL	Substrate used in A.E.M
Flourite	200mL	Substrate to promote bacterial growth in A.E.M
Filtered Water	1,350mL	Medium for Organisms living in the A.E.M
Proline water conditioner (Ammonium Chloride)	0.1080g	Used to jump start nitrification process/food source for Nitrosomonas

Item	Quantity	Purpose
Proline water conditioner (Nitrosomonas)	5mL	Nitrifying Bacteria used in A.E.M
Air stone	1	Provides oxygen to A.E.M
Light source	1	Used to replicate light from sun
Test strips	17	Used to monitor nutrient levels in A.E.M

Procedures

Setting up Basic A.E.M without organisms

1. Sterilize A.E.M box by soaking in 1190 mL of Chlorine overnight.
2. Remove Chlorine salts from A.E.M by soaking box in 32 mL Vinegar overnight.
3. Add 1350mL of room temperature filtered water to A.E.M box or until full
4. Add 200mL Gravel
5. Add 200ml Fluorite
6. Mix substrate and allow particle to settle to the bottom of the A.E.M box
7. Neutralize pH using pH up or down vials by mixing a few drops of acid or base depending on the pH of the A.E.M
8. Add 0.1080g Ammonium Chloride to A.E.M to jump start nitrification process
9. Add 5 ml of nitrifying bacteria (Nitrosomonas)
10. Record Abiotic and Biotic Factors to observe changes in the A.E.M

Adding Organisms to the A.E.M

1. Obtain Clean Container
2. Fill with enough filtered water into container for organism such that it is covered in water
3. Add same volume of new habitat water so it creates a 50/50 blend of new and filtered water
4. Using a disinfected net, capture the organism and carefully transfer into container
5. After 5 minutes, pour out half of the solution
6. Once again add an equal amount of new habitat water and wait an additional 5 minutes to ensure the organism(s) is not stressed
7. Remove all water from container
8. Add Organism to A.E.M
9. Observe organisms and record specific comments

Measuring and adjusting Electrical Conductivity in the A.E.M

1. Remove cap from Hanna Combo meter and rinse with filtered water
2. Turn on meter and switch to “µS” Mode
3. Measure E.C. and pH and log “before” data
4. Add tiny amount of Nutrient mixture to weighing tray
5. Document weight of mixture

6. Mix Nutrient powder in A.E.M water with clean skewer
7. After mixing is complete, Record “after” data for E.C. and pH

Collecting data using test strips

1. Remove lid from A.E.M box and place on dry paper towel or clean surface
2. Remove desired test trip from tube and read directions on how to measure
3. Depending on test strip, hold strip in the water while measuring time with stopwatch
4. Remove test strip from water and without removing water wait the amount of time specified in the directions for the test strip
5. Using color code found on test strip container, match color of test strip with color on the bottle to determine the levels of nutrients

Results

Day	NH3 ppm	NO2 ppm	NO3 ppm	Stress-NH3	Stress-NO2	Stress-NO3
1	0	0	20	0.25	0.5	40
2	0	n/a	n/a	0.25	0.5	40
3	0	n/a	n/a	0.25	0.5	40
4	0	n/a	n/a	0.25	0.5	40
5	3	10	160	0.25	0.5	40
6	1	10	160	0.25	0.5	40
7	1	10	160	0.25	0.5	40
8	0.5	0	40	0.25	0.5	40
9	0.5	0	40	0.25	0.5	40
10	0	0	20	0.25	0.5	40
11	0	0	40	0.25	0.5	40
12	0	0	20	0.25	0.5	40
13	0.5	0	20	0.25	0.5	40
14	1.5	0	20	0.25	0.5	40
15	0	10	20	0.25	0.5	40

Figure A (Nutrients Table)

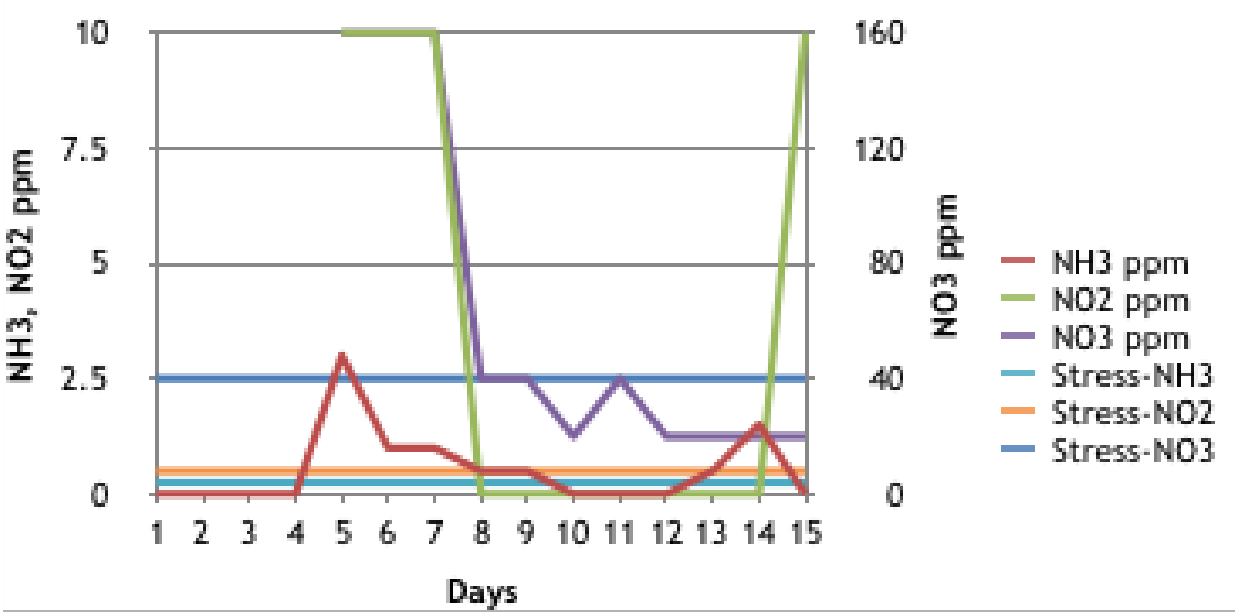

FIgure B (line graph of Figure A)

Results

Day	Plant #1 (cm)	Plant #2 (cm)
1)3-30-17	1.5	1
2)4-3-17	2	1.5
3)4-19-17	4	3.5
4)4-24-17	5	4.5
5)4-28-17	5.5	5
6)5-1-17	6.5	6

Figure C (Plant Growth Table)

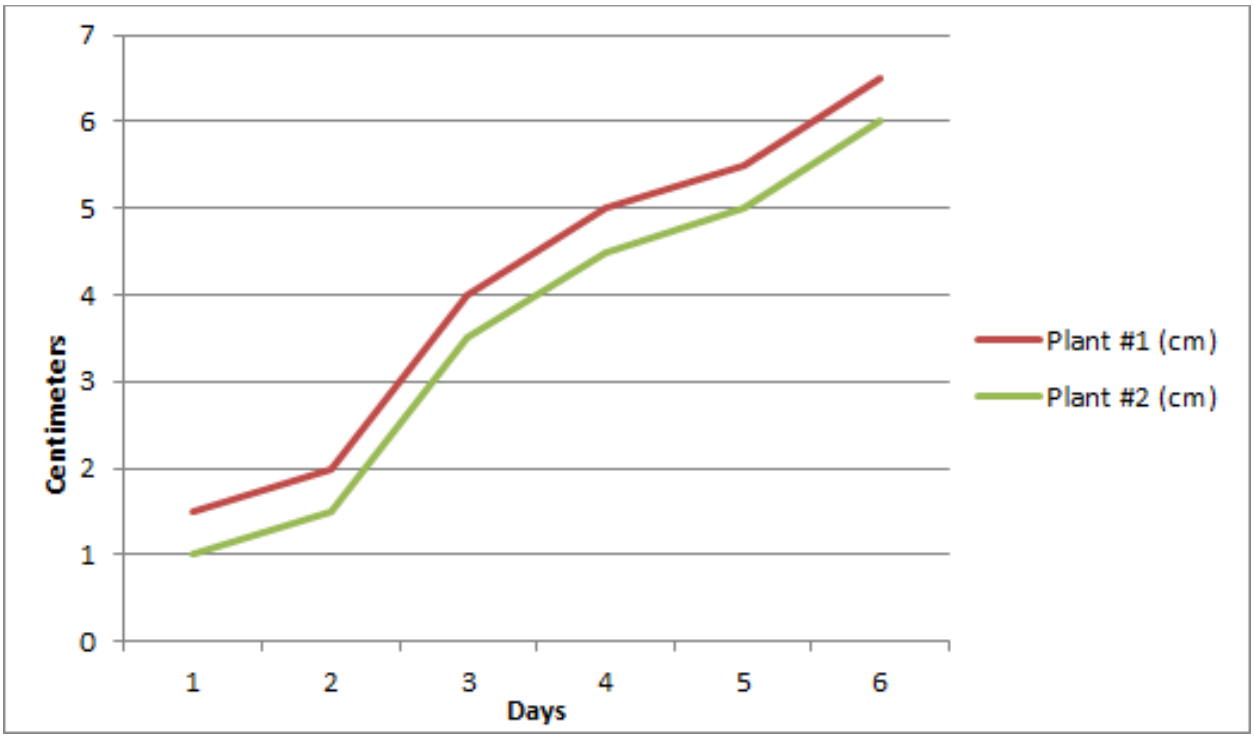

Figure D (Line graph of Figure C)

Figure E (Basil plants #1 and #2 (*Ocimum basilicum*))

Analysis

After collecting data from the A.E.M, many interactions were discovered between organisms as well as interactions between chemical levels in the water. Plant growth was also observed throughout this experiment. The first major interaction that was observed was the interaction of the Assassin Snails (Clea helena), and the Seminole ram's horn snail (Planorbella duryi). After the first day of being in the same enclosure, the Assassin snails consumed the ram's horn snail leaving the empty shells littered along the bottom of the A.E.M. More Planorbella duryi were added to the A.E.M and the Assassin Snails quickly consumed them within a matter of 24 hours of being placed in the A.E.M. Not only did the Assassin Snails consume the Planorbella duryi, but they also consumed the single Ghost (glass) shrimp(Palaemonetes) leaving behind only the shedded exoskeleton. Even though the Assassin snails were at the top of the food chain in the A.E.M., They were not able to consume the Blue velvet shrimp (Neocaridina Heteropoda Var.) or the Neon Tetra (Paracheirodon innesi) because of their superior speed and agility. Another interaction which was observed was the interaction of ammonia levels in the A.E.M. and levels of nitrates and nitrites due to the presence of nitrifying bacteria (Nitrosomonas) (as shown in Figures A and B). In this experiment it was discovered that the levels of ammonia in the A.E.M. directly impact the levels of nitrates and nitrites because ammonia is the main chemical nitrosomonas uses for nitrification. The Third aspect of the A.E.M. that was observed was the growth of the Sweet Basil growing out of the top. From the moment the plants were placed in the A.E.M., Plant #1 was slightly larger than Plant #2 by around 0.5cm. This slight height difference remained throughout the experiment (as seen in Figure E) and it theorized to be due to variations and inconsistency in essential nutrients and light.

Specific Comments

Date: 3-20-17

Blue Velvet shrimp was added to the A.E.M. box and upon close examination, it was revealed that a cluster of eggs was found under the shrimp's tail. It is unlikely that they will survive however due to changes in environment.

Date: 3-27-17

Assassin snail consumes Planorbella duryi leaving empty shell on bottom of A.E.M.

Date: 4-3-17

Second Assassin snail is added to system

Date: 4-24-17

A unidentified species of green algae grew on the outside walls of the A.E.M., this algae is light green and is only on the walls of the plastic box. This new algal growth may be because of an excess of nutrients in the A.E.M.

Date: 5-1-17

On 4-7-17, the pH of the water in the system dropped to an acidic level of 4.9 which caused the nitrifying bacteria to die. Because the nitrifying bacteria could no longer carry out nitrification, levels of nitrates and nitrites decreased while levels of ammonia increased. More Nitrosomonas was then added to combat the rise in ammonia levels.

Conclusion

Overall, this experiment revealed many aspects of the natural world and interactions in the aquatic environment. In this lab, levels of nutrients were observed and monitored. Nitrosomonas was the bacteria used in this experiment to jump start the nitrification process to ensure that there was enough nitrates and nitrites for the Basil plants. After observing levels of nutrients in the A.E.M., it was discovered that the levels of ammonia directly impact the levels of nitrates and nitrites. On Day 10, the pH had gone down to a level of 4.9 which is far too acidic for Nitrosomonas, therefore they died and were not able to continue the nitrification process. This decrease of Nitrosomonas caused the levels of Nitrates to decrease from 40ppm to 20ppm. This observation proves that the levels of nutrients are reliant on the activity of Nitrosomonas. The hypothesis of this experiment was in fact supported because the Basil plants grew at a constant average rate of 0.1cm every 24 hours and it was predicted that they would grow at a rate of 0.125cm every day. The hypothesis was also supported because it was predicted that the Assassin snails (Clea helena) would consume other snails. Not only did the Assassin snails consume other snails but also the Ghost shrimp living in the A.E.M.. In conclusion, this experiment revealed many aspects of the aquatic ecosystem and demonstrated how an aquatic ecosystem maintains itself as well as how Basil plants grow in an aquatic ecosystem model.

Bibliography/Links

Nitrification:

-https://www.epa.gov/sites/production/files/2015-09/documents/nitrification_1.pdf

-https://www.rpi.edu/dept/chem-eng/Biotech-Environ/Projects00/biotreat/nitrification.html

Basil:

-http://www.biology-pages.info/N/NitrogenCycle.html

-http://extension.illinois.edu/herbs/basil.cfm

-http://geekgardener.in/2013/09/24/how-to-grow-herbs-in-a-hydroponic-raft-system/

Aquatic systems:

-http://www.fao.org/zhc/detail-events/en/c/320156/

-http://www.environment.nsw.gov.au/water/waterqual.htm

-http://aquariuminfo.org/water.html