<u>How to Maintain an Aquatic Ecosytem Model</u>

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I. Problem

How is an Aquatic Ecosystem Model (AEM) maintained properly?

II. Background Information

Aquatic Ecosystem Model:

An Aquatic Ecosystem Model, also known as an AEM, is a modeled ecosystem. In it, nutrients, growth, and basic processes can be tracked and measured. It is essential to learn to study the environment. The Aquatic Ecosystem Model contains fish, shellfish, bacteria, plants, and other organisms. The plants are grown hydroponically before they are placed into the AEM.

Hydroponics:

Hydroponics is the act of growing plants using water instead of soil. In hydroponics, nutrients come from the water. The nutrients in the water come from the waste of plants and animals. In the Aquatic Ecosystem Model, basil plants are grown hydroponically. Their roots are put in the water in order to obtain nutrients.

Seeds:

A seed is an iconic figure in nature. Many people know what a seed is but, they do not what is inside of a seed. First off, a seed is the product of plant fertilization. A seed has several major parts. A seed will have an outside covering called a testa. The testa, or seed coat, protects the seed. A seed also has an endosperm. The endosperm contains all of the food and the energy needed for a seed to germinate. Finally there is an embryo. The embryo is the actual organism. The embryo contains the cotyledon, hypocotyl, and the radical. They are very important during germination.

Germination:

Germination is when a seed first starts to grow. During germination the first plant part to emerge is the radical. The radical of a seed is the root of thee seed. It takes in water and nutrients for the seed. Then the hypocotyl emerges from the seed. It is the first part of the stem. After the hypocotyl, the cotyledon emerges. They look like 2 small leaves. They are not regular leafs but they still perform photosynthesis. The cotyledons also have some food storage. Finally, regular leaves emerge from the seed and the germination process is complete.

Basil and Pepper plants:

In the experiment mainly basil seeds and a few ornamental pepper seeds are being used. In order for these seeds to germinate several key components have to be just right. The temperature is one important factor. According to www.chestnut-sw.com, peppers need anywhere between 65- 95 degrees Fahrenheit. Another important aspect is that the seeds need oxygen. Without air they cannot germinate. Seeds also need water. It is very important that they have water. According to www.chestnut-sw.com, peppers will germinate in approximately 8-12 days.

Nutrients:

There are many aspects in an aquatic ecosystem. One very important aspect is nutrients. Plants and animals in an ecosystem need a lot of different nutrients. Some very important nutrients are carbon, hydrogen, oxygen, phosphorus, potassium, iodine, nitrogen, sulfur, calcium, Iron, and magnesium. All of these are very important to an ecosystem. Without the proper amounts of nutrients, an aquatic ecosystem will not be healthy. All of these nutrients in the environment will cycle through the ecosystem. The organisms in the tank will need a precise amount of each of these nutrients. All the nutrients inside of the AEM can be measured by using test strips and scientific instruments.

Organisms in the AEM:

In the ecosystem, there are many different types of organisms. Decomposers are a very important part of the ecosystem. Bacteria are one example of decomposers. They break down dead remains and release the nutrients back into the environment. Producers are also a very important part of the ecosystem. By using photosynthesis, they create their own food. Another major part is consumers. The consumers are animals such as fish. All of the organisms inside of the aquatic ecosystem model symbiotically live with each other. The organisms in the AEM form a complex food chain (seen in the results). The top (tertiary) predator eats the secondary consumers and other organisms. There is also omnivores, decomposers, and producers.

Chemical Parameters:

In the AEM, Nitrogen is an extremely important element. It is a building block of life. Nitrogen is an important ingredient in amino acids. Amino acids are used to make proteins, which are one of the four organic compounds. The other 3 are carbohydrates, lipids, and Nucleic Acids. On Earth Nitrogen is found in many different forms. Among them are NO_2, NO_3, and

NH_3. All three of these compounds are a byproduct of Nitrogen fixing bacteria. These bacteria convert N2 gas which is found in the air intoNH3, also known as Ammonia. After this conversion, a certain type of bacteria called nitrosomonas, eats the ammonia and it creates a waste product called NO_2 (nitrite). Finally, Nitrobacter feeds off of the NO_2 and creates NO_3 (nitrate). Nitrate is a very important compound; Nitrate is used by plants and animals to create amino acids. Too much of these compounds are harmful to the environment. Ammonia is especially potent to the environment; levels of 0.25ppm are considered toxic in the AEM. Ammonia is produced by organisms, such as fish, in the environment. The Ammonia increases the pH in the water. This is due to the fact that it is a very basic substance. In the ecosystem the NO_2 is toxic once it reaches 5 ppm and NO3 is toxic at 80ppm. Other chemical Parameters include phosphate, hardness, and buffering capacity. Buffering Capacity controls how easily the water's pH can change. pH is a measure of how acidic or basic a solution is. The lower the pH the more acidic the solution is. In the Aquatic Ecosystem Model the pH should be slightly lower than 7 (a pH of 7 is neutral). Temperature is also very important in the AEM. Many organisms can only survive in certain temperature ranges.

Microorganisms:

The AEM can support many forms of microorganisms. Among these include rotifers. Rotifers are found in many aquatic ecosystems. They are usually found towards the substrate of the water (berkely.edu). Rotifers are multicellular. The AEM contains microscopic bacteria such as nitrosomonas and nitrobacter which help in the nitrogen cycle. While looking under the microscope, many types of Microscopic organisms should be expected to see. Non-living microscopic particles such as salt crystals can also be seen.

III. Hypothesis

Table 0.1 - Pepper Seed Germination

Day	sprouts	seed total	hyp. Rate	5% error	real rate	supported
8	0	8	50	47.5-52.5	0	No
9	0	8	55	52.25-57.25	0	No
10	ND	8	60	57-63	ND	No
11	ND	8	70	66.5-73.5	ND	No
12	2	8	90	84.5-94.5	25%	No

* ND=no data

Figure 0.1 If the seeds are planted hydroponically then in 8 days 50% will grow, in 9 days 55% will grow, in 10 days 60% will grow, in 11 day 70% will grow and in 12 days 90% will grow.

Day	NH_3 ppm	NO_2 ppm	NO3 ppm
1	6	0	0
2	5.5	1	10
3	5	2	20
4	3	3	50
5	2	4	60
6	2	4	70
7	2	4	90
8	2	4	100
9	2	4	120
10	2	4	140

Table 0.2- Hypothesized NO2, NO3, and NH3 levels in the AEM is shown above. If the Nitrification cycle occurs in the AEM, the on day one the NH_3, NO_2, and NO_3 levels will be 6, 0, and 0; respectively. On day 10 the NH_3 levels will be 2, the NO_2 levels will be 4, and the NO_3 level will be 140. (*note, all of the number are measured in parts per million, also known as PPM.)

IV. Safety

Safety is extremely important, since there are many chemicals involved in the lab. It is required to wear aprons and gloves. During the lab, it is required to wash your hands before touching the tank. If you do not, you can transfer bacteria to the tank. Also there is a possibility of glass breaking in the lab.


Figure 0.3- the chemical safety icon


Figure 0.4- Lab Apron required

V. Materials

Item	**Quantity**	**Use**
sealer sponge	2	to hold seads
rulers	1	to measure sponge halfway
scissors	1	to cut sponge
markers	1	to mark whos sponge is whos
grids		
germinating trays	1	to hold sponges
black garbage bag	1	to cover tray
seeds	38 clusters (4 each)	for growing
paper for seeds		
RO/DI water		to give seeds nutrients
watering can	1	to water seeds
AEM	1	The tank to hold all components
NH3Cl (ammonium chloride)	0.1082g	To Jump start Nitrification cycle
Pro-line Nitrifying bacteria	4.682539 ml	To Jump start Nitrification cycle
small white tray	1	To hold the items while measuring
digital Balance	1	To find the weight of items
NH3 test strips	1 per day	to measure ammonia concentrations
NO2 test strips	1 per day	to measure nitrite concentrations
NO3 test strips	1 per day	to measure nitrate concentrations
Microscope	1	To look at microscopic organisms
Alcohol		To clean the microscope

Cotton swab & Kim wipe	1	To clean glass on the microscope.
Conditioning cup and spoon	1 each	To put organisms in tank
Slide and coverslip	1 per sample	Used to view prepare sample
Pipette	1	To collect sample
Waste water container	1	To hold waste water
Graduated cylinder	1	To measure bacteria

VI. Procedures

❖ Step 1a- Germinating Plants in the AEM

Cut out 3cm cube, 2 for each person. → Cut a cross down the middle of the sponge, do this 2 times. → Label each sponge with a small symbol using the marker. → Add a seed in each small notch made by the sponge.

Place the sponge in tray. Make sure it is 2/3 down and skip every other spot. → Fill tray with water, fill it to the middle of the sponge. → Cover the tray with a black plastic garbage bag. → Check on the seeds every day.

❖ Step 1b- Setting up the AEM

An AEM consist of a lid, the tank and the air stone. → Place the germinated plants into the net pots on the lid. → Add distilled water to the tank, it should fill to the top. → Place the air stone through the lid into the tank.

- step 2- Add Nitrifying Bacteria to the AEM

Measure NH_3, NO_2, and NO_3 levels in AEM, record

Take out Pro-line bacteria supplement, shake bottle.

Measure 4.682539 ml of Pro-line bacteria using a graduated cylinder

Pour the Bacteria into the AEM, measure and record the NH_3 levels

- Step 3- Add Ammonium Chloride (NH_3CI) into the AEM.

Turn on the digital balance and open the sliding door on it. Place a white tray in it.

Close the side of the scale; then press the O/TI button to negate weight of tray

Reopen the scale and put NH_3Cl into the tray with a spoon.

Add 0.1082 grams of NH_3Cl into the AEM. Measure the NH_3 levels in the AEM

- Step 4- Measure the NH_3 levels in the AEM. The NH_3 should be measured every day. Record the data on a data chart.

Fill a vial up to the line with water. Take out an Ammonia test strip.

Place the strip in the vial and move it up and down vigorously for 30 seconds.

Remove the strip from the water and shake off excess water. Hold strip level for 30 seconds.

The strip should turn a certain color. On a NH_3 chart, match the strip color to the chart. The chart goes from 0-6 ppm.

❖ Step 5- Measure the NO_2 and NO_3 levels in the AEM. Measure them every day and record the data. Both nitrite and nitrate are measured in the same way.

Take out a test strip from the bottle and place it in the AEM for one second. → Take the strip out of the AEM and hold it level for 30 seconds. Do not shake off excess water. → After 30 seconds have ended, the test strip will turn a certain color. → Match the color of the strip to the color on the charts. They should be identical in color.

❖ Step 6- To add organisms, such as shrimp and fish, it is required to condition them first.

In a conditioning cup, add half of the water from the organism's original water. → The other half of the cup should be filled with the AEM water → After five minutes, replace half of that water with AEM water. → After repeating the last step as desired, take most of the water in the cup out and pour the organism to the AEM

❖ Step 7- After putting organisms in the tank; use a microscope to observe the water. It is essential to clean the microscope first.

Carry the microscope to a flat surface. When carrying hold the arm and base. → Clean the microscope using alcohol and cotton. → Clean the glass on the microscope by using kim wipes and alcohols.

- Step 8- Make a wet mount slid to prepare water sample

Place the slide on a flat surface → Using a pipette, place a water sample on the slide. → Place a coverslip on the slide by dropping it on an angle → Using a paper towel, wipe off excess water around the coverslip.

- Step 9. - View the slide underneath the microscope.

Place the slide on the microscope when the zoom is on the lowest power. → Using the mirror adjust the light. → Use the coarse and fine adjustment to adjust the focus. → Increase the zoom power when focused.

VII. Results

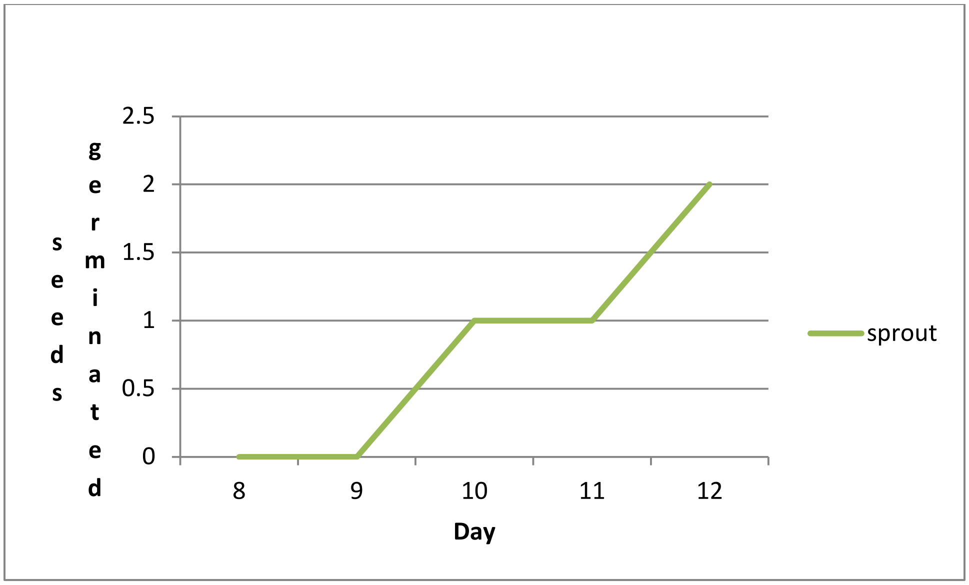

Figure 0.5- The figure above shows the amount of pepper seeds which were germinated. In total only two germinated.

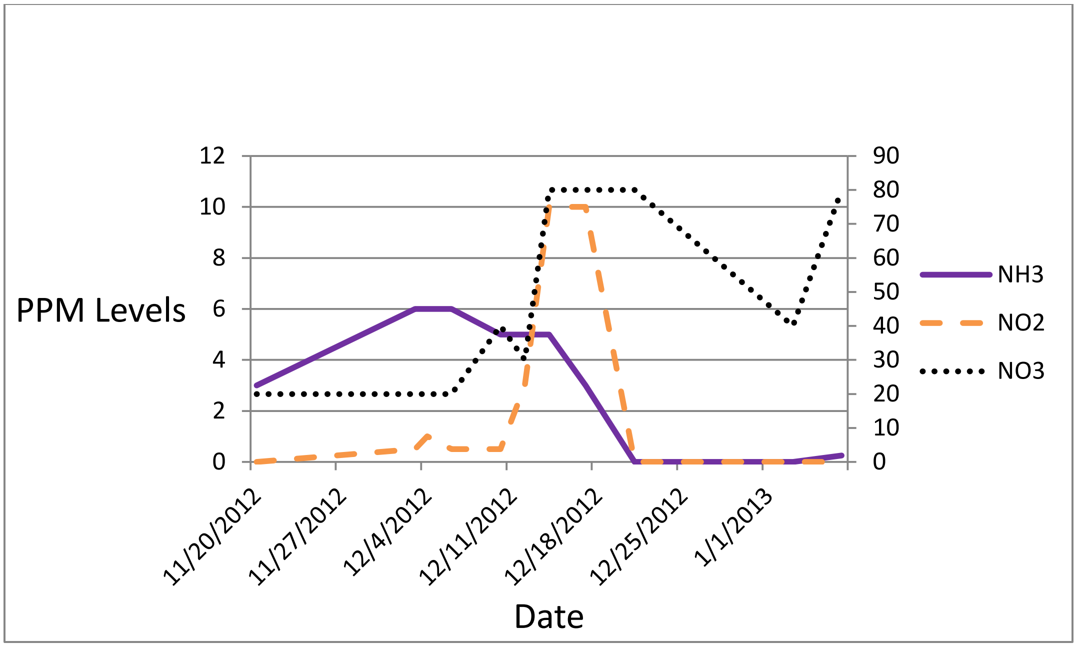

Figure 0.6- The Graph Shows Nitrification in the AEM.

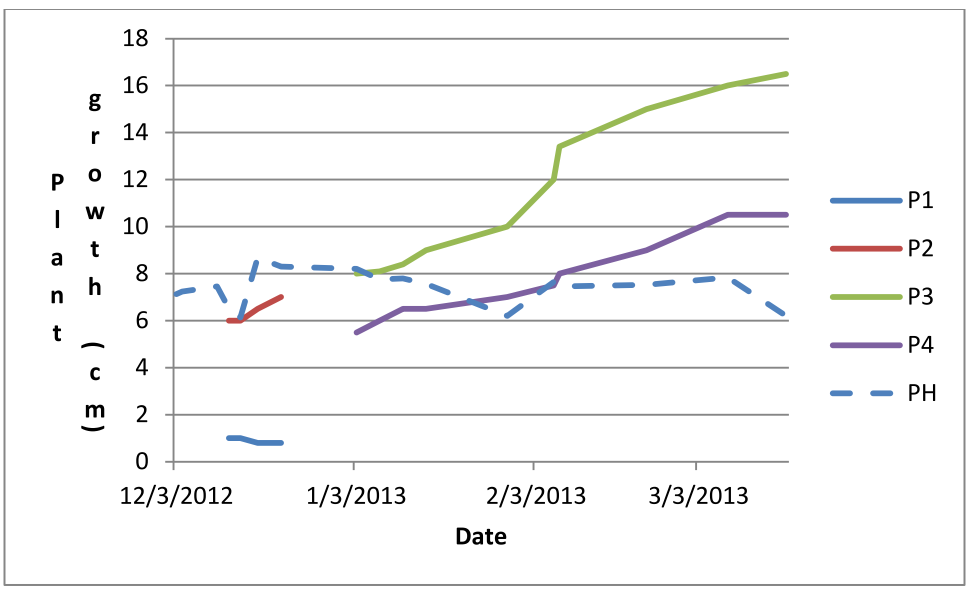

Figure 0.7- This graph shows the relationship between pH and plant growth. When the line ends, the plant died.

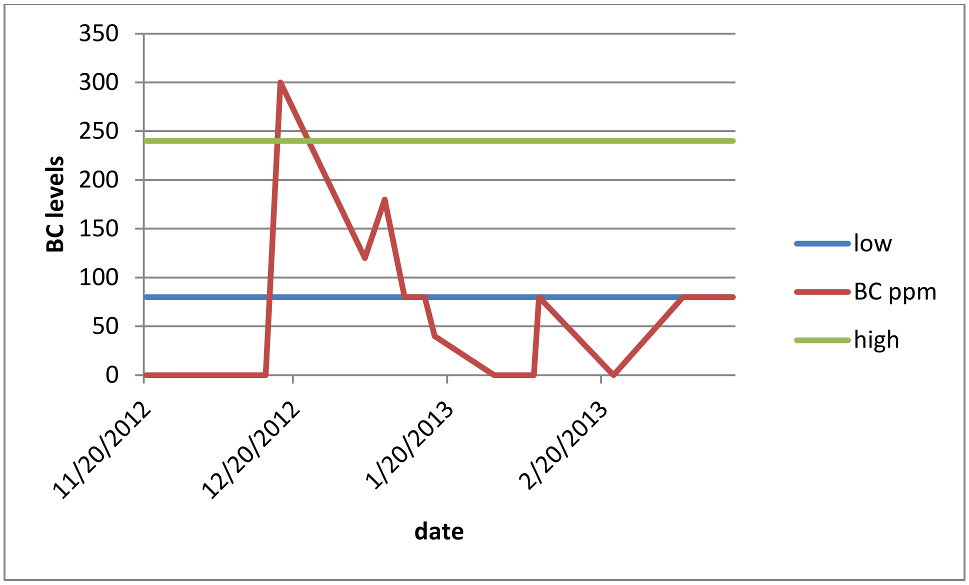

Figure 0.8- The graph shows Buffering Capacity levels in the Aquatic Ecosystem Model.

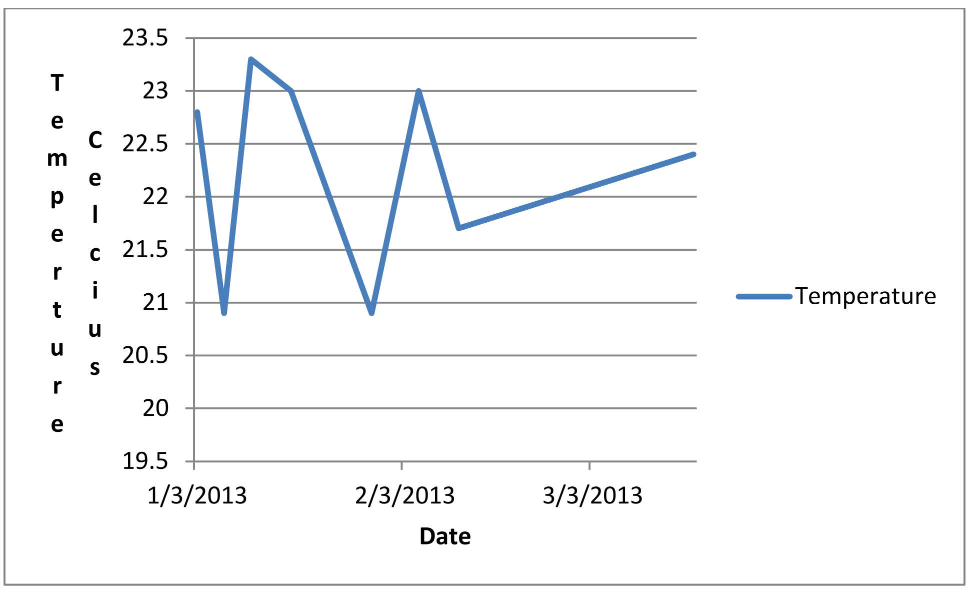

Figure 0.9- The graph above shows temperature in the AEM.

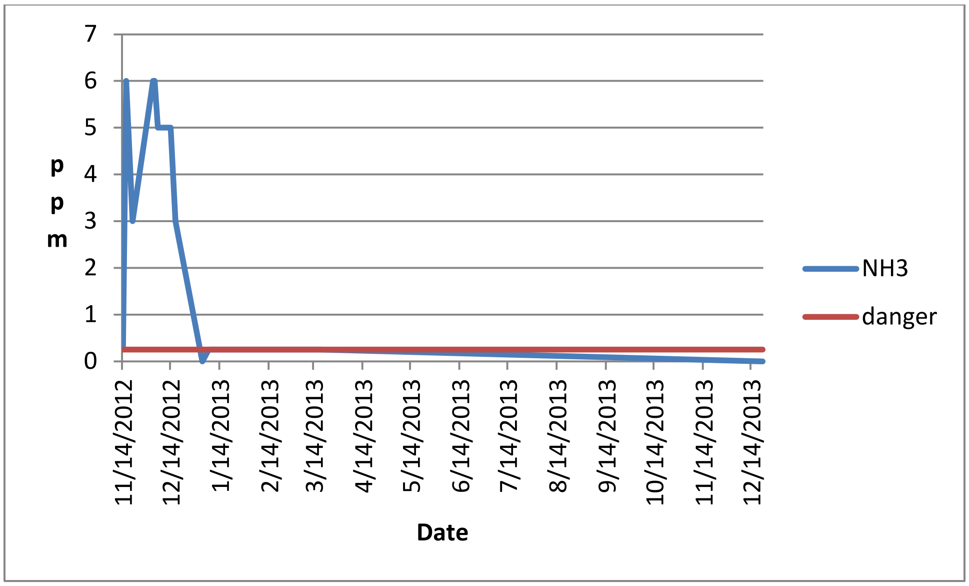

Figure 1.0- The graph shows NH3 levels in the aquatic ecosystem model. The levels spiked up in November of 2012, but came back to healthy levels.

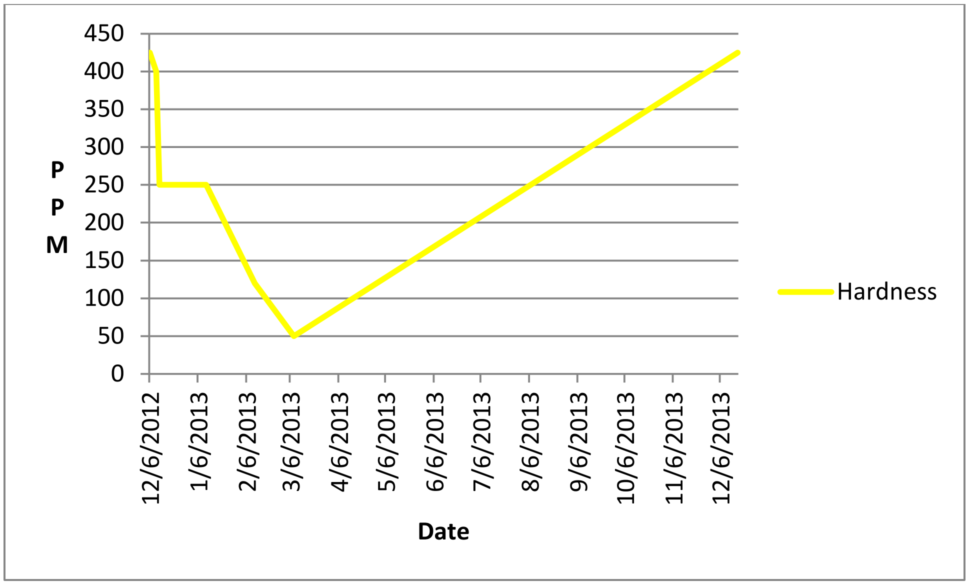

Figure 1.1- The Graph shows hardness levels in the AEM.

VIII. Analysis

Germination:

As seen from the graph (figure 0.4), only 25% of the peppers sprouted in the expected time. Only 2 sprouted out of 8. There were no distinct patterns shown from the data. It can be concluded though that peppers sprout slowly. There could be several reasons for this; some of the peppers seeds might not have been good for sprouting. They could have been destroyed before they were placed into the sponges. Also, the peppers were in the tray with basil seeds. They might have not had the exact temperature that was needed. The hypothesis was not supported by the data. In fact, it was way off. My hypothetical rate was 50% for day 8 but no seeds even sprouted on day eight.

Nitrification cycle:

On the date 11/20/2012, the ammonia level was 3, the nitrite level was 0 and the nitrite level was 20. Soon after that date, all three parameters started to quickly rise. They all increased to levels which were toxic. On 12/17/2012, the levels started to lower again. This can be interpreted that the nitrification cycle takes time in order to fully take effect. The Nitrifying bacteria can not immediately lower all of the levels. Because the Nitrification cycle takes time to complete, it is important not to put fish in a tank right away. Make sure all of the levels are not toxic. Using the data from figure 0.4 and 0.5, it is clear that there is a relationship between the nitrite, nitrate, and ammonia levels. When looking at the graph, when the Nitrite levels spike up, the Nitrate and the ammonia levels also increase. This must mean all of the parameters are interconnected with each other. They all follow a pattern with each other. The hypothesis was not supported by the data which was collected. The hypothesis did not follow a pattern in which all 3 parameters were interconnected.

pH and plant growth:

The relationship between plant growth and pH is as follows: when the pH spiked up the first two plants died. The new plants grew better when the pH was lower than 8. The plants also seemed to grow much faster when the pH was lower than seven. This proves that plants fair better in solutions that are slightly acidic. The growth of both off the plants was pretty constant with each other. They both grew at about the same rate.

Chemical Parameters:

In the Aquatic Ecosystem Model the parameters were not stable at first. After time, the parameters became stable and normal. Towards the start, the Buffering capacity spiked up really high. It then started to lower until it dropped to 0 ppm. When it dropped low, the pH also dropped low. This means that if there is a low Buffering Capacity, the pH will not be stable. Throughout the whole time monitoring, the temperature fluctuated. The fluctuation was not by much though. The range of the temperature was only 2.4 degrees Celsius. The hardness in the AEM started to lower at first but then started to rapidly increase.

AEM food web:

The food web showed the major organisms inside of the Aquatic Ecosystem Model. The tetra was the only fish inside of the Aquatic Ecosystem Model. There were also invertebrates such as snail and the algae eater. Both of the two invertebrates' diet consisted of mainly algae inside of the tank. Over time the Algae eater and snail depleted the Algae supply. Often times, more Algae were needed to add into the tank. In the Aquatic Ecosystem Model, there was a flow of energy. If an organism (such as the algae eater) died, decomposers, such as bacteria, would eat it and release the nutrients in the water.

Microscopy:

While looking under the microscope, many microscopic organisms were able to be seen. Among these were rotifers. The niche of the rotifer can be seen in the food web diagram under results. It could be seen that under different parts of the tank, there was different microscopic organisms. The microscope also allowed for looking at the algae and the basil plant.

IX. Conclusion

- My hypothesis was not supported. I stated that if the seeds are planted hydroponically then in 8 days 50% will grow, in 9 days 55% will grow, in 10 days

60% will grow, in 11 day 70% will grow and in 12 days 90% will grow. This was not to be shown. It can be seen from the data. If the project was to be done again, there are several suggestions. First off, there would be more pepper seeds planted. I feel that eight pepper seeds are not enough. Also if the project was completed again, I would let the peppers germinate for longer.

- The hypothesis was that on day one the ammonia would be 6ppm and the nitrate and the nitrite would both be 0ppm. Then, on the 10^{th} day the ammonia would be 2ppm, the nitrite would be 4ppm, and the nitrate would be 140ppm. This was not supported by the data. The levels were actually 0.25ppm for ammonia, 0ppm for NO2, and 80ppmfor Nitrate. The Aquatic Ecosystem Model is healthy enough to support invertebrates and vertebrates in the water at the moment. All of the levels appear to be stable. Waiting a couple days or so might be helpful since the NO_3 levels are still pretty high, but it will probably go back down. The date 1/11/13 is not shown on the graph, but on that day, the NO_3 levels decreased to 40ppm.
- The Aquatic Ecosystem Model shows how nutrients interact with living organisms in the tank. At first, the levels were unstable but after conditioning the ecosystem, the levels became healthy. Inside of the AEM there are many different microscopic organisms. At first look, they cannot be seen, but they can be viewed under a microscope.
- It took time for the chemical parameters of the AEM to stabilize.
- Certain organisms could only be seen under the microscope
- The plants inside the AEM would grow at different rates depending on the pH levels

X. bibliography

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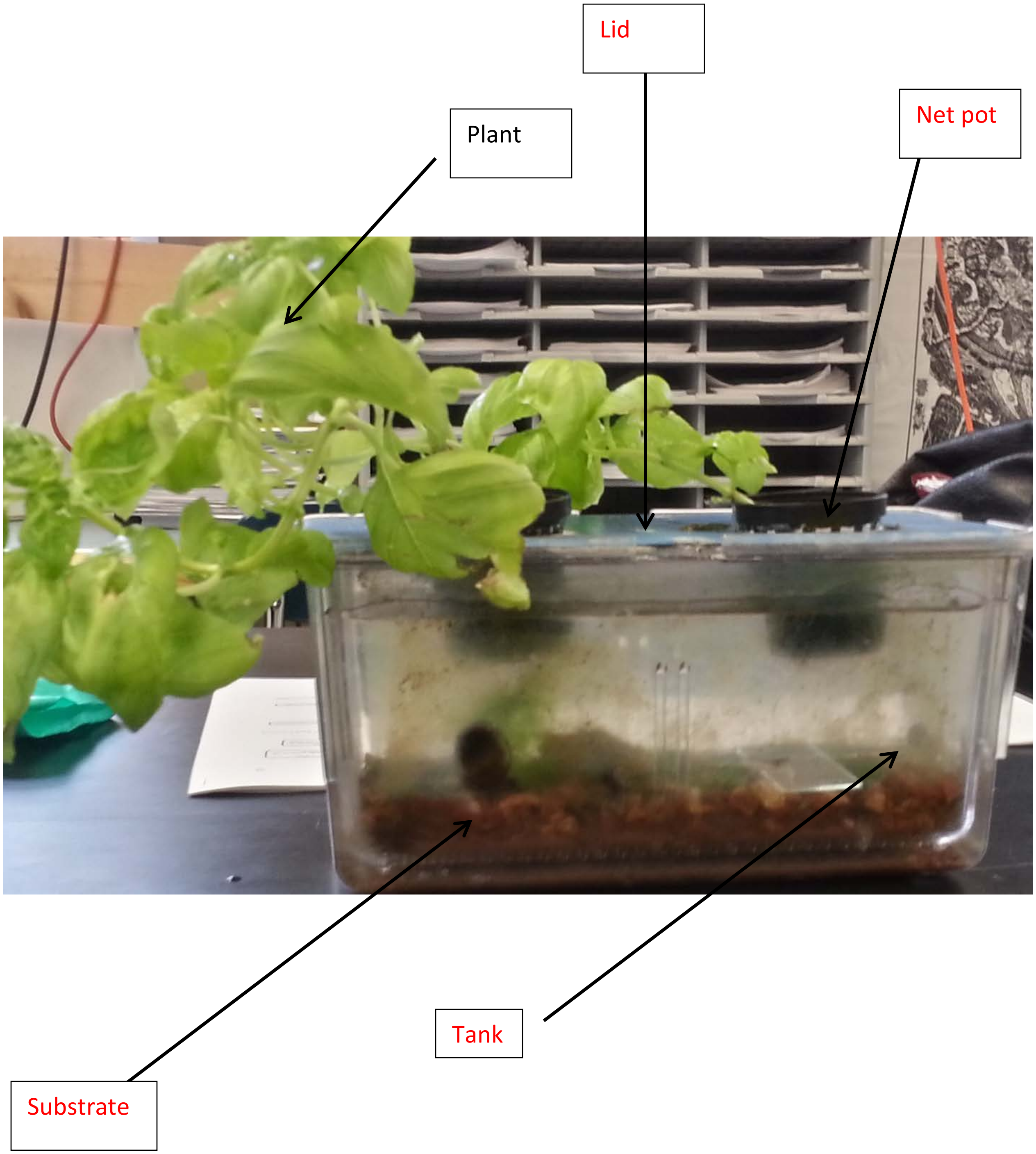
XI. Annex



2 Japanese Algae Eaters

The Japanese Algae Eater is a type of shrimp that likes to hide under and around algae. As the name suggests this shrimps diet consists of algae.

2 Japanese Algae eaters and Nerita Snail

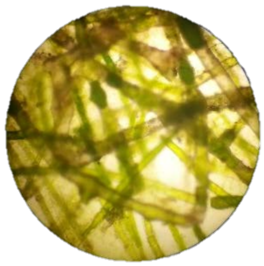
The picture shows 3 organisms inside of the tank. All three of them diet on algae.

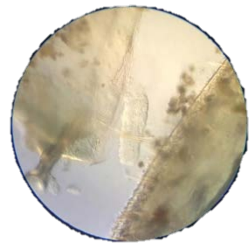
Close Up

This picture shows a close up of a Japanese Algae Eater; below it is a food pellet.

Japanese Algae Eater

The picture shows a Japanese Algae Eater in the AEM.





Algae

This shows algae underneath a microscope.

Microscopic organism

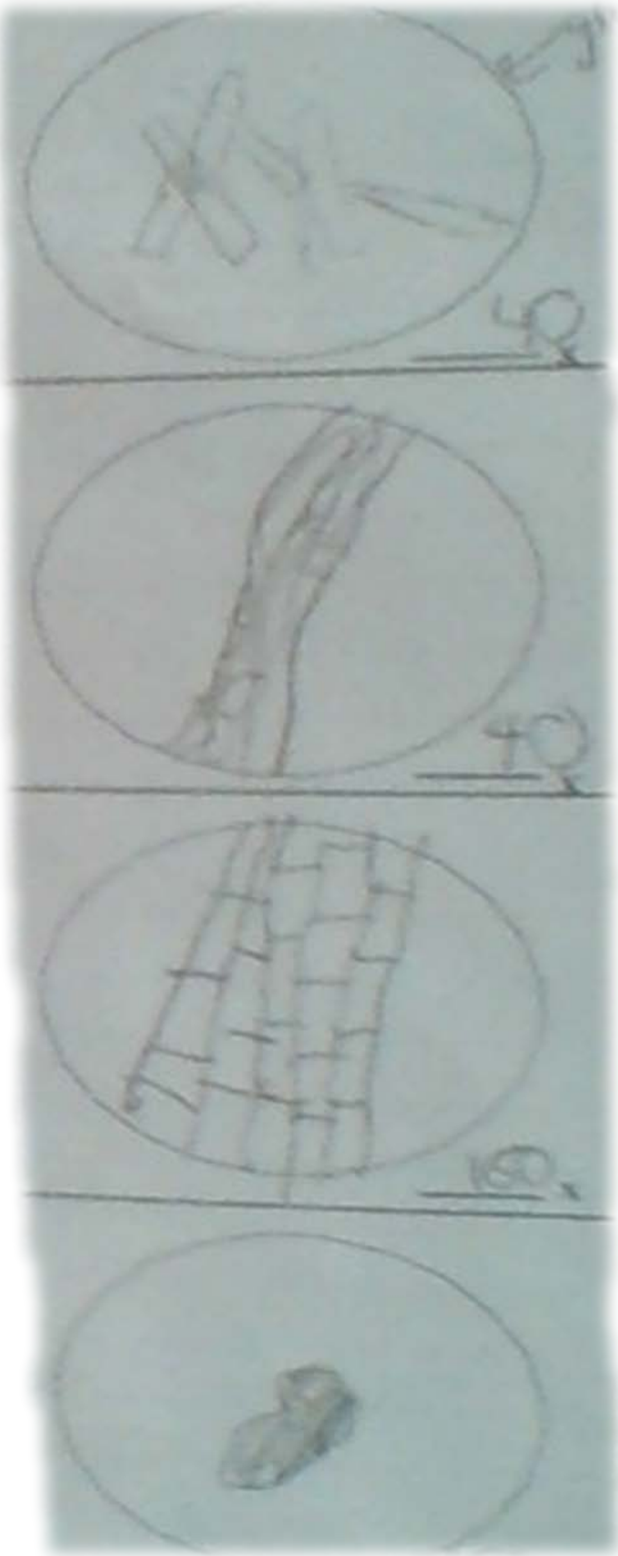
This shows an organism which is believed to be a peranema

Basil Leaf

The basil leaf is shown above

Microscopic organism

The picture shows what looks like animal cells.



<u>Algae</u>

This shows a drawing of Algae under 40x zoom. It is common in the AEM.

<u>Root Hair</u>

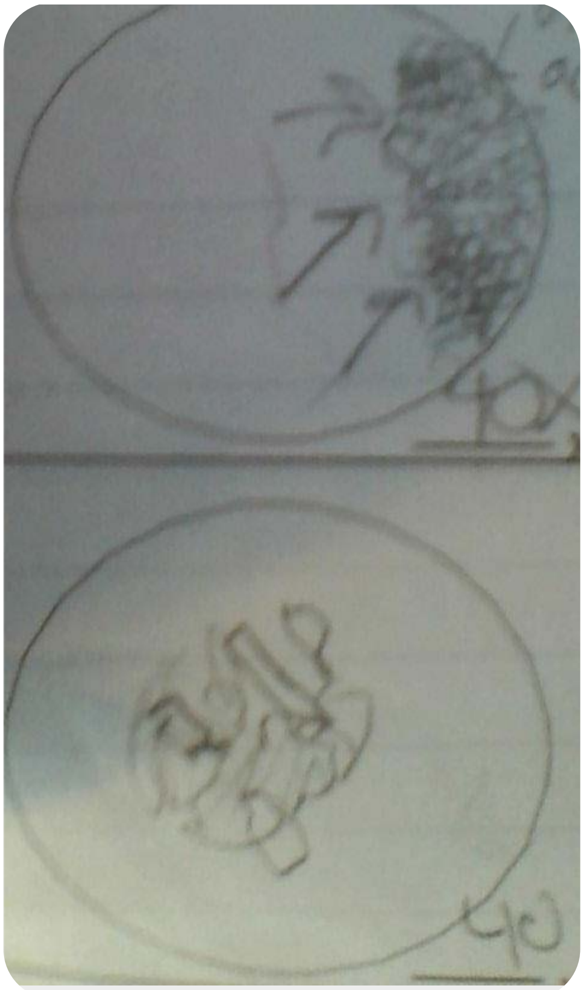
The drawing represents the root hair of a basil plant. The cells can be seen and are rectangular. The zoom is 40x.

<u>Root Hair</u>

This is a high power zoom of a root hair of a basil plant. The magnification is 160x.

<u>Unidentified</u>

This is an unidentified underwater organism



Basil Leaf

This is a dried up Basil leaf at 40x zoom.

Salt Crystal

At 40x zoom, it is possible to see salt crystals in the waters of the AEM.