Aquaponics

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Period 1

General Biology

5/27/16

Research Paper

Aquaponics systems can seem quite complicated at first sight, but the science behind it all is quite simple and digestible for the average person. “Aquaponics is essentially the combination of Aquaculture and Hydroponics. Both aquaculture and hydroponics have some down sides, hydroponics requires expensive nutrients to feed the plants, and also requires periodic flushing of the systems which can lead to waste disposal issues” (Backyard Aquaponics). These aquaponics systems basically cycle water between the fish and the plants. The water in a tank that fish are raised in, will eventually get dirty and it would become time to clean out the tank, but with aquaponics, the dirty water is cycled to a grow bed with plants and they essentially clean the water by taking in the nutrients that would be harmful to the fish as fertilization. Then once the water is filtered by the plants, it all goes back into the tank and the cycle starts again.

The system makes it a win-win for both the fish and the plants. The plants get nutrients to keep growing and the fish get clean water, so they survive. Now, the question we are wondering is how could someone make an aquaponics system that is efficient and would work without the use of electricity, but still be reliable.

The history behind aquaponics can be a bit debatable, especially with when it first was seen. Some say that the Aztecs used systems in lake shallows on islands known as chinampas where they raised and irrigated plants. They raised plants on hand-made rafts on the surfaces of lakes around 1,000 A.D. Others say that early aquaponic systems were first seen in China, Thailand, and Indonesia, where farmers cultivated and farmed rice in paddy fields with fish such as oriental loaches, swamp eels, common carps, and crucian carp. They even used pond snails in combination with the crops. In China, floating aquaponics systems were installed and some were over 2.5 acres. “The first aquaponics research in Canada was a small system added onto existing aquaculture research at a research station in Lethbridge, Alberta. Canada saw a rise in aquaponics setups throughout the ’90s, predominantly as commercial installations raising high-value crops such as trout and lettuce. A setup based on the deep water system developed at the University of Virgin Islands was built in a greenhouse at Brooks, Alberta where Dr. Nick Savidov and colleagues researched aquaponics from a background of plant science. The team made findings on rapid root growth in aquaponics systems and on closing the solid-waste loop, and found that owing to certain advantages in the system over traditional aquaculture, the system can run well at a low pH level, which is favoured by plants but not fish” (Wikipedia).

“The reference Village Aquaponics refers to an aquaponic system specifically set up for the purpose of providing a protein crop (the fish) and a vegetable, herb or fruit crop (the plants) to a specific region surrounding the operation” (Aquaponics.com - John S. Pade).

When an aquaponics system is operating, there’s a cycle- a nutrients cycle, where there’s a movement and exchange of both organic and inorganic materials for the production of living matter. In aquaponics, it’s more specifically the nitrogen cycle, because nitrogen is the main thing that is getting cycled around in an aquaponics system and nitrogen is vital for anything living since it’s used in DNA, RNA, and protein. The “input”, or starting point, for the nitrogen cycle is the fish feed. The fish eat the fish feed, which is rich in protein and therefore is the main source of nitrogen in the aquaponics system. Then most of the nitrogen that the fish digest is excreted as ammonia, or ammonia nitrogen (NH3 and NH4+, two forms of ammonia). Now the NH3 form of ammonia is toxic to the fish and so it has to somehow become less toxic and change into a less toxic form of nitrogen, like nitrate (NO3-). Then the process of nitrification occurs, where NH4+ is changed into nitrite (NO2-) and then converted further into nitrate. Next, denitrification occurs, where the nitrate is reduced to nitrite, then to nitrous oxide, and finally to nitrogen gas. “When water flows through the hydroponic component of the system, NO3- and NH4+ can be taken up by plants. However, NO3- is often the preferred form of nitrogen. After the nitrogen is consumed, the purified water is then returned to the aquaculture component” (Bioenergy Research Group). The fish excrete ammonia, the ammonia converts to nitrites, nitrites convert to nitrates, and the plants absorb the nitrates. Overall, the fish eat, poop, the poop/nitrogen component is cycled to the plants, the plants take in the poop/nitrogen which cleans the water of the toxic materials, and then the clean water is returned to the tank with the fish.

Our system incorporates these cycles because that's just how the aquaponics system is and kind of has to be to function properly. We have pumps to cycle the dirty water up to plants that then clean the water of the toxic material to the fish, and then the clean water returns to the tank of fish. The cycles are incorporated through the components we have working together in an aquaponics system. Our system cycles the water and therefore commences that nitrogen cycle for the fish and plants to continue growing and living coinciding with each other, using each other. The fish make toxic waste in the tank, essentially, our pumps bring that waste to the plants which use that waste as nitrogen/nutrients that is helpful to them and not toxic to them like it is to the fish. And while that all happens for the plants, the water get cleansed and pours gently out of the grow beds automatically and back into the fish tank for the cycle to restart.

The crops that are grown in aquaponics systems range from lettuce to bananas to mint to pak choi. Many crops can be grown in aquaponics, some better than others. Lettuce, kale, swiss, chard, arugula, basil, mint, watercress, chives, and common houseplants are crops that would do well in any aquaponics system. Ones that could only to well in nice, established aquaponics systems are tomatoes, peppers, cucumbers, beans, peas, squash, broccoli, cabbage, and cauliflower. Nelson and Pade Inc have grown some interesting crops in their aquaponics systems, like sweet corn, beets, radishes, carrots, onions, edible flowers, and even dwarf citrus trees with lemons, limes, and oranges on them.

Using aquaponics we could grow completely organic crops that are not GMOs. They would be completely organic because if you were to add chemicals to the plants to keep insects off it would filter down to the fish, and kill them, but if you were to clean the tank using chemicals that were non-harmful to the fish, then they would likely kill the plants, so to keep them alive you would have to use no chemicals. Using aquaponics we would be able to grow crops with little effort, being all you have to do is feed the fish, and clean the tank every once, and a great while.

I think that another very simple application of aquaponics could be in school, just for students, because it helps them with both using their hands and their heads to get something like this worked out/figured out, planned, and put together. It can help students with responsibility and just how these kinds of things work. It's a great thing to incorporate with schooling, because of those reasons - for education both physically and mentally, which is always good and healthy. Another smart application of aquaponics can be home food production. It's as simple as having the aquaponics system, just having a more focused goal on eating the crops you grow in the system. Instead of making a garden out in the backward, make a neat little system with some tanks of water, fish, and crops. It can lead to a more fun, healthy, educational lifestyle. There are many ways to apply the use of aquaponics in everyday life, from research to medical applications. "Aquaponics - One Solution to Global Food Security" (John's Talk).

It almost seems that aquaponics are perfect, but, of course like everything else, they're not. Some cons of aquaponics are that some can use up to 30% more water than a regular garden (but the water used in aquaponics systems is cycled and recirculated) and food safety - is the food grown going to be 100% safe for consumption or could it potentially harm someone or an animal. Also, a lot of companies will just use artificial lighting indoors for aquaponics systems and this counters a big reason behind using aquaponics, which is having greater reliance on renewable energy sources, like solar, which is something that greenhouses use. "Energy usage is rather high with these systems" (One Care Now). The start up cost for building an aquaponics system that is well established can be a bit hefty, with everything being of high quality and heavily stocked with high grade plants and fish. Another few cons on aquaponics systems are that daily check-ins need to be made (but that can depend on the operator), the electricity cost can be a problem for some people, and if the fish die, the whole cycle would be changed and most likely not function. Then it would take some more time and money to restore the system when that happens.

For aquaponics in the future, I think people will get on that "aquaponics train" and start growing all kinds of crops using aquaponics. This way more resources can be saved in the long run and larger quantities of high quality, healthy food will be produced often. And since aquaponics don't require the same things that agricultural farming needs, like tractors, gas-powered farm equipment, herbicides, and irrigators, I would expect more people to move to aquaponics because of those requirements for agricultural farming and all of the extra labor for pretty much the same result. Maybe restaurants could make very nice looking aquaponics systems, show them off, and at the same time be growing crops to use in the kitchen to serve. This way, the food they're serving the customer will be more organic and healthy, and hopefully they'll appreciate that.

In the end, I believe that aquaponics are a great way for both just individuals and even huge businesses (aquaponics businesses). To create an aquaponics system that is effect, reliable, and can operate without the use of electricity, you could incorporate the use of something natural, like wind. Gravity is another option, but I'm not entirely sure that the cycle could be completed upon bringing water back up to the plants with just the use of gravity, but wind can be used quite effectively and sure it isn't super reliable, but it would get the job done. Yes, you possibly could have an operating aquaponics system, that is both efficient and reliable, and can even work without the use of electricity.

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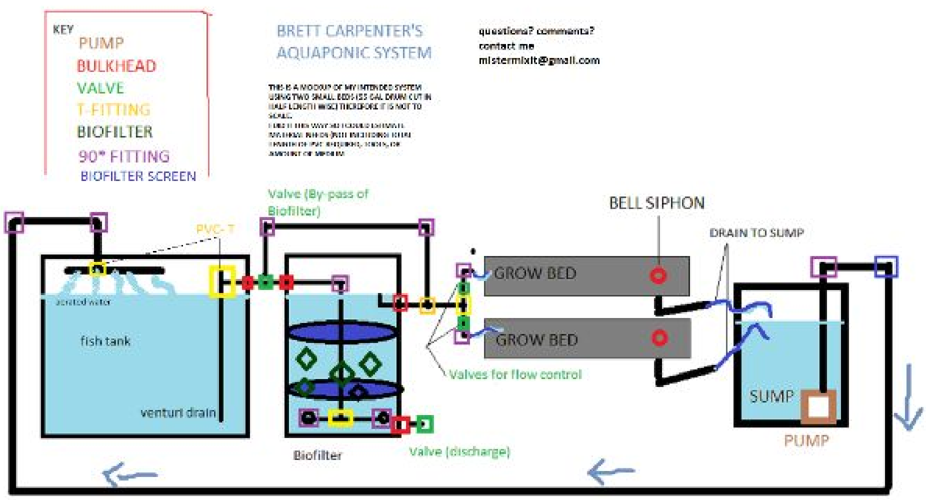
Aquaponics

Schematic


KEY
PUMP
BULKHEAD
VALVE
T-FITTING
BIOFILTER
90° FITTING
BIOFILTER SCREEN
BRETT CARPENTER'S
AQUAPONIC SYSTEM
questions? comments?
contact me
mistermixit@gmail.com
Valve (By-pass of Biofilter)
PVC- T
BELL SIPHON
DRAIN TO SUMP
GROW BED
GROW BED
aerated water
fish tank
venturi drain
Biofilter
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SUMP
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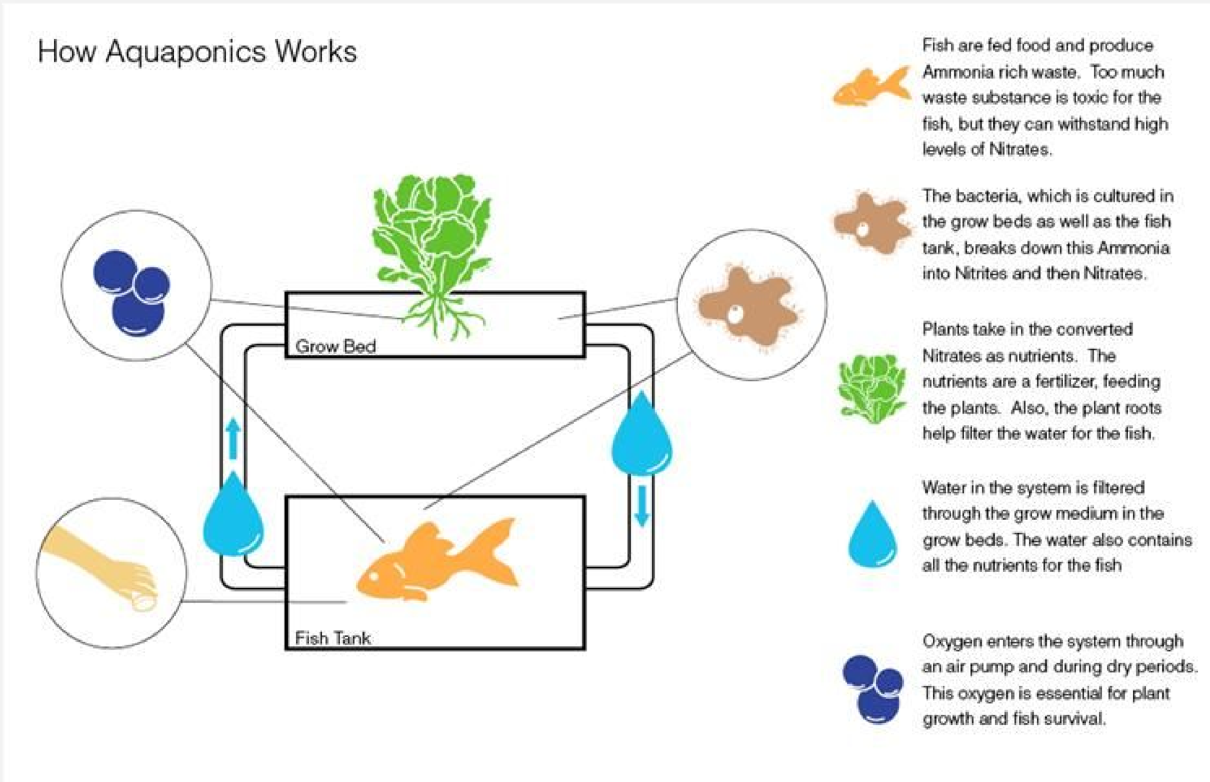
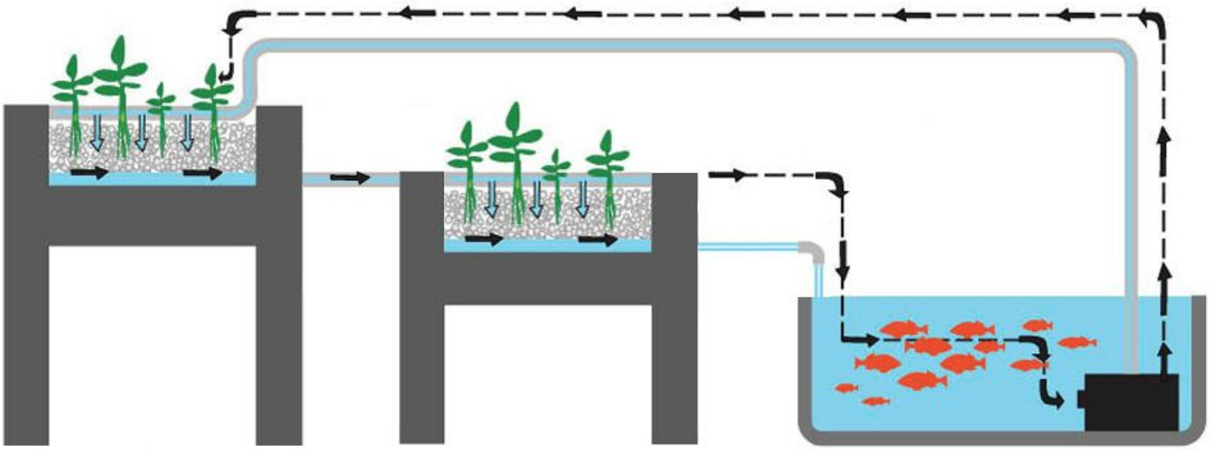


Aquaponics System Design Free



Build Procedure

Two 16-18 inch long 2x4s are placed on the ground with the flat four inch side facing up. Approximately, the two 2x4s have 6 inches of spacing between them. Eight pieces of 2x4s were matched vertically to the two flat, horizontal 2x4s on the ground, with four on each side of the two 2x4s. The eight vertical 2x4s were screwed into the flat, horizontal pieces for stability. Four more 2x4s were placed on the vertical pieces, with one piece laying flat on two of the vertical pieces four times because there are eight vertical pieces and each horizontal piece on top rests on two of the vertical pieces. The horizontal 2x4s on top were screwed down into those supporting 2x4s standing vertical that are on top of the base (the two 16-18 inch long 2x4s on the ground, flat). The glass aquarium is placed in between the standing, vertical 2x4s with supported beams on top for the growing beds. The glass aquarium is perpendicular to the two long 2x4s on the ground, the base, and is filled with freshwater. The grow beds for the plants were placed on the opposite sides of the tank up top on the 2x4 frame, where the flat, horizontal 2x4s rest on the vertical ones, and they were pushed as close to the center and over the tank as possible, so if leaks were to occur, the drips of lost water would still finds its way into the tank. Rocks were dumped into the grow beds and spread around to create a flat surface of rocks. The same was done for the glass aquarium, but with smaller rocks. Two holes were drilled into the sides of the grow beds, one in each grow bed, that faced the tank, facing inwards towards each other and down into the tank at the center of the frame. “Bulkheads” were placed in the holes to ensure that no leaks would occur and the water could safely travel out of the grow beds and into the tanks. Two pumps were placed at the bottom of the tank at opposite sides (lengthwise of the tank) and stuck up against the glass on the inside. Another two holes were drilled into the sides of the grow beds, but this time lengthwise of the grow beds and the holes were high up, so if the water level rose a lot, it wouldn’t leak. At last, vinyl tubing (two separate tubes, one for each pump) was used to complete the cycle of water from the pumps, up through the holes, and into the grow beds about three inches in from where the holes were drilled for the tubes/the edge of the grow beds.

Materials List

- Four 2x4s approximately 14 inches long
- Two 2x4s approximately 16-18 inches long
- One glass aquarium fish tank (61cm x 31.5cm)
- Two plastic grow beds (approximately 50cm x 20cm)
- Two small “bulkheads” (approximately 1.5 inches in diameter)
- Small rocks
- Two small water pumps
- Vinyl tubing (5/8 inch OD ; 1/2 inch ID)
- Two pieces of plywood (70cm x 30cm)
- Screwdriver and screws
- Drill and drill bits

History/Background

Aquaponics is a combination of aquaculture and hydroponics. Aquaponics systems pretty much just cycle the water in them between the plants and the fish for the benefits of both to have from the water. The history behind aquaponics and when they were first seen can be argued about. Some say that the Aztecs used systems in lake shallows on islands known as chinampas where they raised and irrigated plants. They would raise plants on hand-made rafts on the surfaces of lakes around 1,000 A.D. Others say that early aquaponic systems were first seen in China, Thailand, and Indonesia, where farmers cultivated and farmed rice in paddy fields with fish such as oriental loaches, swamp eels, common carps, and crucian carp. They even used pond snails in combination with the crops. In China, floating aquaponics systems were installed and some were over 2.5 acres. In Canada, the first aquaponics research conducted was a small system added with other research on aquaculture at a research station in Lethbridge, Alberta. A rise in aquaponics setups occurred throughout the 1990's in Canada, as commercial installations raised crops of high-value, like trout and lettuce. A setup based on these water systems was created at the University of Virgin Islands. It was built in a greenhouse at Brooks, Alberta where Dr. Nick

Savidov and colleagues researched aquaponics from a background of plant science. The team made findings on rapid root growth in aquaponics systems and on closing the solid-waste loop, and found that owing to certain advantages in the system over traditional aquaculture, the system can run well at a low pH level, which is favoured by plants but not fish.

Nutrient Cycles

When an aquaponics system is operating, there's a cycle - a nutrients cycle, where there's a movement and exchange of both organic and inorganic materials for the production of living matter. In aquaponics, it's more specifically the nitrogen cycle, because nitrogen is the main thing that is getting cycled around in an aquaponics system and nitrogen is vital for anything living since it's used in DNA, RNA, and protein. The "input", or starting point, for the nitrogen cycle is the fish feed. The fish eat the fish feed, which is rich in protein and therefore is the main source of nitrogen in the aquaponics system. Then most of the nitrogen that the fish digest is excreted as ammonia, or ammonia nitrogen (NH3 and NH4+, two forms of ammonia). Now the NH3 form of ammonia is toxic to the fish and so it has to somehow become less toxic and change into a less toxic form of nitrogen, like nitrate (NO3-). Then the process of nitrification occurs, where NH4+ is changed into nitrite (NO2-) and then converted further into nitrate. Next, denitrification occurs, where the nitrate is reduced to nitrite, then to nitrous oxide, and finally to nitrogen gas. "When water flows through the hydroponic component of the system, NO3- and NH4+ can be taken up by plants. However, NO3- is often the preferred form of nitrogen. After the nitrogen is consumed, the purified water is then returned to the aquaculture component" (Bioenergy Research Group). The fish excrete ammonia, the ammonia converts to nitrites, nitrites convert to nitrates, and the plants absorb the nitrates. Overall, the fish eat, poop, the poop/nitrogen component is cycled to the plants, the plants take in the poop/nitrogen which cleans the water of the toxic materials, and then the clean water is returned to the tank with the fish. The system incorporates these cycles because that's just how the aquaponics system is and kind of has to be to function properly. We have pumps to cycle the dirty water up to plants that then clean the water of the toxic material to the fish, and then the clean water returns to the tank of fish. The cycles are incorporated through the components we have working together in an aquaponics system. Our system cycles the water and therefore commences that nitrogen cycle for the fish and plants to continue growing and living coinciding with each other, using each other. The fish make toxic waste in the tank, essentially, our pumps bring that waste to the plants which use that waste as nitrogen/nutrients that is helpful to them and not toxic to them like it is to the fish. And while that all happens for the plants, the water get cleansed and pours gently out of the grow beds automatically and back into the fish tank for the cycle to restart.

Crops

The crops that are grown in aquaponics systems range from lettuce to bananas to mint to pak choi. Many crops can be grown in aquaponics, some better than others. Lettuce, kale, swiss, chard, arugula, basil, mint, watercress, chives, and common houseplants are crops that would do well in any aquaponics system. Ones that could only to well in nice, established aquaponics systems are tomatoes, peppers, cucumbers, beans, peas, squash, broccoli, cabbage, and cauliflower. Nelson and Pade Inc have grown some interesting crops in their aquaponics systems, like sweet corn, beets, radishes, carrots, onions, edible flowers, and even dwarf citrus trees with lemons, limes, and oranges on them. The crop in our aquaponics system is lettuce. One interesting thing, that is also quite concerning, is that the “control” lettuce, the lettuce just growing in regular soil being watered daily, is growing better than the lettuce growing in the aquaponics system. And it’s said that aquaponics systems are supposed to be more efficient than just growing crops in soil and watering the crop manuely.

Data Table/Results

Day	Plant #	Plant Height	Root Length	Average Leaf Length	# of Leaves	Stem Length
5/25	1	10.2	7.0	1.6	2	2.8
	2	8.4	4.5	1.8	2	2.3
	3	7.7	3.7	2.15	2	2.2
	4	9.2	4.6	1.5	2	3.2
	5	7.3	7.9	1.6	2	3.0
	6	9.2	5.0	1.35	2	3.0
5/26	1	10.3	7.0	1.4	2	3.5
	2	9.5	7.0	1.4	2	3.5
	3	7.5	5.0	1.4	2	2.5
	4	8.3	4.5	1.45	2	2.8
	5	7.5	4.0	1.2	2	4.0
	6	7.5	3.5	.9	2	3.4
	1			1.6	3	3.8
	2			1.4	3	3.7

5/27	3			1.7	3	2.8
	4			1.7	3	3.1
	5			1.5	3	4.2
	6			1.2	3	3.6
	1			1.8	3	4.0
	2			1.6	3	3.9
5/31	3			1.9	3	3.1
	4			1.9	3	3.2
	5			1.6	3	4.3
	6			1.4	3	3.9
	1			1.925	4	4.2
	2			1.7	4	4.1
6/1	3			2.15	4	3.35
	4			2.2	4	3.5
	5			1.8	4	4.4
	6			1.55	4	4.1
	1			2.2	4	4.4
	2			1.9	4	4.3
6/2	3			2.3	4	3.7

	4 5 6			2.45 2.1 1.725	4 4 4	3.9 4.6 4.3
6/3	1 2 3 4 5 6			2.5 2.2 2.6 2.75 2.425 1.95	4 4 4 4 4 4	4.6 4.5 4.0 4.2 4.8 4.6
6/4	1 2 3 4 5 6			2.6 2.35 2.65 2.8 2.55 2.2		

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Lab Report

Science

P5

6/10/16

The Effectiveness of Aquaponics on Plant Growth

Introduction

Aquaponics is essentially the combination of aquaculture and hydroponics. Both aquaculture and hydroponics have some down sides, hydroponics requires expensive nutrients to feed the plants, and also requires periodic flushing of the systems which can lead to waste disposal issues. But the use of aquaponics can fix these kinds of problems. Aquaponics systems basically cycle water between the fish and the plants. The water in a tank that fish are raised in, will eventually get dirty and harmful to the fish because of the nitrogen in their feces and that nitrogen takes the form of ammonia. Usually when that happens, it would become time to clean out the tank, but with aquaponics the dirty water is cycled to a grow bed with plants and they essentially clean the water by taking in the nutrients that would be harmful to the fish as fertilization. The plants take in required things it needs, like nitrogen, oxygen, phosphorus, water, and other essentials, to survive. Most of those things plants get from dirt, but once those essential resources are used up, they would need something else to get those essential nutrients, and that is when aquaponics systems come in. Once the filthy water is filtered by the plants and they take in those nutrients that would be harmful to fish, the clean water goes back into the tank and the cycle begins again. The system makes it a win-win for both the fish and the plants. The plants get nutrients to keep growing and the fish get clean water, so they survive. Both organisms in the system benefit from each other. The question is, can an aquaponics systems really do better than just growing crops in soil and watering them every day?

The purpose of this experiment is to observe plant growth, as well as the relationships between two organisms in a kind of symbiotic relationship together, which means they cannot live without each other. In this experiment, the aquaponics system (the variable) is tested against a normal plant growing system to see which can grow plants taller, healthier, and fuller.

Aquaponic systems are an easier, more efficient and renewable, self-sustaining way of growing crops and even raising fish. They reuse and purify the water used in the system, as well as clean the fish tank and supply plants with essential nutrients for them. Traditional planting in soil uses water, that does not get filtered, and only gets the nutrients that are pre-existing in the soil, which means the plants will not be able to get the nutrients they need from anywhere else and will not get any at all once the nutrients in the dirt is exhausted. Our group believes that crops grown in an aquaponics system will grow much better than crops grown out in the sun in a traditional setting of soil and daily watering.

Procedure

To build the aquaponics system: Two 16-18 inch long 2x4s were placed on the ground with the flat four inch side facing up. Approximately, the two 2x4s had 6 inches of spacing between them. Eight pieces of 2x4s were matched vertically to the two flat, horizontal 2x4s on the ground, with four on each side of the two 2x4s. The eight vertical 2x4s were screwed into the flat, horizontal pieces for stability. Four more 2x4s were placed on the vertical pieces, with one piece laying flat on two of the vertical pieces four times because there are eight vertical pieces and each horizontal piece on top rests on two of the vertical pieces. The horizontal 2x4s on top were screwed down into those supporting 2x4s standing vertical that are on top of the base (the two 16-18 inch long 2x4s on the ground, flat). The glass aquarium was placed in between the standing, vertical 2x4s with supported beams on top for the growing beds. The glass aquarium was perpendicular to the two long 2x4s on the ground, the base, and was filled with freshwater. The grow beds for the plants were placed on the opposite sides of the tank up top on the 2x4 frame, where the flat, horizontal 2x4s rest on the vertical ones, and they were pushed as close to the center and over the tank as possible, so if leaks were to occur, the drips of lost water would still finds its way into the tank. Rocks were dumped into the grow beds and spread around to create a flat surface of rocks. The same was done for the glass aquarium, but with smaller rocks. Two holes were drilled into the sides of the grow beds, one in each grow bed, that faced the tank, facing inwards towards each other and down into the tank at the center of the frame. “Bulkheads” were placed in the holes to ensure that no leaks would occur and the water could safely travel out of the grow beds and into the tanks. Two pumps were placed at the bottom of the tank at opposite sides (lengthwise of the tank) and stuck up against the glass on the inside. Another two holes were drilled into the sides of the grow beds, but this time lengthwise of the grow beds and the holes were high up, so if the water level rose a lot, it would not leak. At last, vinyl tubing (two separate tubes, one for each pump) was used to complete the cycle of water from the pumps, up through the holes, and into the grow beds about three inches in from where the holes were drilled for the tubes/the edge of the grow beds. The two pumps were plugged into a power outlet and the water automatically began cycling from the fish tank and into the two grow beds. Six small, shallow holes were dug into the rocks of the grow beds (three in each grow bed). Six “lettuce plants” were obtained and measured. The plant height, root length, average leaf length, number of leaves, and stem length was measured with a ruler and was recorded for each plant (labeled 1-6) on a paper with a data table made and the current date on the side next to the data recorded. The six plants were placed into the six holes carefully. Each of the six plants’ average leaf length, number of leaves, and stem length were measured with a ruler and recorded onto a paper with a data table for the following ten days.

Results

The results our class got in the end of the experiment did not support our hypothesis. The “control” lettuce, or lettuce that was grown in traditional soil, had done better than the lettuce grown in the aquaponics system. The control lettuce had grown much taller, healthier, and fuller than the lettuce grown in the system. Our group (maybe even the whole class) did not receive the data for the control lettuce grown in regular soil and watered daily, but we know that the control lettuce did much better than the lettuce grown in the aquaponics system. The lettuce in the aquaponics system did not grow as well as most people expected. Most of the class predicted that the aquaponics system would be much more easier, efficient, and reliable to use to grow crops and that it would do much better than the lettuce. It could just be that since it was lettuce, the particular final aquaponics system was not fit to grow that type of crops, but who knows - lots of the problems came from how the aquaponics system operated and it had its’ hiccups throughout the eleven day experiment. Another problem could have been that the aquaponics system was not even filtering the water properly and so then the water would not be clean for the cycle. The only way to really know if aquaponics systems are either superior or inferior to traditional crop growing in regular soil and watered daily, is to utilize these techniques in the real world and have both of them do a similar task in growing crops. Then see, after multiple accurate experiments, which way was more easier, efficient, and overall a reliable way to grow crops that were fuller, taller, and just generally healthier than the other way with its’ crops.

Aquaponics Data Table for Plant Growth In Aquaponics System

(all length/height data is measured in centimeters)

Day	**Plant #**	**Plant Height**	**Root Length**	**Average Leaf Length**	**# of Leaves**	**Stem Length**
	1	10.2	7.0	1.6	2	2.4
	2	8.4	4.5	1.8	2	1.9
5/25	3	7.7	3.7	1.95	2	1.8
	4	9.2	4.6	1.5	2	2.6
	5	7.3	7.9	1.6	2	2.5
	6	9.2	5.0	1.35	2	2.5
	1	10.3	7.0	1.6	2	2.4
	2	9.5	7.0	1.8	2	1.95
5/26	3	7.5	5.0	1.95	2	1.9
	4	8.3	4.5	1.6	2	2.6
	5	7.5	4.0	1.65	2	2.5
	6	7.5	3.5	1.4	2	2.5
	1	-	-	1.625	2	2.45
	2	-	-	1.85	2	1.975
5/27	3	-	-	1.975	3	2.0

	4	-	-	1.65	2	2.75
	5	-	-	1.7	3	2.55
	6	-	-	1.45	2	2.525
	1	-	-	1.625	2	2.5
	2	-	-	1.85	2	2.1
5/31	3	-	-	1.975	3	2.175
	4	-	-	1.7	3	2.8
	5	-	-	1.8	3	2.6
	6	-	-	1.5	3	2.6
	1	-	-	1.65	2	2.55
	2	-	-	1.875	2	2.25
6/1	3	-	-	2.0	3	2.35
	4	-	-	1.8	3	2.875
	5	-	-	1.85	3	2.75
	6	-	-	1.6	3	2.7
	1	-	-	1.675	2	2.65
	2	-	-	1.9	3	2.375
6/2	3	-	-	2.05	4	2.5
	4	-	-	1.85	3	2.925
	5	-	-	1.9	3	2.825
	6	-	-	1.75	3	2.8

6/3	1	-	-	1.7	3	2.7
	2	-	-	1.925	3	2.45
	3	-	-	2.1	4	2.65
	4	-	-	1.9	3	3.0
	5	-	-	1.95	4	2.850
	6	-	-	1.85	3	2.95
6/6	1	-	-	1.725	3	2.775
	2	-	-	1.95	3	2.5
	3	-	-	2.15	4	2.8
	4	-	-	2.0	4	3.1
	5	-	-	2.0	4	2.875
	6	-	-	1.9	4	3.0
6/7	1	-	-	1.75	3	2.8
	2	-	-	1.975	3	2.6
	3	-	-	2.2	4	2.9
	4	-	-	2.15	4	3.225
	5	-	-	2.05	4	2.925
	6	-	-	2.0	4	3.075
6/8	1	-	-	1.775	3	2.85
	2	-	-	2.0	3	2.65
	3	-	-	2.25	5	3.0

	4	-	-	2.2	4	3.275
	5	-	-	2.1	4	2.975
	6	-	-	2.1	4	3.15
6/9	1	8.5	5.3	1.8	3	2.9
	2	11.0	5.7	2.0	3	2.7
	3	13.7	8.0	2.3	5	3.1
	4	13.2	8.5	2.3	4	3.3
	5	18.5	8.0	2.1	5	3.0
	6	16.9	10.2	2.2	4	3.2

Aquaponics Data Table for Plant Growth In Traditional Soil and Watered Daily

(Control Data)

(all length/height data is measured in centimeters)

Day	Plant #	Plant Height	Root Length	Leaf Length	# of Leaves	Stem Length
5/25/16	1	9	4.3	1.85	2	2.7
	2	6.8	3.5	1.55	2	2.5
	3	6.9	3	1.7	2	2.2
	4	6.6	2.7	1.85	2	2.3
	5	10.3	6	1.6	2	3
	6	9	5	1.9	2	2.2
5/26/16	1			2.1	4	
	2			1.7	3	
	3			1.85	3	
	4			2.0	3	
	5			1.9	3	
	6			2.2	4	
5/27/16	1			2.3	4	
	2			1.6	3	
	3			2.0	4	

	4 5 6			2.1 2.2 2.5	4 3 4	
5/31/16	1 2 3 4 5 6			2.8 1.8 2.25 2.2 2.5 2.9	4 4 4 4 4 4	
6/2/16	1 2 3 4 5 6			3.1 2.1 2.7 2.4 3.1 3.2	5 5 5 5 5 5	
6/3/16	1 2 3 4 5 6			3.6 2.4 3.4 2.9 3.4 3.5	5 5 5 5 5 5	

6/6/16	1 2 3 4 5 6			4.7 2.7 4.0 3.8 3.7 4.0	6 6 5 5 5 5	
6/7/16	1 2 3 4 5 6			5.6 3.2 4.5 4.1 4.4 5.4	6 6 5 6 6 5	
6/8/16	1 2 3 4 5 6	23 13 15.3 13 21 20.5	12.1 5.2 6 4.0 10 10.1	6.4 3.6 4.9 4.5 4.9 6.0	6 6 6 6 6 5	2.6 1.5 1.2 1.3 2.6 2.3

Discussion

The results that were gathered in this experiment disproved our hypothesis, that the aquaponics system would grow crops better than traditionally growing them in regular soil and daily watering. When comparing the measurements from both systems' plants, it was seen that the plants in the soil grew much more better than the ones in the aquaponics system. Despite that, the plants grown in the aquaponics system still grew substantially well.

We chose to use the system that we did because we voted as a class and it seemed to be the most successful, it was pretty good size and a nice, simple build, that was not too complicated and actually looked reliable. It was able to successfully pump water through the two sets of pumps and tubes and filter through the rocks, where the plants rested. If we had fixed some of the problems a lot quicker, the hypothesis would have been supported through the results.

We did not get the results we predicted because we thought that the plants would do better in the aquaponics system than the traditional soil method, but when problems with the pumping of water and leaking occurred, it became obvious that the predicted results would not occur.

Conclusion

Things we could improve can be having a larger grow bed for a crop like lettuce, since lettuce needs a lot more horizontal space than vertical space. And in our aquaponics system, it did not seem like there was any flat space for the lettuce to grow out and expand into, so I think that was a problem from the very beginning. The control lettuce grown in the soil, just grew on some flat dirt in a pretty big grow bed. Another improvement to this experiment can be to make sure that there will not be any leaks in the aquaponics system, from tank, grow beds, or vinyl tubing. Because our aquaponics system was leaking water, someone had to go out to water the plants and add back water into the tank, or else the fish and plants would die and that would not be good. One last improvement to this experiment can be being prepared for anything that could happen that could ruin the entire experiment. Always keep backup pumps ready and fresh water on hand for any loss of water that could be an emergency/danger to the fish and plants. During this experiment, one of the pumps on an aquaponics system stopped working and since there were no extra pumps lying around at that time, it had to be fixed instead of replaced. Another aquaponics system had a problem with pumping water up quite far and the distance up was too great for the water-pump to pump water up and out into the aquaponics systems' gutters, where the plants were held.

Here are some very possible applications of aquaponics systems that could be out there in the real world. Using aquaponics we could grow completely organic crops that are not GMOs. They would be completely organic because if you were to add chemicals to the plants to keep insects off it would filter down to the fish, and kill them, but if you were to clean the tank using chemicals that were non-harmful to the fish, then they would likely kill the plants, so to keep them alive you would have to use no chemicals. Using aquaponics we would be able to grow crops with little effort, being all you have to do is feed the fish, and clean the tank every once, and a great while. Another very simple application of aquaponics could be in school, just for students, because it helps them with both using their hands and their heads to get something like this worked out/figured out, planned, and put together. It can help students with responsibility and just how these kinds of things work. It is a great thing to incorporate with schooling, because of those reasons - for education both physically and mentally, which is always good and healthy. Another smart application of aquaponics can be home food production. It is as simple as having the aquaponics system, just having a more focused goal on eating the crops you grow in the system. Instead of making a garden out in the backward, make a neat little system with some tanks of water, fish, and crops. It can lead to a more fun, healthy, educational lifestyle. There are many ways to apply the use of aquaponics in everyday life, from research to medical applications.