Manual for
Building an Aquaponics System
with 55 gallon barrels (Barrel-ponics)

by FoodChain

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A Bit of Background

The first aquaponics system that FoodChain ever built was a small demonstration system, using recycled 55 gallon barrels and locally available materials. This system houses approximately 100 gallons of water that is continuously cycling throughout. Our aquaponics system can be constructed using whatever materials you have access to, and only cost FoodChain roughly $350 to construct in the spring of 2012. Since its construction, we've grown a variety of plants in its grow beds and raised two varieties of fish. Now that it is well established it requires very little maintenance and upkeep is very simple. As more people are interested in getting their feet wet with aquaponics, we believe that this system is both highly adaptable, approachable, and replicable. It is therefore our hope that by putting together this simple manual that we'll be able to encourage others to take the plunge!

So, what is Aquaponics?

Aquaponics is a way of growing both fish and plants symbiotically. As the fish are fed, they naturally produce waste, which over time can become toxic to them. However, this waste is very rich in nitrogen, in the form of ammonia, and plants need nitrogen to grow. The nitrogen of the ammonia is made available to the plants through naturally occurring nitrifying bacteria (the good kind!) that turn the ammonia into nitrate, which works as excellent plant food. Therefore, in an aquaponics system, the fish waste is used as free fertilizer for plants who then absorb the nitrogen from the water, which cleans the water that then goes back to the fish.

Construction

These directions are intended to provide only one way of how such an aquaponics system can be constructed. There are countless variations that can be made, and we encourage you to the make the most of the resources most available in your area. Feel free to experiment to find what works best for you! Also, keep a look out for repurposed or recycled items that can be used, provided that they've been cleaned and didn't previously contain harmful chemicals.

Supplies

From Hardware Store:

- Lumber
    - (2) 8' 2x6 – cut into (6) 30" lengths
    - (2) 8' 2x8 – cut into (6) 30" lengths
    - (4) 10' 2x4 – cut into (4) 64" lengths and (4) 33" lengths
    - (2) 10' 2x4 – cut into (4) 54.5" lengths
    - (2) 8' 1x2 – cut into (4) 48" lengths
- PVC
    - 10' length 1" PVC
    - 3' length of 3" PVC – cut into (2) 18" lengths
    - (4) slip elbows for 1" PVC
    - (1) "T" for 1" PVC
    - (2) endcaps for 1" PVC
- Metal Chain (to support lights)
    - (4) 60" length
    - (2) 12" length

- (4) S-hooks to hold chain

- 300gph Fountain/Water Pump
- 20' ½" flexible tubing (to fit pump)
- Metal clamps to hold tubing to pump and bulkheads
- Duct tape or metal c-clamp

- (2) 48" Florescent Shop Lights with plugs
- (2) cool 48" bulbs
- (2) warm 48" bulbs

- (8) Cinder Blocks
- Twine
- Box 2" Deck Screws
- Power Strip

- Timer for lights

From Hydroponics Store (bolded ones are local)
- Aquarium Aerator (with 4 nozzles)
- (4) air stones
- 20' airline tubing (to fit nozzle on aerator)

- (2) ¾" to ½" tubing barb bulkhead fittings
- (1) Uniseal for 1" PVC

- Aquarium Heater for 100 gallons

Local Supplier
- (4) Cylindrical Blue Tanks - 24" x 36" – 55 gallon capacity (these can be recycled barrels, just be sure they've been cleaned thoroughly and are BLUE. This indicates that they didn't hold chemicals previously and are food grade)

- ¼ cubic yard of expanded shale (sold as Kenlite from many landscaping companies.) Hydroton can be substituted though it's more expensive.

Power Tools:
- Power drill with a hole saw bit of 1.75"and 1.375" and a drill bits of ¼"
- Jigsaw for cutting into plastic barrels

For Maintenance:
- A water test kit for testing pH, ammonia, nitrite and nitrate. We recommend the API Freshwater Master Test Kit.

Directions

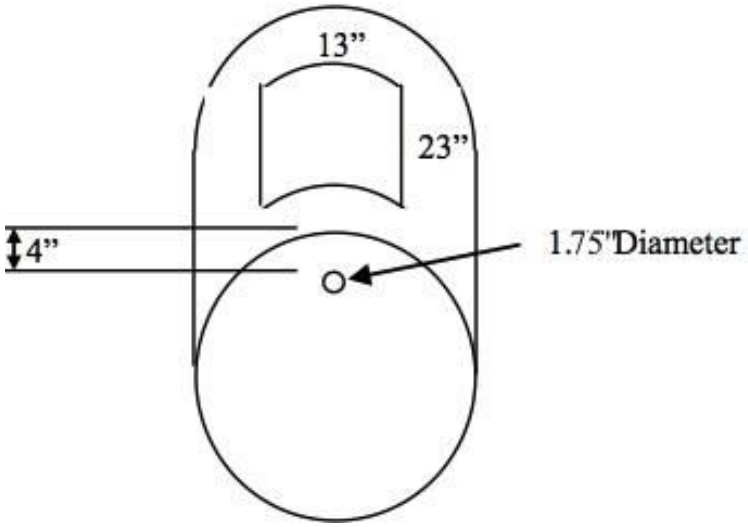
Barrels:

Each of the 4 barrels will serve a different purpose.

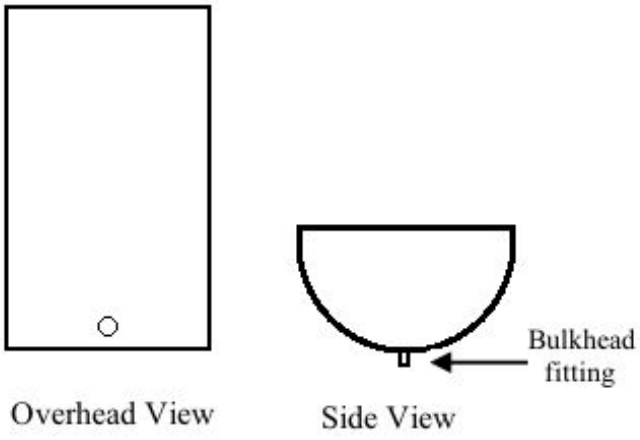
a. Tank 1 will be the fish tank
b. Tank 2 will be the grow beds
c. Tank 3 will be the sump tank
d. Tank 4 will be the extra holding tank

1. Tank 1: You will cut a rectangular hole along the side of this barrel. It should measure approximately 23" in length by 13" in width.

2. Repeat step 1 on Tank 3.



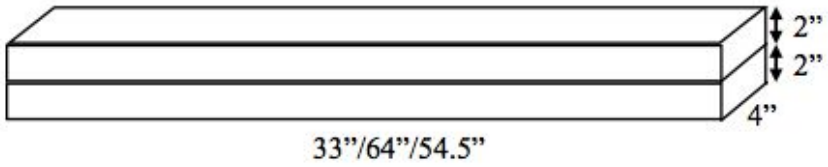
3. Going back to Tank 1, you will need to drill a hole on the circular side of the tank. Use the 1.75" hole saw for this, and cut the hole approximately 4" from the outer lip of the barrel, in line with the rectangular hole already cut.
4. Now slip the 1" Uniseal through this hole.
5. For Tank 1 and Tank 3, you'll want to be sure the bungholes are fully screwed in and plugged, as these tanks will hold water on their sides.
6. For Tank 2, using the seam already in the barrel, cut the barrel in half lengthwise so that you have two half-moon shaped barrels (see images below). Be sure to cut through the two holes on the edges. You will not need the bunghole plugs for this tank.
7. Measuring approximately 1" from the lip of the barrel, drill a 1.375" hole on the bottom of each half tank using the hole saw bit. Thread the barbed bulkhead fitting through this hole and affix it so that ½" barbed fitting is on the outside of the half tank and the inside of the bulkhead is mostly flush with the inside circumference of the half tank.



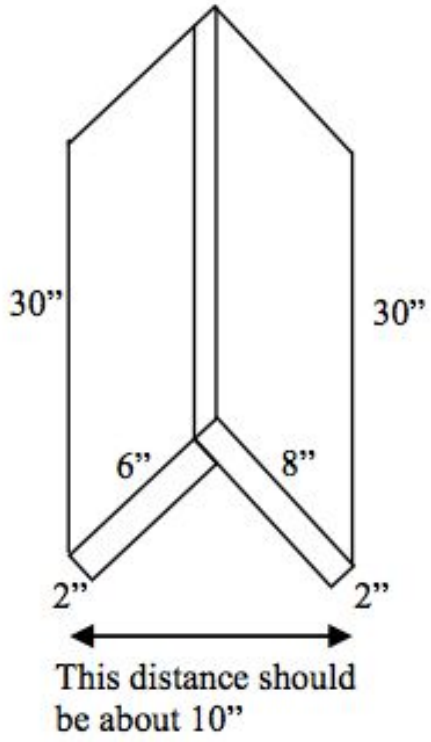
8. Tank 4 simply needs the top removed, which can be done with a jigsaw. It will stand up on its end and hold water to be aerated and added over time to the system to top it off.

Lumber:

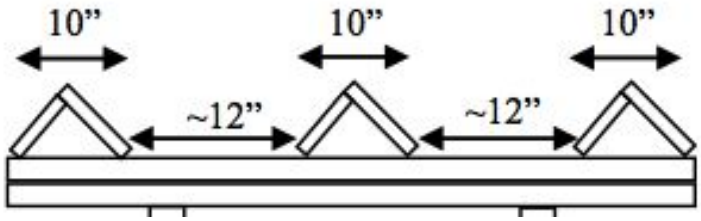
1. Using deck screws, attach one of the 33" 2x4 sections to another 33" 2x4 section to make essentially a 33" long 4x4 (timbers).
2. Repeat this step with the other pairs of lumber to make 2 33" timbers, 2 64" timbers and 2 54.5" timbers.



3. Using a 30” length of the 2x6 and a 30” length of the 2x8, create a “V”. Use deck strews to affix these together by drilling from the 2x8 into the 2x6. Construct 6 of these “V” pieces.

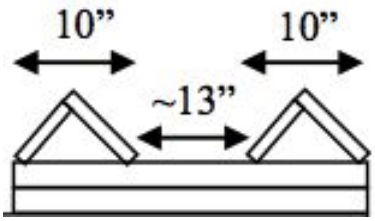


4. Lay out the 2 54.5” timbers so that they run parallel to each other, about 30” apart.
5. Position one “V” on each end, with the V facing downwards and affix them to the 54.5” boards by drilling screws through the outer edge of the V down into the board on both sides.
6. Measure approximately 12” from the inner edge of the one of the outside “V”s to find the placement for the center V. Affix this one in the same fashion.



This is referred to as the Grow Bed Stand

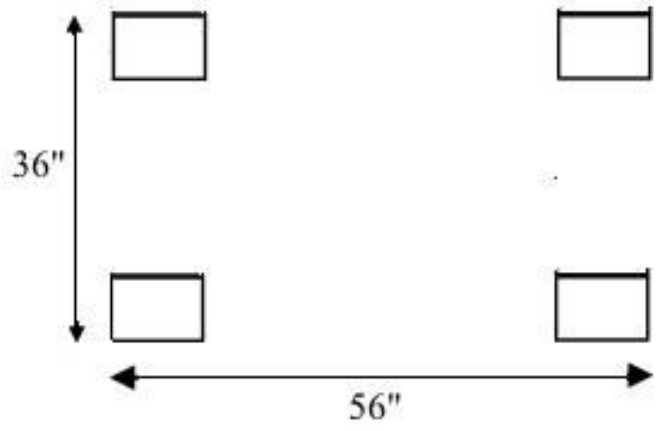
7. Lay out the 2 30” timbers so that they’re parallel to each other, about 30” apart.
8. Position one “V” on each end, with the V facing downwards and affix them to the 54.5” boards by drilling screws through the outer edge of the V down into the board on both sides.



This is referred to as the Fish Tank Stand.

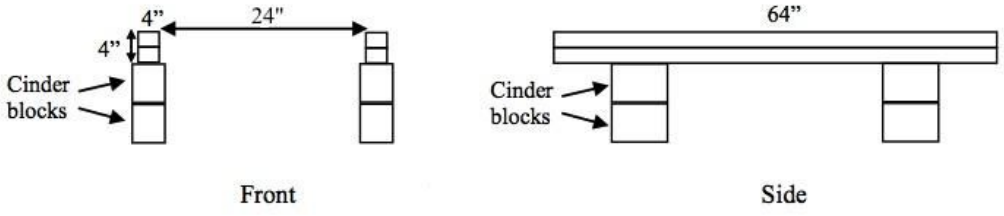
Assembly:

1. Using cinderblocks, make the footprint of the system with a rectangle of 36” x 56”. Use four cinderblocks to mark the corners with the outer edge of each block marking the outer edge of the rectangle. Then place a 2nd cinderblock on top of each corner to make four corners of double-stacked cinderblock columns.

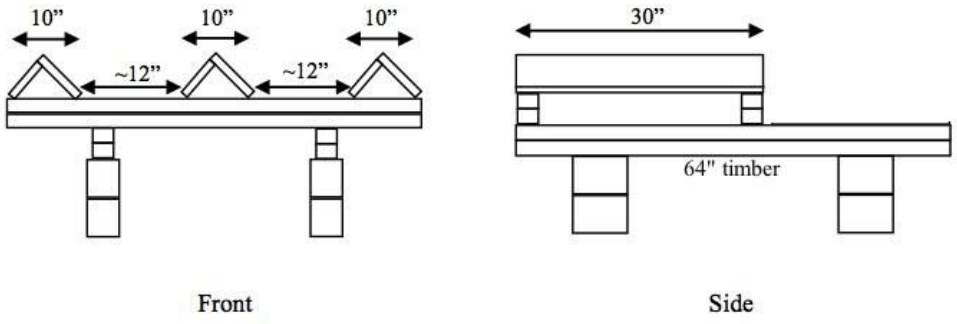


Overhead View

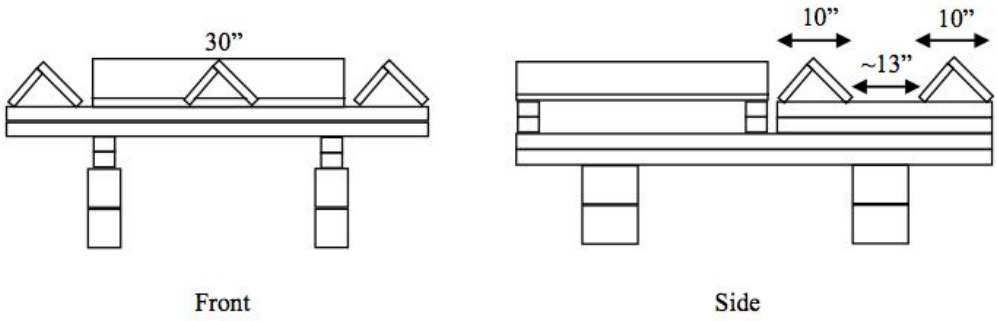
2. Place a 64” timbers on top of two cinderblock columns, which are 56” end to end.



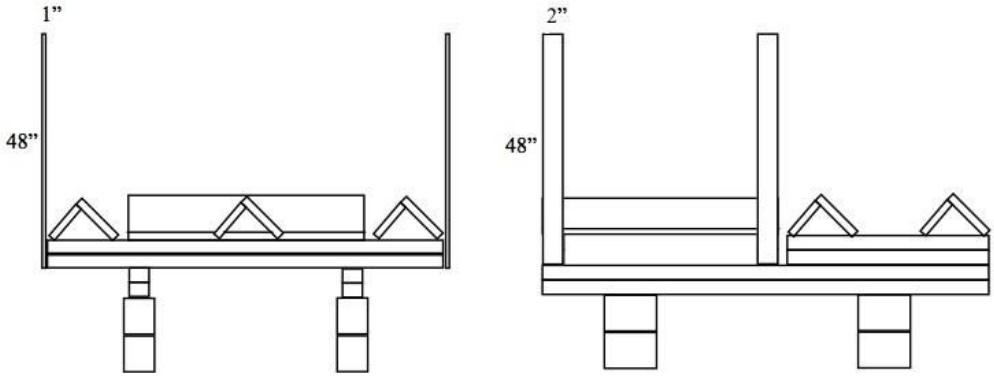
3. Overtop of the 64” timbers, balance the Grow Bed Stand, with the Vs facing towards the front. The edge of the outer V should be flush with the front edge of the 64” timber, putting the Grow Bed Stand towards the front portion of the 64” timbers.



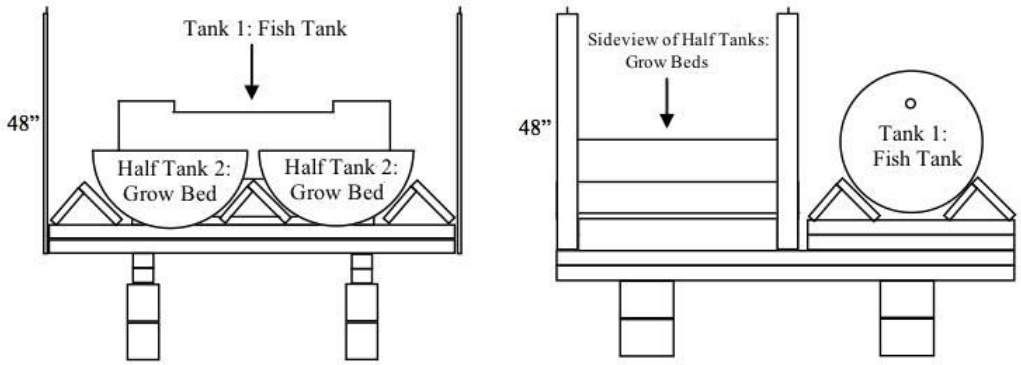
4. Now place the Fish Tank Stand on the back portion of the 64” timbers with the Vs perpendicular to the Vs on the Grow Bed Stand. The edge of the back V should be flush with the back edge of the 64” timbers.



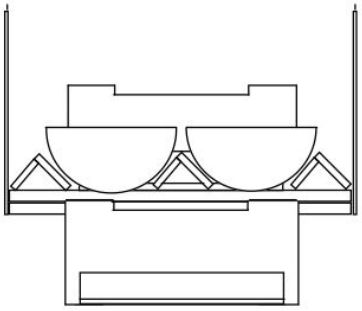
5. Position a 48” length of 1x2 to the corner of the Grow Bed Stand, keeping the bottom of the board flush with the bottom of the 54.5” timber. The 2” width of the board should be along the 30” side of the Grow Bed Stand. Use a deck screw to affix the board in place. Repeat on all 4 corners, similar to a poster bed design.

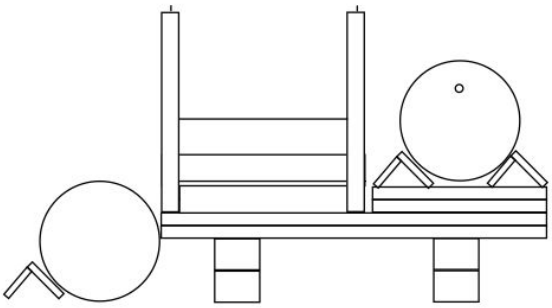


6. Affix a single screw in the top of each of the 1x2 posters with a small length sticking out. Later you will attach chains to hold the lights with these posters by threading a link in the chain over the protruding portion of each screw.
7. It's now time to add the tanks. Place Tank 1 on the Fish Tank Stand with the barrel sides supported by the two downward facing Vs. The Uniseal hole should be at the top of the barrel facing outwards. Place the 2 halves of Tank 2 in the two supports of the Grow Bed Stand, where again the Vs will cradle the barrel sides. The barbed ends of the bulkhead fittings should be pointing down and are closest to the front edge of the system, opposite the Fish Tank.



8. Finally, place Tank 3, with the cut side up, on the floor in front of the Grow Bed Stand, and brace it in place using the final unused V.





Adding the PVC (Carrying the water from the Fish Tank to the Grow Beds and back):

1. Cut a short section of 1" PVC, approximately 3" long. Push this section through the Uniseal in the fish tank so that only about 1" sticks into the tank with the remainder sticking out.
2. Add an "L" connector to the end of this piece so that the next PVC pipe will go straight down along the side of the tank.
3. Cut another piece of PVC approximately 4" long and attached it into the L connector, ending about midway down the height of the fish tank.
4. Add another "L" connector to the end of this piece to change the direction to head towards the Grow Beds.
5. Cut a 4" section of PVC to slip into the L connector and travel beyond the edge of the fish tank.
6. Add another "L" connector to the end of this piece to change the direction to wrap around the midsection of the tank. This will make the next piece of PVC travel along the length of the Fish Tank.
7. Cut a 16" length of PVC and fit it into the L connector. This piece should end roughly near the midpoint of the long dimension of the fish tank.
8. Add a final "L" connector to the end of the PVC to change the director to point away from the Fish Tank and towards the Grow Beds.
9. Cut a final 4" section of PVC and slip it into the L. It should end over the Grow Beds, running between the two halves.
10. Add a "T" connector to the end of the pipe to split the flow between the two Grow Beds. If necessary, add a short section of PVC to each side of the T so that the water flows into the Grow Beds, rather than in the crack between the two halves.

Adding the Siphons (Carrying the water from the Grow Beds to the Sump Tank):

1. Using a ¼" drill bit, drill a hole into the end wall of each Grow Bed Half Tank near the upper edge. This should be on the same side near the bulkhead fitting sticking out of the bottom.
2. Affix a 24" section of ½" black vinyl tubing onto the barb end of the bulkhead fitting in the Grow Bed Half Tank. If needed, you can use a metal clamp to secure this tubing on so that it doesn't leak from the barbed fitting.
3. Thread a 12" section of twine through the ¼" hole at the top of the Half Tank.

4. Twist the vinyl tube into a loop so that the other end of the tube ends overtop of the Sump Tank below. Hold it in place by looping the string through the highest point of the tube and tying it in a knot. The highest part of the tube should be approximately 2" from the top lip of the Half Tank, and this will be the high water mark of the Grow Beds.
5. Repeat steps 1-4 on the other Half Tank.

Installing the Pump

1. Using a metal clamp, affix the end of the remaining black vinyl tubing to the outflow of the water pump.
2. Place the pump in the bottom of the Sump Tank.
3. Snake the tubing along the outside of the Sump Tanks and Grow Beds and up the side of the Fish Tank so that it ends up at the opening in the fish tank. This will return the water from the Sump Tank back to the Fish Tank.
4. Affix the tubing to the Fish Tank either with duct tape or a metal C- clamp.

Final Touches

1. Using one of the 18" lengths of 3" diameter PVC, center it around the hole in the Grow Bed that leads to the bulkhead fitting and the loop siphon.
2. Holding this pipe in place, fill the bed with either expanded shale or Hydroton grow medium until it is 1" below the rim of the half tank.
3. Repeat steps 1 and 2 for the second Grow Bed.
4. Install the Heater so that it rests in the Fish Tank. This can be dangled into the fish tank through the opening on the top.
5. Run two lengths of airline tubing with air stones from the Air Pump to the Fish Tank. This will provide the necessary oxygen to your fish.
6. Run two more lengths of airline tubing with air stones from the Air Pump to the Holding Tank (Tank 4). This aeration will help dissipate the chlorine from the tap water.

Congratulations! You've now assembled your Aquaponics System and you're ready to begin operations!

Operations

Adding the Water

For a healthy aquaponics system you need a supply of fresh, clean water with NO CHLORINE! Typically city water is treated with either chlorine or chloramine to keep it from growing bacteria, and you'll need to dissipate that chlorine before adding living organisms to your system. We recommend doing this by aeration and movement. Now's the time when you'll add the bulk of the water to your system. Add water to the Sump Tank first and after the water level is above the pump, you can turn on the pump to send water up into the Fish Tank while you continue to add water to the Sump Tank. Keep adding water until the Fish Tank is fully filled and begins overflowing through the pipe into the Grow Beds. You can continue to add water to the Sump as the Grow Beds fill, until either the siphons trigger on or until you've filled the Sump Tank 2/3rds full. In total you should add about 100 gallons of water to the system.

Once all the water is added, you want to be sure to check for leaks and that everything is running as it should. The pump in the Sump Tank should never get close to running dry. If you find this happening, you need to add more water to the system. Also, this is the time to check that your loop siphons in each Grow Bed work. Each Grow Bed should fill with water to about 2" below the rim, when it will then begin trickling out of the loop siphon. As more water pressure builds it will eventually force all the air out of the tube and create a siphon that drains the water

in the Grow Bed faster than it is filling from the Fish Tank. When it has drained to the bottom of the Grow Bed, the siphon will make a sucking noise until the siphon breaks, once again filling with air and the water will stop flowing until it triggers on again when the bed is filled with water. This creates a natural "ebb and flow" pattern in the Grow Beds, which will provide the plant roots with alternating access to nutrient rich water and oxygen.

After you've ensured there are no leaks and the siphons are functioning correctly, let the water run throughout the system for at least 4 days. This will eliminate all the chlorine. It can be confirmed with an aquarium chlorine test if needed. During this time you can also switch on the heater and the aerator to begin preparing the water for the fish.

Next Comes Fish

Once you've confirmed there's no chlorine in your system you can add your fish. We recommend tilapia as these do very well in reciruculating systems and are very hardy. As they are tropical fish, though, they'll need a water temperature of at least 75 degrees F so be certain your heater has been on. If you chose a different fish, check to ensure your water temperature meets their specific needs. You'll also want to check the pH of the water to ensure it is in a range appropriate for your fish. Tilapia tolerate a wide range of pH, but ideally between 6.5 – 8.

There is no magic number of fish to add, though we recommend starting with 6-8 small fingerlings, around 4" in size. If your fish are smaller you can add more. You won't be operating your system at its limits so as long as you don't overcrowd it, it should be fine. The feed rate is actually what will determine your plant growth, not the number of fish.

Once your fish are added, ensure they have enough oxygen. You can do this visually by ensuring that they don't "gasp" at the surface. If you have access to it, you can also use a Dissolved Oxygen (DO) meter, where you want a reading of at least 4 mg/L.

Finally, you'll want to get a basic fish feed. The tilapia will eat as much as they're given, but ideally you'll feed them 1 or 2 times per day for about 10 minutes at a time until they stop eating the feed.

Next Comes Waiting….and Water Testing

The next phase is called cycling and you're essentially waiting for the nitrifying bacteria to show up. These naturally occurring bacteria will essentially "unlock" the nitrogen from the fish waste (ammonia) to make it available to the plants first in the form of nitrite and then nitrate. Before these bacteria colonize though, you aren't ready to add plants since they won't have any food. This is very vulnerable time for

the fish, too, since they won't have the filtration of the plants and bacteria to remove their ammonia waste and therefore they need to be fed sparingly. Too much feed will cause them to be sick and potentially die.

During this time you'll also get comfortable with your water testing kit. Every day you'll test the pH, along with the levels of ammonia, nitrite and nitrate.

pH: You just want to ensure that your water pH doesn't change radically. Ideally, the system will hold around 6.8, but an established system could drop in pH. In this first stage of operations, you'll likely hold fairly steady.

Ammonia: This is fish waste. Therefore, once you add your fish, you'll begin to see rising levels of ammonia. Ammonia is toxic to fish, though, so if it rises too high, you want to cut back on feed or hold off feeding them entirely for a few days. (This won't hurt the fish, but rather they'll simply slow down their metabolism.)

Nitrite: This is the fist sign to show your bacteria are colonizing. The first wave of bacteria will begin to convert the ammonia to nitrite so once you see this show up, you should notice a corresponding drop in ammonia. You're well on your way now!

Nitrate: This is plant food and also the final product from the bacteria. The second wave of bacteria converts the nitrite to nitrate. Therefore, as you see the nitrate levels appear, you should see diminishing nitrite levels. By this point the ammonia levels should be close to zero. After a few more days, the nitrite levels will also drop to near zero and all the fish waste will be available as nitrate for your plants.

Once your water tests show low to no ammonia and nitrite but measureable levels of nitrate, you've got a fully cycled system and you're ready to add plants! You can also now feed your fish more aggressively!

Adding Plants

You can either add seeds directly to your Grow Beds or seedlings. If you use seedlings you can "rinse" the dirt off the roots so they're planted bare roots. Just be sure you plant them low enough so that they get moist from the rising water (but not washed away if using seeds). Seedlings are easier as they're already established. You can arrange them in whatever pattern you'd like, but be mindful of where your grow lights cast light. Good plants include herbs like mint and lettuces. Experiment to what grows best in your system though. (Be sure to plug your lights on once the plants are added, and if you want, put them on a timer to give the plants up to 6 hours of darkness at night).

And you're DONE! You've now got a fully functioning Indoor Aquaponics System!

Maintenance and Troubleshooting

Maintaining your Aquaponics system is a relatively simple process, it just needs a watchful eye.

1. Fish: You'll want to feed your fish each day (can be up to 3 times a day for maximum growth). They'll tell you when they're full. If after 30 min there is still food in the tank you can feed less next time. If it's all gone within the first 5 minutes or so you can feed more.
2. Plants: Keep an eye to see that the plants are growing and when things look read feel free to begin harvest!
3. Water Quality: Continue to monitor your pH, ammonia and nitrate levels. Ammonia should stay close to zero and nitrates can rise to as much as 100ppm, though between 30-60 is better. The pH should hover around 6.8 and within the range of (6.5 – 7.2).

Still have questions? Here are some common questions and hints.

About the Fish

1. *My fish seem to be "gasping" a lot at the top of the tank, is this normal*?

Yes and No. Fish that come up for air and "gasp" at the top of the tank do so because the water does not contain a sufficient amount of oxygen for them to be comfortable. You can find this out by using a Dissolved Oxygen (DO) meter; you want a reading of at least 4 mg/L. This however is most likely due to your air pump, so you should check to make sure that it is working properly and bubbles are rising from the air stone. A simple fix might be to add an additional air stone or a stronger pump.

2. *My fish keep dying, but I'm feeding them regularly, what's going on?*

With this, any number of things could be happening. The most likely situation is that the ammonia that the fish are producing is not being cycled properly into the rest of the system and is polluting the holding tank. Check this by using a water test kit for testing pH, ammonia, nitrite and nitrate. We recommend the API Freshwater Master Test Kit. If there is too much ammonia in the water, you can lessen the strain on the fish by simply replacing some of the water with new dechlorinated water. However, this issue is probably caused by either a blockage in the system, or with the bacteria dying off. For a short term solution stop feeding the fish (don't worry they won't die, but they wills top pooping which should allow your bacteria time to catch up). When the levels drop again to zero or close you can resume feeding but just do less.

3. *I put feed into the tank, but my fish don't seem to be eating. Is this normal?*

Fish have a tendency to be very shy when it comes to eating, and they may simply be waiting for you to leave. One thing you may check is the water temperature, as fish may not be likely to eat when they're cold. Always try to keep your temperature just above 75 to make the atmosphere as comfortable as possible for the fish. Oddly enough, the size of the feed may also be in question. Compare the size of the feed to the mouth of one of your fishes. Fish do not have teeth, and must therefore be able to gulp entire pellets of feed. Often if feed is too big for them they will wait and allow it to dissolve in the water before they attempt to eat.

About the Plants

1. *How long can I expect until I see my plants start growing?*

Every plant is different, and will grow at different rates. For example, herbs will grow much quicker than a tomato plant. However, if you are working from seedlings, it will generally take about two weeks for a plant to get fully acclimated to a system and to start growing new sprouts. Naturally, if you began with seeds, the process will take longer. Don't despair though, as with all manner of growing, patience is key.

2. *I'm getting a lot of yellowing leaves from my plants, is this normal?*

Yellowing leaves simply mean that the plant is not healthy, and could be caused by any number of things. First, check to make sure they are getting enough light. You do not want your grow lights high above the plants. Have your grow lights a few inches above your tallest plant. Check the water levels as well to make sure you have enough nitrate (plant food). If your system has been running for a while, you may be running low on iron. In our system, when needed, we supplement our plants by adding some chelated iron (we recommend Grow More Organic Iron Chelate

Concentrate, available on Amazon). We add it directly to the sump tank. Look online for more details on this procedure and amounts.

3. *I'm noticing some insects in my system, what do I do with them?*

The most important thing to note here is not to use any form of insecticide. The ingredients in insecticides will immediately kill all the bacteria in the system, which will severely cripple it, as well as your fish. The best thing to do is to either physically remove the bugs, or to place sticky yellow traps around the edges of the system. You can prevent insects by removing sick or dead leaves and plants from the tank, and cleaning out any accumulated dead plant material.

About the System Water

1. *How frequently do I need to do water quality testing?*

Ideally everyday. This will ensure nothing happens suddenly. With only 100 gallons of water in your system, things can change quickly!

2. *There seem to be some sort of solid accumulating at the bottom of my fish tank, is this normal?*

Yes, it's normal, but it's not ideal. The solids can get stirred up in the water and eventually hurt the fish as they break down into ammonia. The best way to clean these solids out is to buy an Aquarium Vacuum at the local pet store (it's a simple siphon) and siphon off any solid fish waste or uneaten food you see that accumulate.

3. *According to my meters, my pH levels are getting really low, what can I do to fix them?*

First this is a good thing and means your bacteria are healthy! The best and most efficient way to push your pH level back up is to add Calcium Hydroxide (available at most hardware stores as a garden amendment) into the sump tank so that it may be slowly funneled through to the rest of the system. Look online for more details on this procedure and amounts.

4. *I've recently had a huge spike in ammonia, what's going on?*

A big spike in ammonia could result in the death of a lot of fish so you want to take it seriously. You may already have a dead fish in the system, which is breaking down already. (Note: not all fish float when they die, some sink, so be sure to dredge the bottom of the holding tank from time to time) Our recommendation is to stop feeding immediately (fish can go a few days without being fed), check to make sure you don't have large amounts of solids in the bottom of the fish tank or a dead fish and let your bacteria convert the surplus ammonia to nitrate. If that doesn't work and the ammonia is still high after a few days you may need to resort to a water exchange with chlorine free water. This is the last resort though.

5. *My power has gone out, what do I do?*

The plants can go some time without receiving light, but the most important electrical aspect of the system is the Air Pump. Without it the fish may not receive enough oxygen and could quickly die. If you have a means to provide electricity to the system via generator, first get the air pump back on, the rest can then follow.

Other

If you do not see your question on this list, there are obviously a lot of other resources for assistance. The internet has hundreds of pages for reference and many forums. Also, your local County Extension Agent may be able to help with plant questions.