Aquaponics Common Sense Guide

Table of Contents

Preface

This document contains valuable and time saving knowledge for aquaponics newbies (noobs). It was written by an amateur enthusiast much like you. I am an information junkie when I get into a new hobby which has led me to this document and since others shared this information with me piece by piece, I decided to share it with you in one lump sum to save you the time it takes to gather this much knowledge about aquaponics. This is a compilation of many, many hours of reading online forums, digging through internet websites, and initial startup of a small aquaponics system. Other practicing aquaponic enthusiasts, who have operated systems for years, have reviewed this document for accuracy and contributed as well. Many thanks go out to them and everyone else who has shared their experiences, questions, and answers in the forums and blogs. This is not a complete guide of all topics or newer methods but a really good introduction and overview of system parts, construction, and uses of different components to aide you getting started and some operating assistance. Adapt these suggestions for system design to your budget and size requirements.

There is a lot of information in this document but once you learn the basics, an aquaponics system is easier to maintain. Also included is a basic troubleshooting section that is by no means a complete list of all problems or all solutions. Resource website links provided in this document were what the author found at the time of writing and gives many thanks to the companies supporting fish and plants! Print this out and have it nearby your system for those troubleshooting times you may need it and add your own notes as you learn more in your own research.

Also please contribute to online aquaponics forums as much as you read them. Post the good and the bad learning experiences for others who may not have made it to that point yet. Thank you and enjoy!

Aquaponics Introduction

*Hydroponic*s is agriculture with other growing medium besides soil. *Aquaculture* is fish farming without plants. Aquaponics is a symbiotic combination of the two.

S & S Aqua Farm pioneered the aquaponics system as we all know it today. Please visit them at: http://www.jaggartech.com/snsaqua/page2.htm

In an aquaponics system, fish eat food and produce waste (mainly ammonia). Ammonia is hazardous to fish, even in small quantities (.04 mg/l) and toxicity increases in relation to pH and temperature. Ammonia (NH_3) is food for beneficial bacteria (Nitrosomonas) which turns it into nitrite (NO_2) waste and then another type of beneficial bacteria (Nitrobacter) turns the nitrite into nitrate (NO_3) waste. Nitrate is less harmful to fish. The nitrate, phosphorous, and potassium are food for plants/algae which remove these from the water the fish live in. This is known as the "Nitrogen Cycle". When the system is in balance, the water will be crystal clear and ammonia and nitrite levels will be zero. Short videos reiterating this are at: http://www.youtube.com/watch?v=bCV7DABEz20&feature=related

Aquaponics is based on the common belief of an organic production of plants and fish. Fish production using aquaponics regularly uses Tilapia, Bluegill, and Catfish. Other common fish that are used in an aquaponics environment, but not necessarily for fish production, are carp/goldfish, perch, trout, silvers, jades, and bass. All fish, including goldfish and tropical fish, are okay to use for plant and vegetable production, even in small tanks. Ensure that the fish can tolerate your environment. Plant production varies with the amount of food the fish are able to consume, thereby generating waste as food for the beneficial bacteria and plants. People also use other freshwater animals such as crayfish (crawfish, crawdads, marron), prawn, and mussels. Aquaponics systems range in size from small converted aquariums to large commercial operations producing plants and fish for sale to restaurants and consumers.

Internet Discussion Forums

The internet is a great source of knowledge for system building and operation. Listed below are a few of the more popular websites. There are many more you can find. You are encouraged to find a forum that appeals to your type of system and possibly geographic location, and then inquire the members of that forum for additional help and assistance. It is best to consult aquaponic forums online first for basic plant and animal questions before asking employees at your local nursery landscaping supply and pet stores, as they may not understand the needs of an aquaponic system. Common forum abbreviations:

AP = aquaponics	CHIFT PIST = Constant Height In Fish Tank, Pump In Sump Tank
GB = grow bed	ppt = parts per thousand
FT = fish tank	ppm = parts per million
DO = dissolved oxygen	+1 = I agree with what someone else posted.

http://tech.groups.yahoo.com/group/barrelponics (they have a complete how-to-build guide with parts list)
http://www.backyardaquaponics.com/forum
http://www.aquaponicshq.com/forums

Information Websites (as of 2009)

This is a small list of known websites that contain relevant information on aquaponics. You Tube and Google Video are great places to see videos of real aquaponic systems in action.

Aquarticles.com	http://aquarticles.com
Aquaponics Journal	http://www.aquaponicsjournal.com/articles.htm
Aquaculture Network Information Center	http://www.aquanic.org/index.htm
You Tube	http://www.youtube.com/results?search_query=aquaponics
Google Video	http://video.google.com/videosearch?q=aquaponics#

Basic Aquaponics Setup

A basic aquaponics system consists of a fish tank with fish, a grow bed with plants, and a water pump. Also commonly used are air pumps and additional bio/mechanical filtration components. Aquaponics ecosystems must have the proper balance to maintain healthy fish and plants.

In the picture to the right, panels on top help shade plants in the grow bed from the heat of the day. Shade cloth is also commonly used to shade the fish tank and to protect the fish from predators and to prevent fish from jumping out.

Picture link URL: http://backyardaquaponics.com/forum/viewtopic.php?f=18&t=5417&p=193545#p193545

System Types of Aquaponics (from simple to complex)

Type 1: few thousand gallons hole in the ground "tank" out on a farm ranch, no pumps
Type 2: small home aquarium with floating plants
Type 3: fish tank, grow beds and combined/separate biological/mechanical filter.

The most simple of systems is a ranch tank, also known as green pond agriculture. Algae is the main plant in this type of system. Some fish will eat algae as well as smaller fish and insects and bugs that get into the tank. Rain helps aeration of the water. Wind and wild animal activity prevent stagnant water. These are usually lightly stocked to achieve system balance. Plants are not usually harvested from this type of system.

The second type of system is a home fish aquarium with floating oxygen creating plants such as floating water lettuce or other plants on something buoyant (Styrofoam) with the roots reaching down into the water.

The third type of system is a system with a water pump that pumps water from the fish tank up in altitude to a biological/mechanical filters and/or sump/flood tank and/or grow beds where the water gets filtered through beneficial bacteria and plants and gravity brings the water back down into the fish tank. If a sump tank is used, then the sump tank can be setup to have the fluctuating water levels and allow a constant height in fish tank (CHIFT). The order and placement of pumping and gravity returns can be altered to fit a particular system. This activity can be continuous or intermittent. This guide mainly discusses the setup of the third type of system using freshwater. Saltwater aquaponics systems do exist with seaweed/kelp as plants.

In this third type of system, water is run through it using one of multiple methods. Consult with others on which method is best for you and your system design. Other aquaponics articles online will go into more detailed depth about each method and how to make each method work successfully. Word of advice: always put in emergency overflows that will drain excess water back to the fish tank should your primary drain fail. Check online forums for developments of sequencers to cycle one drain into multiple grow beds.

Intermittent Flow

Intermittent Flow is generally used with a water pump on a timer that pumps once per hour. The water is pumped into the grow beds and drains out permanent drain holes and back to the fish tank.

Continuous Flow / Nutrient Film Technique (NFT)

Continuous Flow or Nutrient Film Technique is where the water pump runs continuously pumping water through the entire system. This is the simplest to build but is susceptible to root rot due to lack of enough oxygen reaching the roots. Plant production is normally limited to lettuce and other plants that can sustain growing in constant water.

Raft systems generally consist of Styrofoam floated directly over the fish tank. Plant roots grow in holes down to the water. Sometimes the plant roots are suspended within grow media inside "net pots" that dip down into the water either in the fish tank itself or in a contained water flow channel. Some large scale production has been known to use this method.

Ebb and Flow (Flood and Drain)

Ebb and Flow is where the water is periodically pumped through the system either by means of a timer on the water pump (and drain holes in the grow beds) or where the water pump runs continuously and floods and drains out of the grow beds by means of an automated drain or surge device. Oxygen is allowed to get to the plant roots when the water is drained. Draining water into

the fish tank also provides extra oxygen getting mixed in with the returning water. Flood and drain times vary between setups. Allow some drying time to prevent root rot but not enough that the roots dry out completely. There is no magic length of fill and drain times.

Ebb and Flow is the method most frequently used. Different outlet methods have been developed. Be forewarned that autosiphons are very finicky about the amount and flow rate of water coming in as to the siphon type and siphon pipe/tubing sizes. For a siphon to stop draining, it must suck in enough air to break the water tension. Water throughput can be adjusted by use of ball valves in-line with the tubing/piping. Some drainage methods work better than others for slow water throughput; these are the Barrel-Ponics System method and pivot outlet. If water intakes or drains are used in the fish tank, protect the fish from getting sucked into them or being able to swim into them.

Barrel-Ponics System

In the Barrel-Ponics system invented by Travis W. Hughey (some systems have flood tanks with volumes of over 700 gallons) a toilet flush valve is mounted in the bottom of the flood tank assembly. When the water reaches the preset height (volume) in the flood tank a small siphon begins filling a counterweight attached to the flapper valve. As the counterweight fills and gets heavy enough to overcome the pressure and weight of the water, the valve is pulled open allowing the contents of the flood tank to empty into the grow beds. When the water column is low enough to cease the small siphon, the counterweight begins to empty through a small hole in the bottom of the counterweight. When the counterweight gets light enough the toilet valve closes and the cycle repeats. Water volume is controlled by the height at which the small siphon begins and cycle time is controlled by adjusting the inflow from the fish tank. This system allows very low flow rates to operate large volumes of water comparatively for grow bed flood and drain cycles. A free step by step guide to building this type of system can be found at http://www.fastonline.org/content/view/15/29/

Pivot Outlet

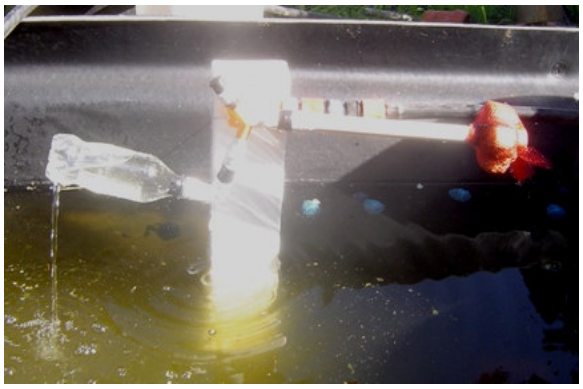
Inner Container Pivot Outlet

An inner container pivot outlet is also known as a floating outlet. A production unit (not the sample pictured here) known as the "Flout®" by Rissy Plastics can be found at http://www.flout.net. It looks like a bendy straw with a partially open box on the inside end. The outlet end is outside the container piped through. The water inlet end is inside the container laying flat on the bottom. The interior end opening is inside an open "cup" structure that acts as a float. As water rises in the container, the interior end pivots up due to the float. Once the floated end is at its maximum height, water will rise a little more and enter the open box and continue filling until it enters the piping exit hole which is at least midway high in the box and

begins the draining out the other end. As this action takes place, additional water now in the box helps sink that end down until all the water has drained, including most of the water that helped initially sink the box. It is important that all the air inside the box escapes as it sinks or it may not sink all the way, extra weight may also help it sink. When the box has most of the water out of it again, it can begin to float again and the cycle starts over. Picture link URL:
http://www.backyardaquaponics.com/forum/viewtopic.php?f=8&t=1468&hilit=flout

Outer Container Pivot Outlet

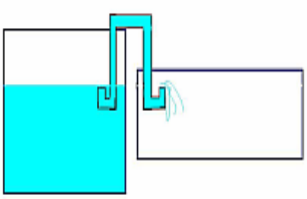
An outer container pivot outlet is designed similar to a bamboo pivot water feature (aka: deer scarer). The pipe is kept at a slant by use of a rotating stop and counterbalance weight on the other end. Water enters the pipe (generally at the pivot point) and fills the angled pipe. Once the water reaches high enough in the pipe so that the weight of the water overcomes the weight balance on the other end, it dips down and drains the water thereby starting the draining action. The upper water collecting side should be sealed except for one drainage hole that the water will flow out of once it has pivoted downward. The hole should be located in a position so that air is not allowed to enter until the siphoning action has completed, thus keeping extra water at the draining end which keeps it weighted (and in the down position) until it has completed draining. Putting larger containers on the ends of the pipe for water accumulation and counter balance weight make it easier to match the weights so the unit works more effectively. If the water accumulation end can not stay downward until the cycle is complete, the pivot will develop into a pattern seesaw action that is fun to watch. Picture link URL:
http://www.backyardaquaponics.com/forum/viewtopic.php?f=18&t=1639&st=0&sk=t&sd=a&start=90



Siphon Types (autosiphon)

Siphon types are J-bend, loop siphon, bell siphon and pivot siphon. People use all types and generally prefer one over the other but it depends on their individual experience as to which one they prefer. A good rule of thumb in plumbing these is to use the same size tubing, or one size larger, than your water pump uses. The maximum height of water in siphons will match the maximum height of water in the container so you need to adjust your siphon size and position accordingly so it works at the proper water level. Another important item to note is that if siphons trap air at the top of them, they may not function properly so it is best if they are tube shaped.

J – Bend (Carlson surge device) / U-Bend



A J-Bend it is a tube bent like the letter “J” and used upside down. The long end is the drainage outlet end. The short end is where the water will enter and seal off the opening. Once the water level is high enough to cover the top of the upside down “J”, the siphon is started. These are used inside the container with the long end

protruding through the container. A small U-Bend water trap at the bottom of the outlet pipe may be helpful if difficulties arise using this type of siphon. Picture link URL: http://www.backyardaquaponics.com/forum/viewtopic.php?f=8&t=4086

No Holes Overflow

Three U-Bends are assembled together to create a siphon-activated raised tank "no holes overflow" to transfer water outside a container without drilling holes through it and without spilling over the top of the container. It must be primed with water to remove all internal air and both ends at the same height to prevent air leaking in. **WARNING:** No holes overflows must be checked regularly to ensure no air has accumulated inside the top of them preventing normal operation. This is not normally visible when it happens.

An "overflow box" is an upside down U-Bend/U-Tube with both ends in separate boxes and works on the same principal. Search the internet for pictures and explanations of possible failures for this device.

Loop Siphon

A loop siphon is a loop of tubing with the outlet end usually pointed down. The open input end is where the water will enter and seal off the opening. Once the water level reaches the height of the top of the loop, it starts to push air and water down the output side which engages the siphon affect. It works the same way as a J-Bend but the tubing forms a complete circle. A loop siphon can be used inside and outside the container. Picture link URL: http://synaptoman.files.wordpress.com/2008/01/siphon-loop1.jpg?w=519&h=392

Bell Siphon

A bell siphon consists of an open vertical standpipe for the water to drain into. Ideally, this pipe should be straight with both ends open. Around it is another pipe with crenellations (holes/slits) for water flow at the bottom and an air tight cap on top that allows the creation of a water vortex once the water reaches the top of the inner standpipe. This outer pipe is called the siphon pipe and sits over the standpipe by use of gravity. Ensure the siphon pipe cap is not sealing off the top open part of the standpipe. It is better to have too tall of a siphon pipe than one that is too short. One bottom crenellation slightly higher than the rest can also act as an air break.

Some people use an alternate air break with a small air hole near the top of the siphon pipe with an air tube that runs down to just above the crenellations of the siphon pipe. This air tube helps break the siphon once the water level drops back down. This helps conquer siphon pipe size/crenellation problems since the air tubing creates a horizontal air hole inlet. Picture link URL: http://www.aquaponicshq.com/forums/showthread.php?t=582&highlight=bell+siphon&page=4

Aquaculture Permits

Aquaculture permits may need to be obtained depending on where you live. Respect local laws governing wildlife breeding and containment. The laws were put in place mainly due to very harsh effects to the ecosystem when certain wildlife was released and mixed into an area that could not adapt to it immediately. Even if you plan to keep an enclosed system, there may be laws governing species restricted from your area.

If you decide to get out of the hobby of wildlife containment, please call the local wildlife authority and ask them where it is safe to release your species of animals. They will be happy to help you do the right thing for all of us. **Do NOT ever release animals from a contained environment into the wild without the approval of wildlife experts.** Our planet does not need a horrible chain reaction to occur.

Email or call your local state wildlife authorities and ask them if there are any fees for operating an aquaponics system on your property and where to find regulations. They will be happy to tell you, it makes their job easier if you follow the rules sooner. Research the natural habitat of any fish and other animals you intend to utilize to ensure you can provide a legal and adequate healthy living environment.

Some example governmental regulations (Check similar regulations in your own area):

United States, Texas aquaculture permit (in 2009) may be $250 USD and $350.00 USD for an Exotic Permit for most Tilapia although Mozambique Tilapia is the only species of Tilapia that is legal to stock in private impoundments in Texas without a permit.

In Texas it is legal to use caught fish from public waters with regular fishing permit regulations. Check the Texas Aquaculture Association for an approved fish list and supplies list if you plan to sell fish. There are usually more regulations to abide by if you intend to sell wildlife.

Texas Parks and Wildlife Recreational Fishing Regulations
http://www.tpwd.state.tx.us/publications/annual/fish/

Texas Aquaculture Association
http://www.texasaquaculture.org/id236.htm

In the online forums in February 2009, somebody posted that Oklahoma, USA requires an annual $10 USD fee for raising non-commercial fish on private property.

Following quoted for Alabama, USA on 2009-03-04 from: http://www.outdooralabama.com/Fishing/freshwater/regulations/unlawful-stockings.cfm. “It shall be unlawful to intentionally stock or release any fish, mussel, snail, crayfish or their embryos including bait fish into the public waters of Alabama under the jurisdiction of the Division of Wildlife and Freshwater Fisheries as provided in Rule 220-2-.42 except those waters from which it came without the written permission of a designated employee of the Department of Conservation and Natural Resources authorized by the Director of the Division of Wildlife and Freshwater Fisheries to issue such permit. The provisions of this rule shall not apply to the incidental release of bait into the water during the normal process of fishing.“

System Parts

Only use food grade plastics and materials normally used for potable water such as Rubbermaid, Behlen/Farmaster and PVC. Some plastics will degrade from weather and break down or leak chemicals into your system. Do not use copper or other metals for parts the fish and water will be in contact with.

Many people use recycled items for the system parts. Refrain from using materials that had previous chemical use or where the previous use is unknown. Caution that even marine grade paint and galvanized materials could be potential for chemical and metal leakage into your system. When in doubt it is best to use an approved liner.

Each aquaponics system will not use all the parts listed here but they were all included for a more complete listing of what is being utilized. Use dark colored materials to prevent as much light as possible from getting to the water as algae needs light. Unless your specific species of fish eats algae, it is not preferred. There are different types of algae and the fish may or may not eat the types your system has.

auto feeder	Remember your fish when you go out of town! Search the internet for koi feeder.
autosiphon	Not normally available for purchase. You have to make these yourself to fit your system.
bacteria	Free! These already exist in surface water, soil, and air. If you build it, they will come. They take time to multiply but they will. Use some water from a local river, lake, or established fish aquarium to get a starting boost. You can also get a starting boost from urine (contains urea) but please do not use this method if you are on medication or caffeine. It is also available at the pet store. Note that chlorine and chloramine (even in tap water) will kill beneficial bacteria.
batteries	Battery backups in case of power outages. If you have to go cheap, concentrate on aeration.
biological filter media	This is for the beneficial bacteria. Beneficial bacteria need all the surface area you can provide. Most used: lavarock(scoria), hydroton, Bio-Balls, clay balls, Springflo, gravel, bedrock If filter media will double as grow media, it will need to be able to support the plant weight. Note: Limestone gravel will generally buffer water over pH7.5 which may slow plant growth. Be wary about additive in any products you utilize. Quilter's poly batting and filter floss have excellent surface area but can also create air pockets. Sand has great surface area but is difficult to work with. Cheap donut shaped nylon pot scrubbers offer an abundance of surface area. Scrubbies and other floating media is generally used in an enclosed container.
electricity	Use GFCI outlets and outdoor approved extension cords. Also research battery backups.
fish	Beware of disease potential from any place you get fish. Local watering holes, fish hatchery. Start with smaller feeder fish. Recommended limit of ¼ pound (~110g) of fish per 1 gallon (3.78l) of water. Leave room for growth.
fish food	feeder fish, feeder insects (crickets, black soldier fly larvae), worms and microworms-nematodes, flakes, pellets, vegetables, tadpoles, soaked oatmeal, duckweed, dry dog food ensure good nutritional contents for any feed)
fish tank	Common fish tanks are blue plastic barrels, IBC, farming stock tanks/water troughs (fiberglass, hard poly tank, lined cement and lined galvanized metal tanks), whiskey ½ barrel with pre-formed poly drop-in (sold at hardware stores), in-ground lined ponds, non-working hot tubs, old bathtubs and non-toxic pond liners in a support frame. If you use pond liners, use type HPDE or EPDM 45mil or greater. Ensure any coatings, paints and linings are approved for potable water. It probably better to not use a trash can as a fish tank although it has been done. Trash cans have less surface area for oxygenation and fish like to swim side to side, not up and down. Do not use

	common plastic store storage tubs as they were not designed thick enough for full time water holding and they may bow, crack, and fail (as may thin trash cans). They may hold water better if you build a rigid support frame around them.

Plants

There are many good shops on the internet and your local area for plants and seeds. Read all seed packages for germinating and pollinating instructions. Some lettuce and other plants can be grown directly in water on Styrofoam with holes for root growth into the water. Beware of potential seed coatings that may not be safe for fish.

Use winter plants for colder weather producing. You can grow flowers and potted trees too! Note that fish and bio-activity will slow down at lower temperatures, refer to the "Winter" section.

Take note that it is normal for plant sprouts to shoot up quick and then appear to stall out for a few weeks. During this time the plants are actually growing the root system out beyond the initial seed nutrients to support future growth.

Duckweed grows directly on top of water and multiplies quickly with proper conditions. Some fish eat it naturally while other fish may take some time to coax into eating it. Protect some so the fish don't eat it all up. Not everybody is successful at growing duckweed in their system.

Fish

Ensure you research habits (feeding, breeding, and habitat) of any fish you stock.

http://www.overtonfisheries.com
http://www.morningstarfishermen.org/education.html
http://www.miami-aquaculture.com/lvstk.htm
http://www.valmeyerk12.org/clubs/valmeyer_ffa%20TILAPIA.htm

Resource for tilapia fingerlings: Travis W. Hughey aquaponic70@yahoo.com (minimum order of 25)

Resource for tilapia fingerlings: http://www.miami-aquaculture.com/tilapia.htm
(they may have a minimum order of 150, get a small group together to split an order)

Resource for worms: http://www.ourvitalearth.com/

Other Animals

Animals such as turtles and snails may work for general pond watching activity but may be harmful to an aquaponics system. Turtles eat fish and while snails eat algae, they usually reproduce beyond control (some people claim into the hundreds) and plug up your pump intake, filters, other parts of your system and may eat your plants and your plants roots. Growing snail shells will also deplete your system of carbonates causing a drop in pH level. Do your research and ask questions before adding new life to your aquaponics system. Also protect your system from your pets and visa-versa.

System Setup

System design is critical as water will be moving throughout the system. It is possible to set it up wrong to where all of the system water is in the grow beds at the same time, which leaves no water for the fish! Consult with others on how to prevent this for the size of system you are planning.

Setup grow beds so the maximum water flood level is at least 25mm (1 inch) below the top of the grow bed media. This helps prevent algae as most algae needs water and light to grow. A separate sump container is sometimes used which allows for a constant water height in the fish tank. Sumps are not included in the below paragraphs but feel free to utilize them if that is what is familiar to anybody helping you build your system.

If you are pumping water directly into the grow beds, put a ball valve on each grow bed inlet to control the speed of fill time. This will produce back pressure on your water pump so provide a water return back into the fish tank from the water pump to eliminate undue stress on the water pump and to allow it to pump at full speed as it was designed for. This will also introduce more oxygenation into the tank water which is good.

Direct grow bed drainage back into the fish tank. This ensures good circulation and returns oxygen back to the tank quicker. This also allows for grow bed modification should you decide to change your system. Ensure that the water pump will not completely drain your fish tank should another part of the system fail to return water back to the fish tank due to mischievous animals, people, or an unforeseen leak. Raise the water pump off the bottom of the fish tank and make sure it is secure and will not move around. Keep in mind that 100 gallons of water is about 800 pounds if you will be raising the fish tank off the ground (construct adequate support, more is GOOD). Also provide good support for grow beds as they will contain grow media and water.

Shade fish tanks to prevent algae growth and to reduce stress to the fish. Fish prefer dark hiding places and have less stress if they have them. Include at least one object in the water for this event in addition to shading the top. Do not seal off the fish tank as the fish still need oxygenation to happen, whether it occurs from air bubbles, returning falling water, or fish “piping” at the surface of the water.

If you are interested in spawning: Many fish will spawn if you give them a green “spawning mop” (search the web) or create a dark “pot cave”. Place a terracotta pot upside down with a notch cut out at the bottom or on it's side with sand in it. Different fish will use this setup differently. Some will use the sand and some will use the hard under-surface while others will use the crevice created on the outside touching the bottom. Some fish require a certain speed of water current. Separate fry to protect them from being eaten by the bigger fish (including the mother). Feed fry small pieces of flakes, brine shrimp, small worms, and soaked oatmeal. Research your fish species and their natural habitats to determine which method they use.

Setup your biological filter with filter media. Some people combine this with the grow media. Route water from the tank into your biological filter and then routed to the grow beds and finally back to the fish tank. For initial system material cleansing, route the water through a clean towel/sock (that has no fabric softener or fragrances, additives, etc) to catch any silt. This also makes an easy exchange filter for particles of bigger waste and debris should you decide to leave it in the system permanently. Some people prefer bigger fish waste to be deposited in the grow beds to feed beneficial worms living there.

Fill the grow beds with grow media. The grow media will anchor plants and also be home to beneficial bacteria and possibly worms. Some people add worms and sometimes they show up on their own to feed and break down accumulated solids and sediment, providing mineralization. So long as you have enough bacteria to clean the water and provide worm food, you could develop surplus worms to feed to the fish as a bonus for those raising carnivorous fish.

System Starting - Getting your system to "cycle" (Nitrogen Cycle)

Be patient. Repeat; be patient. Don't expect your system to be running smooth in less than 4 weeks. Get comfortable to testing your water with a water test kit. Good practice is to test your tap water immediately out of the tap and test it again after it has sat a couple days. There might be a change in pH reading levels you need to be aware of.

Some city tap water has chlorine added. Let this water dechlorinate and evaporate before adding it to your system by letting it sit in another container for a day or so. If your tap water contains chloramines, this will not evaporate so use a chemical neutralizer available from the local fish shop, and continue to do so for topping up the system at regular intervals.

Put your system together (pipes, water containers, media) and fill it with water. Add some quick growing seeds (beans) or young plants. Run the system (pumps and drainage) for a day or two without fish. This step will let you find and repair any leaks and should also be enough time to let chlorine dissipate from the system. It will also let you evaluate if you need to rearrange your system for more optimum plant growth in the sunlight or to give your fish tank more shade (fish like that). Ensure any timers and drainages are functioning and timed properly. Once you are satisfied with the system flow, add any bacteria boost if you have from a local lake, river, or an established aquarium.

For "fishless cycling", add 1 teaspoon of urea or **pure** Ammonia (check ingredients) about twice per week to build your bacteria colonies, but only if water test results show the ammonia level below 1. Do not add fish until you have seen the reading level for nitrite return back down to zero. Stop adding ammonia at least three days before adding fish so the readings can return to normal. For trying to get your system going with fish (expect to kill some if you are a newbie), start with a couple small fish and check pH, ammonium, nitrite, and nitrate levels once per week. (FYI: 10% pure ammonia of 1ml per 1 gallon = 4ppm.)

> **Important note on pure Ammonia:** The only acceptable ingredients are ammonium hydroxide and water. Any other ingredients are bad. Surfactant (in bottles labeled as CLEAR AMMONIA) is detergent and will foam if you shake the bottle and will kill fish. Perfumes and dyes (in bottles of Parson's Ammonia) will ensure your fish die as well. Sometimes the ingredient list is difficult to find and mixed in with the directions. If your system is foaming, completely clean it out with hot water and replace filters and any porous system parts (most rocks are porous, terracotta pots, quilt batting is too hard to clean properly). 25% Ammonia to 75% water is strong stuff. 25% or less is recommended. "Janitorial Strength Formula" at Ace Hardware, in the United States and on the web, is pure and safe.

Run the system like this for a few weeks until ammonia and nitrite levels are zero or near zero. Signs of algae growth indicate that aquatic life can be supported and naturally multiply the beneficial bacteria on the grow medium/filters and will convert any initial ammonia in the water, including what you may have added to build up the bacteria. A higher pH level is good for this activity only. You can lower the pH once the system is "cycling" properly. If you place too many fish or too few plants in your system before this happens, expect the fish to die (known as "New Tank Syndrome"). Do not use prize fish, use feeder fish for testing initial setup.

Check temperature, pH, ammonia, nitrite, and nitrate levels, preferably with liquid water test kits available at your local aquarium or pet store. Keep a log of date and reading levels and any changes made to the system, including adding/removing fish/plants/grow beds/air pumps, caves, and amount of salt and feed put into the system so you can trace issues later. The more detail that is recorded in the log offers more chance for success of others helping diagnose system problems.

Each aquaponics system will level out at a different pH reading. This is determined by your water source and components and media in the system. If nitrite level is not zero, then run the system another week and recheck. If the readings are off the charts for over a week or two straight with no changes to the system or addition of ammonia (and you did provide surface area for bacteria), it is best to ask for help to evaluate your situation as to why your system has not cycled. The system may be imbalanced or materials may be affecting it.

If reading levels are good, add plants if you haven't already done so within the past week. Add fish last at a slow rate, maybe a couple every week. Be sure to temperature match the water before releasing fish into the tank (see transporting section). Add plants and fish at a slow rate to make sure that the water nutrient levels are stable and to give the system time to adjust. Once the system has “cycled”, the water should be clear. Larger systems can adapt and absorb changes easier than a smaller system. Expand slowly.

Operating Knowledge

Conversion: 100 gallons = 378 liters 1000 liters = 264 gallons 500 liters = 132 gallons 200 liters = 52 gallons

Note: Adjusting pH fast can be hazardous to fish. (pH changing by .2 quickly can be dangerous)
If you are unsure, it is best to avoid trying to manually change pH. The experienced try to avoid it.
Note: If your system has a pH crash, remedy what caused it to begin with also!
Note: Smaller crushed particles work faster, larger particles work slower to maintain system pH.

- Keep "pH increase" equivalents on hand: sodium bicarbonate (baking soda), limestone, calcium carbonate (egg shells, snail shells, sea shells) It is easier to increase pH than it is to decrease.
- Keep "pH decrease" equivalents on hand: vinegar, pure citric acid (lemon juice, lime juice), iron sulfate fertilizer (available at your local mega-mart store), pine straw, deadwood, peat moss
- Keep 100% sea salt (non-iodized salt) for micro-nutrients and for treating fish disease (in quarantine). Consult others about the proper use of salting with freshwater fish and plants.
- Keep clove oil for euthanasia instances. Only humane option and does happen. Available at pharmacy.
- Keep a spare bucket/cooler with air pump on hand for system emergencies and fish separation if needed.
- Keep a dechlorinated water bucket nearby with 10% volume for topping up the water levels.
- Rotate plant growth so the plants do not all die off at the same time causing the system to crash.

Prepare for system failure. Multiple pumps and battery backup ensure system success in the event of equipment failure or power outages. The extra equipment can sit on a shelf waiting for events to happen (and waiting for you to return home) or can be running double duty to not even allow chance for full system failure if you are not home. It is important to note that air pumps and extra aeration promote a healthier system with greater dissolved oxygen. Optimum water temperature is around 26°C (80° F), although it really depends on each particular fish and plant species.

Plants:

Plants may be added to the grow beds as seedlings or as seeds. Most seeds require to be moist (not drowned) and warm to germinate and sprout. Certain seeds require certain amount of light or darkness to germinate. Wash off any dirt from transplanting plant roots before introducing them into the grow beds. Consult with local nurseries for additional help with your plants in your local environment.

Plant about $1/4^{th}$ of your plants to begin with. Plant another $1/4^{th}$ after 2 weeks. The trick here is to stagger plant growth so there is less chance of all plants dying off at the same time causing a crash to the system. When the first group dies off, immediately replant that group to keep the rotation going. If you plant all of your plants at once, you may be facing a future crash.

Dechlorinated Water:

Keep water on hand in an open bucket/tub big enough to hold 10% water change. Let it sit for at least 24 hours before adding to system so it can dechlorinate if it came from the tap. Refill and repeat process. Water changes should be unnecessary when your system has "cycled" proficiently, but water will still evaporate and be used up by plants and more will need to be added to the system on a regular basis. If you do add tap water directly to your system, do not add it directly to the filter media as the contaminants may kill some beneficial bacteria.

Water:

Water levels reading pH 7.0 is neutral. Some systems have found a slightly different pH level to be optimum. A pH crash will read low levels and commonly, fish will be franticly breathing at the surface of the water as a side effect. This activity known as “piping” is due to lack of enough dissolved oxygen (DO) in the water and requires immediate action. Refer to the troubleshooting section for remedies.

Rainwater may be used. Remember to filter out non-water sediment or it may clog water pumps. Also be careful of any chemicals that may leak into the water from roofing materials. Measure pH levels of any water after it has set out a day to be sure of how it will affect the system. Proper pH must be maintained for fish, bacteria and plants to live.

Oxygen:

Fish, bacteria, and plants need oxygen. Generate oxygen from air pumps and return water falling into tanks.

Fish Food:

Live foods are good sources of supplements and provide food variety for carnivorous fish
Resource for live food: http://www.lfscultures.com/

Fish should eat all food within 3 minutes. Overfeeding will lead to food decomposition toxicity. Manually remove uneaten food. Most people feed at least once a day. Feed a variety of foods to ensure proper nutrition and to help avoid finicky eating.

Keep fry (newborns) separated from bigger fish so they don't get eaten.
Feed fry a diet of microworms (nematode), brine shrimp, soaked oatmeal (soft things).
Feed fingerlings (between newborn and mid-grown) small fish flakes.
Feed bigger fish a diet of fish pellets, worms. It is easier to view food consumption time if it floats.
Some fish eat worms. Earth/Blood/Compost worms will grow in grow beds eating the fish waste.
Add a submersible low voltage LED light to attract bugs at night, free food!

The 7 day fish feeder food blocks are based on a pH of around 7.0. A high pH will cause it to dissolve much slower (2 weeks for pH ~8.0) and low pH will cause it to dissolve much quicker (under 3 days).

Many people have a nearby compost bin for worms or black solder fly (http://thebiopod.com).
Ensure that any live fish food is grown from healthy feed that does not contain pesticides or chemicals.

Duckweed:

Duckweed is a popular aquaponics feed. Duckweed is the second smallest flowering plant in the world (watermeal is smallest). It can restrict algae development due to shading. It floats and grows directly on top of water. Not all fish take to duckweed immediately. Duckweed grows in calm waters. It will produce oxygen for the water in sunlight and consumes oxygen from the water on cloudy days and nighttime. It's best to keep a separate slower flowing duckweed grow bed. Skim some duckweed into containers or baggies and freeze or dry for later fish food or serve as is. It is important to note that duckweed consumes more nutrients than most plants. Duckweed has up to a 45% protein level surpassing that of soybean. It also has essential amino acids.

Resource for duckweed: http://shop.ebay.com/?_nkw=duckweed
Resource for duckweed: http://www.petsolutions.com/Default.aspx?ItemID=99969

source for duckweed: http://store.aquaticplantdepot.com/floatspaw.html
source for duckweed: http://www2.mailordercentral.com/pwg/
source for duckweed info: http://www.p2pays.org/ref/09/08875.htm

d:

ny people breed worms and black soldier fly larvae in compost bins. Some people grow ckets, roaches or other insects as feed. Some people grow maggots and also feeder fish. There many good resources on the internet and local pet stores for more information on breeding er small animals as food. It is perfectly acceptable to only feed your fish store bought food so g as it is in their normal diet. Research the eating habits of your fish and try to vary their diet ensure good nutrition. Remember that some fish only eat plants (flakes, algae, vegetables), me fish only eat smaller animals (fish, worms, insects, etc), and some fish eat both.

ation and Quarantine Tanks:

not 0195(f)2.9980-2(m7l)-2(l)-2(e)4d trnsorting or0-2(m7l)-2(l)-2(e)4d in(qua)4(r)3ae(t)-2(i)-2((e)4(t)-2(n)-1 okweeirpuom(s)-1(a)4(nd(i)-2(c)4(e)4(.)20W)-65(he)4n(im)-1.99707(c)4(e)4(om)-2(e)4lits, (t)-2ea)(or)3(0-2(m7l)-2(c)4(h(s)-1(l)-2(0-2((s)-1odokw)2(n t)-2(he)4(om)-2(e)4(t)-2ae)4((ol)-2 i)-2(s (s)-1(e)4(a)4nutmati feeder34(s)-1(or)3(a)4.00147(ur)3(e)4blble frind t feed your fis diof yo(g)10(

Troubleshooting Problems

Troubleshooting Plants:

Resources:

http://www.hbci.com/~wenonah/min-def/list.htm

problem: plants are dying
reason: potentially any reason - not limited to oxygen, water, minerals, temperature, pH, bugs
solution: consult plant and aquaponic experts and describe plant appearance and activity

problem: plants are dying (not in winter)
reason: fish/plant ammonia ratio out of balance, not enough food for plants (also see above)
solution: feed fish more, reduce number of plants, get more fish

problem: plants are dying (in winter)
reason: fish move less and eat less in colder water, hence less ammonia (also see above)
solution: heat water more, reduce number of plants, feed more (if fish are still eating)

problem: plant leaves are not healthy
reason: almost always a mineral deficiency, can also be toxins or environment factors
solution: check fish food contents and nutrients
reference similar pictures: http://4e.plantphys.net/article.php?ch=t&id=289

problem: aphids eating plants
reason: nature happens
solution: plant dandelions, carrots to attract ladybugs, buy a bag of ladybugs from local nursery
look to see if ants are farming the aphids at which they will kill your ladybugs
introduce ladybugs at night

problem: caterpillars eating plants
reason: nature happens
solution: use garlic spray on plants, put caterpillars into tank as free fish food (or use “Dipel”)

problem: plants are discolored
reason: normally this indicates a mineral deficiency
solution: consult with fellow ap enthusiasts (inquire about Maxicrop in the US, Seasol elsewhere)

problem: plants not growing / extremely slow growth
reason: pH may be too high, not enough nutrients in water
solution: check pH, increase feed if fish eat it all too quickly or reduce number of plants in system

problem:
reason:
solution:

problem:
reason:
solution:

Troubleshooting Water:

problem: pH over 7.5 - pH less than 6.5
reason: acidity of water is too low or too high, levels are determined by components, water source
solution: quick pH level changes are hazardous to fish!

Since most systems find their own operating pH level, adjusting this is difficult. If a system component (like media, water content) is already buffering the system, additives will only change pH temporarily. Consult with others on adjusting this.

problem: low water level
reason: surface evaporation and plant transpiration, plants use more water the bigger they are
solution: check for water leaks, top up system with dechlorinated water

problem: water is green
reason: too much algae due to water having too many nutrients and too much light
solution: feed less, shade tank, darken sides of grow beds
note: algae eating fish may or may not like the type of algae your tank has
note: algae eating fish may or may not be food for fish you may be growing

problem: water is dirty
reason: usually too much food and fish are not eating it all or system is under-filtered
solution: feed less, use towel/sock filter on return water to filter out sediment, check for blockages

problem: water is cloudy (also see “water is dirty”)
reason: overfeeding, system is out of balance, algae growth
solution: reduce feeding, system should clear up within a week, if not, check other factors

problem: top of tank is completely iced over
reason: weather too cold
solution: if fish are still alive, add air bubbles to keep water moving at surface and for oxygenation

problem: water is foaming in an established system
reason: detergents or other chemicals have been introduced into the system
solution: Perform 50% dechlorinated water changes every day until the foaming is gone.

Note: You want to prevent fish shock in this situation as much as possible but you also need to eliminate the contaminants as much as possible. Be careful not to eliminate most of your beneficial bacteria, they keep the system cycling properly, so refrain from cleaning media.

Side note: Cleaning individual system parts is a waste of time if the parts will be going right back into the system that still has 50% contaminated water.

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

Troubleshooting Fish:

You can diagnose problems by consulting with your fish supplier. Feed your fish at a rate appropriate to the biomass of your fish and stage of growth.

General Fish Resources (not necessarily geared towards aquaponics):

http://fishbase.org
http://fins.actwin.com
http://www.kokosgoldfish.com/typesoftreatment.html
http://www.fishdoc.co.uk
http://www.plantedtank.net/articles/Common-Freshwater-Fish-Diseases/13/
http://www.practicalfishkeeping.co.uk/pfk/pages/tools.php

problem: dead fish
reason: unknown
solution: remove dead fish from the tank immediately to prevent decaying ammonia buildup!

problem: fish seriously sick, almost dead, no hope of saving
reason: unknown
solution: euthanasia : (don't flush, freeze, or use antacid, it's inhumane and hours of torture)

method 1: flatten fish's head hard and quick with a brick

method 2: move fish to big cup with same water
mix clove oil/bud vigorously with water in ziplock baggie...(speeds up process)
SLOWLY add mix to cup with the fish...
should slowly peacefully die within 20 minutes...if not, make solution stronger
wash out cup well afterwards to remove oil mix

problem: one, some, all fish are at surface of the water and not normal for them (& not feeding)
reason: lack of dissolved oxygen, fish are getting more oxygen than water provides ("piping")
solution: immediately add air bubbler, manually splash water but try not to stress fish
water/air exchange introduces oxygen into the water
if pH levels are low, add "pH increase" equivalent but not too much
(pH changing by .2 quickly can be dangerous)
reduce fish/water volume ratio, increase amount of air/stones/bubblers

problem: fish acting funny / weird, floating sideways, floating upside down
reason: certain foods don't always suit individual fish
solution: try different food, sometimes they like variety, consult fish experts

problem: fish are jumping out of tank (1)
reason: water level is too high (this is not the main reason this happens, see "piping "above)
solution: reduce water level, cover tank with wire mesh/netting

problem: fish are jumping out of tank (2)
reason: fish are trying to eat flying insects
solution: cover fish tank with netting to keep fish in

problem: fish are jumping out of tank (3)
reason: extremely poor water quality
solution: test system levels, filter water sediment better

problem: fish has creamy white film slime
reason: could be low pH level, could be breeding behavior, could be disease
solution: check pH level, check for other indications of problem

problem: fish has been determined to have Ich / Ick disease
reason: Parasite that looks like sand size white spots on fish.
Stress (environment change / fighting) may have reduced immune system to ward off Ich.
Ich normally infects the entire tank.
solution: 1 tablespoon sea salt (non-iodized salt) per 1 gallon water in the system (~ 3ppt)
Higher concentrations of salt may be used in a quarantine tank for other problems.
Higher concentrations of salt may be harmful to plants. (FYI: The ocean is 35ppt.)
Higher water temps will reduce the time it takes to remove Ich, know your fish limits.
Gradually raise water temp to around 30°C (86°F) and Ich will die.

problem: fish doesn't look right
reason: disease or poor water quality
solution: http://fins.actwin.com/articles/disease/chart1.php

problem: fish is acting funny
reason: fish behavior changes could indicate breeding
solution: monitor activity

problem: fish disappeared
reason: critter got to them, probably a raccoon, turtle, snake, bird, cat, or possibly other fish
fish may have jumped out of the tank and flopped around, look nearby
solution: cover tank with wire netting and seriously secure it from being taken off
try a pond scarecrow, close greenhouse at night, monitor aggressive fish

problem: algae on fish
reason: algae does not grow on fish, it grows on fungus on your fish
solution: consult local fish shop

problem: fish aren't eating in colder weather
reason: fish eat less the colder the water gets (less ammonia too, keep an eye on plants)
water temperature controls fish metabolism, fish are cold-blooded
Water temps in the 10° C (50° F) range seems to be the magic number.
Many hardly feed at all below this. Beneficial bacteria cease operation below this, hence, fish eating and generating waste will seriously offset the balance in the system. Fish digestive enzymes also do not work well below this level and food in their system will rot or cause infection.
solution: feed less or stop feeding

problem:
reason:

solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

Troubleshooting System:

problem: power outage
reason: power grid is unreliable
solution: use emergency battery powered air pumps
put grid air pumps on interruptible power supply (UPS) backup
add dechlorinated ice to tank to release oxygen/slow metabolism until power is restored

problem: water pump stops
reason: old age, defective, clogged pump, lack of electricity
solution: if the system quits circulating altogether, it will probably crash under 24 hours
use battery operated air pump to keep fish alive, change out 10% water
replace defective pump with your backup pump (you do have a spare backup, right?)
manually pump water to keep plant roots moist, clean/repair old pump
best to have multiple pumps in service in case one goes out when you are not home

problem: air pump stops
reason: old age, defective, clogged pump, lack of electricity
solution: replace air pump, the system should be okay for a few days if it is established
some people don't use air pumps but they can help a system thrive better

problem: system is leaking water
reason: parts are old and cracking, sealants/tape defective
solution: temporarily seal holes in pipes with Teflon plumbers tape, replace worn parts
use ball valves to shutoff water flow to parts of system that are leaking and fix

problem: red worms appeared
reason: came from feed or nature
solution: do nothing, red worms are your friend and free fish food, research other types of worms

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

problem:
reason:
solution:

Troubleshooting Bell Siphon:

Note: 90% bell siphon problems can be solved by using a wider and taller siphon pipe. 9% can be solved with a cheater air break tube, cheater bottom bends, or larger crenellations. The other 1% probably used too wide of a siphon pipe, have extra holes where they do not belong, forgot the airtight siphon pipe cap, need to shorten the cheater air break tube, or have too many bottom bends. A good size of siphon pipe width is one that is around two standpipe widths wide.

Normally: standpipe is the inner drain pipe. Siphon pipe is the outer pipe with top cap. A protective shroud pipe with many holes is around the unit to allow maintenance while preventing media from smothering it.

problem: bell siphon isn't working properly
reason: poor design
solution: most bell siphon issues can be solved with a wider and/or taller siphon pipe

problem: bell siphon will not start
reason: standpipe is not level, water flows over one edge instead of entire edge surface
solution: cut the top of the standpipe so it is level

problem: bell siphon does not stop draining
reason: siphon is not strong enough to break water tension at bottom of siphon pipe
solution: make one crenellation/hole at bottom of siphon pipe higher for an air break
make siphon pipe taller if it is too close to the top of the standpipe to increase vortex area
if that still does not work, use a wider siphon pipe

problem: bell siphon never engages, standpipe only drains water output to equal water input (1)
reason: siphon pipe cap is not airtight or cap is missing
solution: seal cap on top of siphon pipe

problem: bell siphon never engages, standpipe only drains water output to equal water input (2)
reason: standpipe (output pipe) is too wide to create a water lock and begin the siphon action
solution: reduce width of standpipe or add an adapter to the top of it that reduces the opening
some people may use a bend at the bottom of the standpipe to find resolution
this may also indicate too wide of a siphon pipe

problem: bell siphon takes a long time from dribble to fully starting the siphon
reason: siphon pipe does not have enough headroom to initiate a vortex over the standpipe
solution: make siphon pipe taller

problem: bell siphon does not drain fast enough
reason: bell siphon designed to small for amount of water coming in
solution: reduce incoming water flow with ball valve in or use an entire larger bell siphon

problem: bell siphon stops draining midway
reason: water pressure has equalized inside and outside the siphon at the standpipe height
solution: use fewer crenellations in siphon pipe or use smaller diameter siphon pipe

Appendix A: Author's First System

So what type of system did the author put together and what were his direct experiences? My first system attempted was a continuous flow system without success. Seeds wouldn't grow much and developed root rot. I tried to grow seeds using the popular “baggie method” without success either. I eventually changed the system into a flood and drain model and now I start seeds in the grow beds like most people do.

I started with a problem I was unaware of at the time. The original ammonia that I was trying to fishless cycle with had detergent in it. The ingredient list was not easily found until later. But sure enough, shake the bottle and it foamed at the top. It was also keeping the pH between 5.5 and 6.0. Once I realized the problem, I completely cleaned out the system throwing away the filter and any porous materials and bought pure ammonia. My pH now remains above 7.6 due to the local aquifer and my grow beds being limestone. I think this is why my plant growth has been very minimal, I have already changed one grow bed to Aerolite media and will change the other grow bed once test levels have returned to normal from the first one being changed.

“Minigeyser”

In the midst of the people online searching for ways to run their system off the power grid or at least with only air pumps (for more reliability and less power), I developed the “minigeyser” pump. It uses pressurized air to push a small amount of water through a tube up to a grow bed. It provides more head than using the same air pump as an airlift pump. The bottom is made of a ¾ inch PVC slip plug with ¼ inch hole water inlet with a #10 o-ring and standard marble inside as a check valve. The top half is ¾ inch PVC slip cap with two ¼ inch holes. One hole is the air inlet and has ¼ inch tubing that goes from the air pump to just inside the PVC capsule. The other hole is the air/water outlet with ¼ inch tubing that starts about ¼ inch away from the marble. The outlet tubing allows enough room to let the marble move but close enough to the water inlet hole to let enough water in before the air pressure builds to prevent an airlock. The entire unit is about 1.5 inches in length and with a 1.5 watt air pump (1200cc), it pumps 4oz (½ cup) water per 2 minutes which equates out to ~237ml (1 gallon) every 64 minutes. A stronger air pump at 3.5 watts pumps twice the amount In the of water in the same amount of time. If the outlet tubing gets clogged, the marble check valve doubles as an air pump diaphragm saver and will give way for air to escape until the problem can be resolved. A larger version can be made with a shooter marble and 1.25 inch slip cap, slip plug, and #15 o-ring with silicone to prevent it from moving out of position. I have not fully tested the larger version. The outlet hole must be at least the same size as the water inlet hole to prevent the air from going out the wrong hole due to resistance. These need to be taken apart once a month and cleaned of the buildup in them. Picture link URL: http://backyardaquaponics.com/forum/viewtopic.php?f=1&t=2192&p=171829&hilit=minigeyser#p171829

Amount of turn over of tank water through the bacteria is important for biofiltration. Aquaponic people suggest turning over the water volume of your tank at least once per hour. This is to ensure water with ammonia can be processed by the beneficial bacteria living on the bio-media. The water pump rating will always put out less than stated due to the head height of the water you are pumping vertically. However, I chose to run my system only with air pumps for less power usage and proof of concept of only using air pumps. Pumping a lot of water per hour simply isn't feasible with only a few small air pumps and the minigeyser. The minigeyser was designed to lift water to grow beds, not for massive water movement. I have my smaller air pump running an air stone for water movement and aeration. Extra air helps with the amount of dissolved oxygen the fish can utilize in the water. Dissolved oxygen is created by the amount of surface area between air and water, so smaller bubbles will produce more dissolved oxygen. With such slower water movement in my system, it requires tank

sediment cleaning more often and my ammonia conversion speeds are slower.

The adventures continued. I had issues getting the drainage to work with my small shoebox size containers. After much research I concluded that it was because I was trying to use too big of PVC drainage lines and tubing for my system which could only provide a small trickle of water input. I tried building more types of siphons than most people are willing to take on. This research developed the troubleshooting bell siphon section of this document and the descriptions of how each drainage system works. Once I used the same size tubing as my water pump (the minigeyser) used to provide input, the siphons started working. The bell siphon still acted erratically once bacteria slime built up so I have quit using it. At this point, I have connected the two grow beds by use of a no holes overflow so they can both use the more reliable inner container pivot outlet. I had fun testing different ideas and trying to overcome the laws of physics in the process.

This picture was taken shortly after I added the sprouts, two ivy clippings, and 10 blacktail shiner minnows. This setup defied the suggestions of 1:1 grow bed ratio and nitrite levels remained around .25 as a result, until I lost some fish due to other circumstances. I am now running one 3.5 watt air pump with two outlets, both running a minigeyser pump to a plastic shoebox size grow bed. The grow bed drains into a mechanical filter that drains back into the tank on the opposite side. It still isn't enough filtration for the fish waste. I manually clean it once a month. I use another 1.5 watt air pump for aeration and one 50 watt heater to keep water temperature around 25°C (75°F) in the winter. My shallow grow beds would not support big heavy plants, so I planted leaf plants such as spinach, parsley, and flowers. I also added a 350VA/200watts uninterruptible power supply for $40 USD which will provide 3+ hours of backup power for my low power setup (not including the heater). I found out my analog pH soil tester was no longer accurate and switched to a liquid test. I tried to reduce pH levels too quickly and now have half as many fish. Live and learn. I have since had algae growth and covered the outside of the beds with duck tape and the tank with foil. It has been good experience I can put to use when I build a bigger system in a greenhouse. I now know my pH was high because of the limestone bedrock I was using. I am now using other grow bed media. Picture link URL: http://backyardaquaponics.com/forum/viewtopic.php?f=18&t=4915

It is enjoyable to watch fish and the plants (only the ivy and beans thus far due to high pH) growing. Watching drainage systems work and hearing the pumps in the background gives a sense of accomplishment. Train your fish to eat food that is nutritious and readily available to you. Have family members and friends help you build your system and feed your fish. It is much easier to obtain success when there are others to help and compare experiences with.

Many others have had similar experiences such as mine and each person has their own individual conquests with their system. For most of us, this is a hobby and we have fun trying new techniques. Some people are using this as a commercial business and are usually willing to share information. Others are using medium/large systems to help feed and support their local community in areas of the world that are less fortunate. Plan out as much of your system as you can before you start obtaining materials to save time and money. Have fun and we will catch you in the online forums!