easy! DIY Aquaponics™

CORE PROCESS MANUAL

members.easydiyaquaponics.com

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Welcome to the Aquaponics Community

Congratulations on taking this step towards self sustainability! Aquaponics is one of the smartest new ways to overcome the challenges of a struggling economy, higher gas prices and food shortages. With your own Aquaponics system you are empowered with the ability to create all the fresh, organic fruits, vegetables and fish you need for your family and then some.

If you've ever planted or worked on a garden, you know how much labor is involved with the bending over in the soil working on your knees, raking, hoeing, and fertilizing, weeding and pest control. And the list goes on not to mention the amount of land you need. For many people the labor is worth the payoff in the end while for others, the amount of hard work can be a serious deterrent to those who would otherwise like to grow their own food.

Aquaponics is by no means a panacea, but it does take address many of the problems gardeners and farmers face when planting and harvesting crops while still maintaining the benefits. No more bending over weeding, cultivating dirt or having to manually water your crops. Aquaponics systems also have a much smaller footprint and use water much more effectively by recycling the water rather than losing it through evaporation.

One of the limitations of a conventional garden is that it is confined to seasonal use. The soil is fertilized and seeds are planted in the spring. The plants use up the nutrients in the soil until it is depleted and the plants die off. The plants yield as much vegetation as the nutrients, water and sunlight will provide and the food is harvested in the fall. When the plants die off the soil will then need to be re-fertilized and replanted. This system is heavily dependent on a steady watering schedule and fertilization of the soil.

In an aquaponics system plants are never without water and thus have access to all the nutrients it needs to grow vegetation as fast as it possibly can. This is what gives aquaponics such an advantage over a conventional farm or garden.

The advantages of owning a home Aquaponics system:

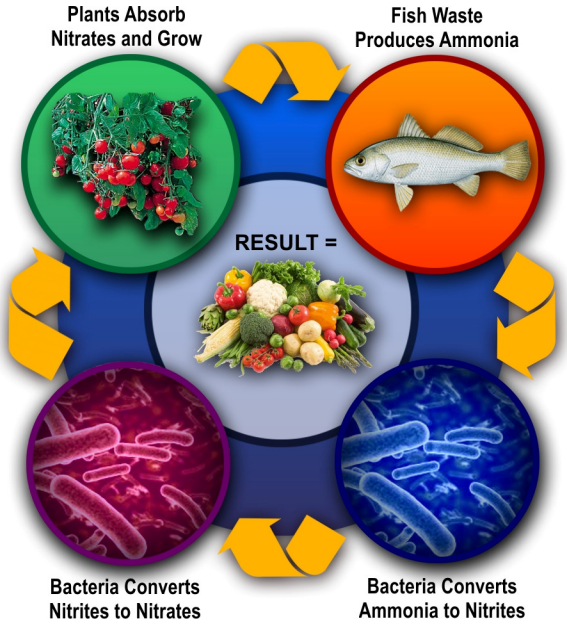
- Plants yield 5 to 20 times more food in half the time compared to garden plants.
- Vegetables grow up to 2 times faster than those grown in soil.
- Because there is no soil used, aquaponics requires half the space or even less than a conventional garden.
- Low set-up and operating expenses. – Electricity for a small pump is less than $20 per month and even that can be offset with the use of solar panels or small wind turbine.
- Aquaponics uses 80% less water than gardening.

- Easy to build and maintain. – Following the step-by-step instructions make building easy and fun and once setup is complete, maintenance is virtually care-free.
- Most parts can be found off the shelf at your local hardware/garden store.
- Save money by growing your own produce.
- Eat fresh, healthy, organic food and fish grown by someone you trust!

Remember that each system is scalable so it can grow as your needs change by adding more grow beds and tanks or by upgrading to larger ones as time goes on.

What is Aquaponics?

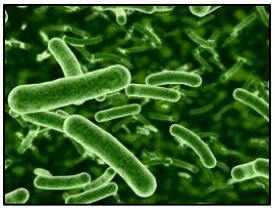
Aquaponics is the combination of hydroponics and aquaculture and is based on productive ecosystems found in nature.



Hydroponics is the growth of plants without the use of soil. Because of this, hydroponic systems require water treated with man-made nutrients to make the plants grow.

These nutrients are a careful balance of chemicals and must be flushed out of the water periodically to prevent toxicity to the plants.

Aquaculture is the cultivation of fish or shellfish for food. Commercial systems are often heavily stocked which creates polluted tank water with high concentrations of ammonia created by fish effluent. This water needs to be constantly filtered otherwise it would be toxic to the fish and it can be costly to process.



Aquaponics creates compatibility between the aquaculture and hydroponics by adding a third step which is to allow microbes to break down the fish waste from ammonia into nitrites and then into nitrates for plant fertilizer. The ammonia is pumped up into the gravel grow beds and is recycled into nutrients for the plants without the use of chemicals that are harmful to the fish and fresh water is pumped back from the grow beds into the fish tank. Water can be recycled this way indefinitely and will only need to be replaced after it is lost through evaporation.

Aquaponics systems can be as simple as floating vegetation on water surface or it can be very complex with several components which allow higher yields and more fish.

Hydroponics Techniques Explained

In hydroponics/aquaponics there are three main methods of getting nutrients to the plants.

Nutrient Film Technique. (NFT)

This method is used mostly in commercial hydroponic systems to grow mass quantities of certain types of vegetables, but it is not common in aquaponic systems. The nutrient rich water is channeled through narrow troughs creating a thin film for the plant roots to feed from. The plants are suspended in small plastic cups to start and are often transplanted to larger pots during the growing process depending on the type of plant. This method is suitable for leafy type vegetables with small root systems such as lettuce.

Deep Water Culture (DWC)

The DWC method is similar to NFT except that instead of a thin film of water, the roots hang in a bed of several inches. The plants are grown in specially designed hydroponic net pots suspended by floats or foam. DWC can be done by floating a raft on the surface of the fish tank but it can be extremely difficult to manage the chemical composition.

For most plants and fish (especially a variety of plants in the same grow bed), a third mechanism is required to filter out the fish waste and allow it to be recycled into nitrates. Without this crucial step the water will be toxic to the fish and the plants will not grow as well.

With DWC you are also limited in the types of plants that will work best under constant submersion. Some plants grow very well in this environment and you may want to try using it when focusing on quantity rather than variety.

Media Filled Grow Beds

The other method most used in Aquaponics is to suspend the plants in a medium such as gravel or clay pellets. Media filled grow beds hold suspend the nutrients where the roots are and also provides a natural place for the bacteria to recycle the fish waste.

This method also allows you the most freedom when deciding which vegetables to plant. You can grow just about any kind of plant in a media filled grow bed as opposed to the other methods that work well with a just a few such as leafy greens.

When deciding whether to use clay pellets or gravel, although it is much cheaper and easier to get, gravel is extremely heavy.

Not only do you have to consider the weight of the water when building your support structure, you also have to account for the weight of the rock.

Gravel also can affect the pH of the water depending on the type of rock it came from. Because Aquaponics systems rely heavily on water stability, it may be difficult to maintain a balanced pH level within limits when using gravel.

Clay pellets are much lighter than gravel and are pH neutral. They also hold moisture well while allowing air to access the plant roots. This is why most aquaponic systems use clay pellets.

Watering the Plants

The two most popular methods of applying water to the media filled grow beds is through continuous flow or by flooding and draining.

Continuous Flow

This method is the same as the NFT except the water flows through the gravel or pellets rather than straight to the plant roots. The challenge with this method is that it can be difficult to get water to all the media in the bed.

Simply placing a water source at one end and drain at the other will result in a small section of media receiving water and nutrients while the majority flows to the bottom and down the drain. You can raise the drain to keep water in the bed but then there is no air getting to the roots and there is no longer an advantage to using media filled grow beds. To counter this, a series of irrigation pipes can be laid across the surface to distribute water evenly.

Ebb and Flow (Flood and Drain)

This method, which is the most popular, is to grow the plants in a medium of gravel or clay pellets which are periodically flooded and then drained. Water from the fish tank is pumped into the grow bed until it reaches a pre-determined capacity level after which the water is drained and the cycle repeats. A siphon system allows the water to flood and drain automatically but very little can be done to adjust the timing other than controlling the flow rate of the water. Alternatively a timer can be used to determine the frequency of flooding cycle. This method allows air to get to the plant roots when the water is drained.

This method is regarded by most enthusiasts as the easiest to maintain and find success with especially as a first system.

The following are a few different ways to employ the flood and drain method:

Simple Flood and Drain

As the term implies, this is the simplest and easiest way to flood and drain the grow beds. The pump is placed directly in the fish tank and pumps water to the grow bed until it fills up to a certain height when the water is flushed via gravity siphon and drained back into the fish tank. One of the drawbacks is that the pump is in the fish tank and needs to be able to handle fish waste and may also require more maintenance to keep clean and operating properly.

Another minor disadvantage is that the water level in the fish tank fluctuates with the rise and fall in the grow bed so it's important to keep enough water in the system especially when you have more than one grow bed.

CHIFT PIST

(*C*onstant *H*eight *I*n *F*ish *T*ank – *P*ump *I*n *S*ump *T*ank)

This is similar to the "Simple Flood and Drain" method except that water is fed from the fish tank to a sump tank before it is gravity fed into the grow bed/s. Again the auto siphoning system is used to drain the bed after flooding but the water goes into a secondary tank called the sump tank. This way the water level in the fish tank stays constant while the sump tank water level fluctuates.

Having the pump in the sump tank makes it easier to maintain and keep clean while the water level is always the same in the fish tank.

The disadvantage is that the fish tank needs to be raised above the grow bed and the sump tank lower than the grow bed to allow gravity to pull water through the system.

Two-Pump System

To make things even more complex you can add another pump to the fish tank making it a two-pump system. Water from the fish tank is pumped into the grow beds so there is no need to place the tank water level above the beds as in the previous example. Water then drains into the sump after the beds have been flooded. Once the water reaches a certain level, a float valve activates the sump pump and water is sent back to the fish tank.

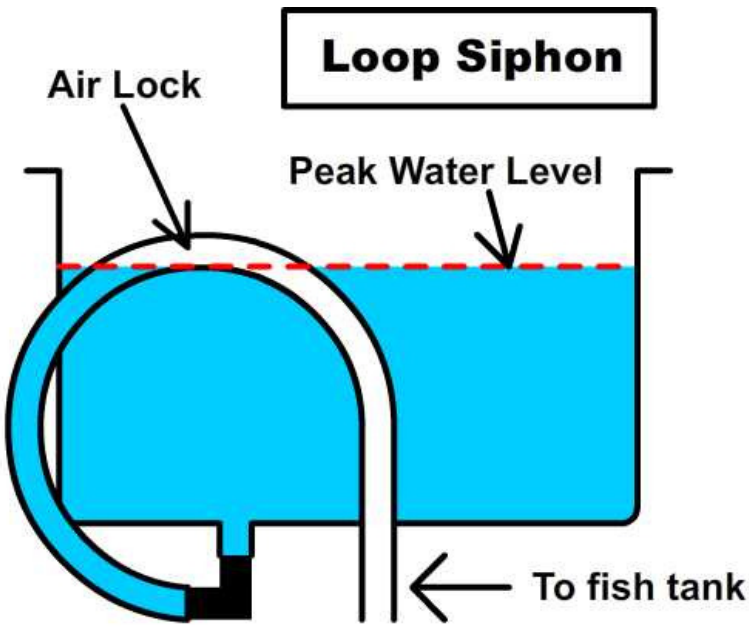
The advantage to this is that larger systems can be built without having to suspend or bury heavy tanks to accommodate a gravity drained system. Fingerlings can also be placed in the sump tank until they are large enough to be placed in the fish tank.

If this is all starting to sound a little complicated, don’t worry. There will be plenty of time for experimentation after you build your simple flood and drain system. For now we will concentrate on just the basics and when you are ready to expand, creating new additions will be easy for you.

About Siphons

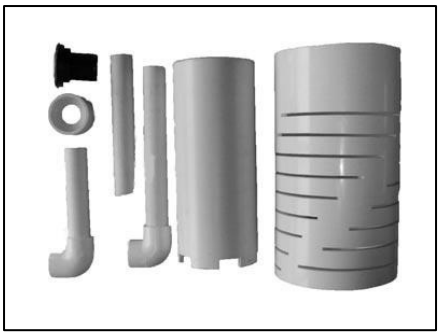
Loop siphon

This is the simplest way to flood and drain the plant beds. All it takes is a hose or flexible tubing that is attached to the drain. The top bend of the hose is held at the maximum flood level. Once the water level reaches the top of the tube, the airlock is broken, the siphon starts and the water drains completely and air is again introduced back into the tube. This is the same principle used flush a toilet once it gets full after a water flush.



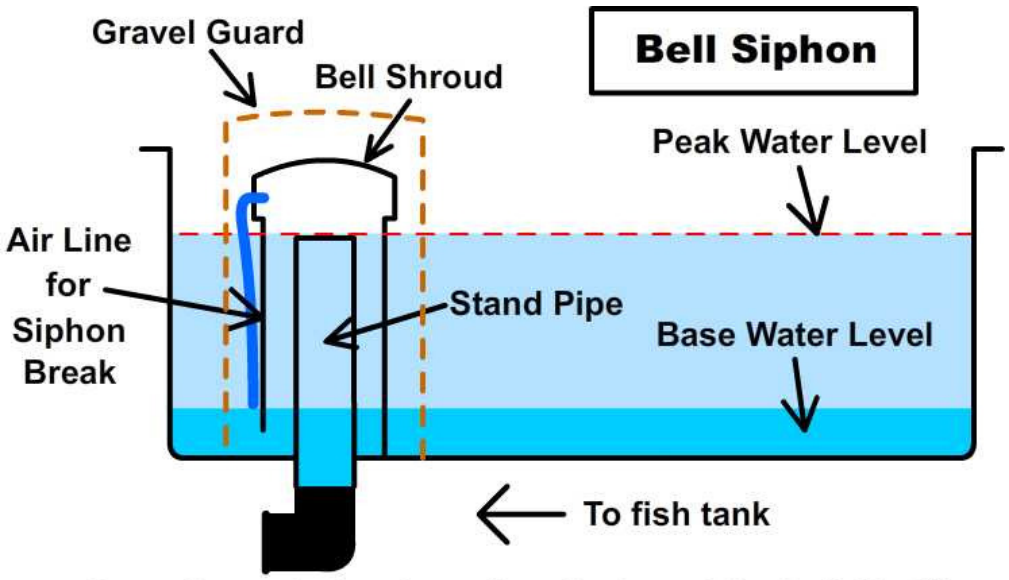
Once the water level reaches the top of the loop, it will begin to drain and create a siphon when enough water flows to break the air lock.

Bell siphon



A bell siphon works on the same principle as the loop siphon but is a bit more complex to complete as it consists of several components starting with a vertical stand-pipe. The height of the stand-pipe will determine the maximum level of the water before drainage occurs. Our grow-bed is 6” deep with the clay media filling it to the top. The water level should be 1” below the top of the media so the standpipe would need to be 5”.

There are 3 parts to a bell siphon. The standpipe which determines the water level, the bell shroud with air-line which determines the level at which the water will stop draining, and the gravel/media guard.



Once the water level reaches the top of the bell, it will begin to drain and once it flows enough to cut off the air coming in from the bottom, it will create a siphon.

A standpipe is all that is needed when using the deep water culture method but in an ebb and flow system the standpipe is surrounded by another pipe called the bell which is twice the size and is covered with a cap at the top with holes or slits at the bottom to allow water to enter. A small tube is inserted in the top cap and runs along the side to the bottom where air can enter once the water drains to a certain level to break the siphon.

The gravel guard is a perforated shroud is placed around the assembly to keep the gravel/rock medium away from drain.

You can download a PDF file from the **College of Tropical Agriculture in Hawaii** that explains bell siphons in detail here:

http://www.ctahr.hawaii.edu/oc/freepubs/pdf/BIO-10.pdf

This may seem like a complex process but once you understand the principles behind the design, it's really quite simple and works very well for our grow-bed system.

The difference between the loop and bell siphons is that the loop system will drain the bed completely of water while the bell siphon will always leave a layer of water and sediment at the bottom (Unless you place your drain outlet on the side of the bed). This is very beneficial for the plants and gives the bacteria a place to grow. Plant beds in operating in this manner for a year or two will actually see an increase in growth rates and plant yields.

Aquaculture Permits

A permit may be required to grow certain types of fish depending where you live. Contact your local or state wildlife authorities for regulations and fees (if any) for keeping an enclosed aquaponics system on your property. Releasing wildlife into a controlled ecosystem can have disastrous effects. Take care if you ever decide to release your fish into public waters. Species of fish have been known to ruin lakes because of carelessness.

The Aquaponics System

When sourcing parts, be sure to use only food grade plastics such as Rubbermaid products and PVC. Black or darker colored plastics are more UV resistant and will last longer. If you are using light colored plastics for your fish tank, paint the outside with a dark colored paint specially made for plastics. This will keep algae growth to a minimum. (In our example, we use a black Rubbermaid feed trough for the fish tank and a 2'x4'x6" hydroponics flood table for the grow bed).

Metal parts should be avoided for use when in contact with fish or water. If you are using recycled parts or used plastics, know the history of use and avoid those that have had contact with chemicals. When in doubt, always use fish/plant friendly parts.

There are a number of online systems that you can purchase for anywhere between $2,000 and $6000. If you haven't already seen these, a good example of what's available and the cost can be found at http://www.backyardaquaponics.com

We show you how to build a comparable system for around $300. Obviously when you do-it-yourself you can save thousands! Here's the breakdown for our system and list of all the system components you'll need:

Stock Tank	**$80**
Grow Bed	**$45**
Cinder Blocks	**$22**
Wood Planks	**$04**
Hydroton Pellets	**$60**
Water Pump	**$25**
Air Pump	**$25**
Plumbing Parts	**$40**
Total:	**$301.00**

Fish Tank – You can use just about anything for a fish tank that is durable and holds water well. Make sure that you know the history of used plastic and that it hasn't been used to store chemicals. If your tank allows light through paint the outside of it with paint specially formulated for plastics. We sourced our fish tank locally for $89 at a local animal feed store. You should be able to find the same at any agro/feed store. I've found a 100 gallon tank online for $77 from True Value but shipping will cost an extra $32.00.

You can use something as cheap as a Rubbermaid 50 gallon trash can for about $20 at Wal-Mart, however fish like to swim horizontally rather than vertically and the more water surface area you have, the better for keep the water oxygenated.

The size of the tank should be determined by the number of grow beds/size you plan to use. The ratio for the amount of water in your tank to the amount in your grow beds is about 1:1. If you have a 100 gallon tank you can easily service four 25 gallon capacity 2'x4'x6" grow beds (already accounting for the displaced media).

If you don't have access to these locally, you can order them online at any of these websites: http://www.usplastics.com, http://www.aquaticeco.com , http://www.plastic-mart.com

Grow Bed – Plant grow beds can be difficult to find locally but are available on the internet by doing a search for "flood table" or "hydroponic flood table". These are made specifically for hydroponics and the price can fluctuate by as much as $100 depending on where you buy so shop around.

I found a 2'x4'x6" Hydrotek flood table online for less than $50 including shipping. There are more expensive tables on the market that are thicker and more durable.

I would definitely recommend one of these if you are planning on using gravel media because it is so heavy. Otherwise the less expensive ones should work just fine.

It takes more work to do so but you can build your own out of wood quite cheaply and use a plastic bed-liner to make it waterproof. Just make sure that your drain hole is well sealed from leaks. For the sake of simplicity, we are using a plastic 2'x4' flood table.

Your grow bed/s should be at least 6" deep to accommodate the clay/rock medium and about 5" of water. The volume capacity of the grow bed/s should be more or less equal to the volume of your fish tank. So if you are using the 100 gallon tank your grow bed/s should be able to accommodate 100 gallons of water. Keep in mind that when using Hydroton (clay media) it will displace about half of that volume so a 25 gallon grow bed will hold 10 to 12 gallons of water just before the drain cycle.

note: For Aquaponics, a 12" deep grow bed is recommended for the widest variety of plants especially root plants such as carrots, onions and beets. The problem is that these trays are extremely expensive and require twice the amount of Hydroton. You can still grow most vegetables in a shallower tray which cuts costs considerably.

When starting out don't worry if your grow bed isn't as big (in capacity) as your fish tank. All you have to do is use less water by lowering the peak water level in your tank or by displacing the water with any type of pH neutral material in your tank until you are ready to add another grow bed. Just remember the 1:1 ratio. *Note: a 1'x1'x1' area of water holds about 7.5 gallons of water.*

http://americanaquaponics.com is a good source for ready-made plant beds or do your own google search for “flood tables” to bring up a list of online suppliers. You should be able to pick one up for around $50 including shipping.

Sump Tank – This is an optional tank to prevent the water levels from fluctuating in the fish tank during the flood and drain process. A sump tank must be placed above the level of the grow bed or a second water pump must be used. Keep in mind that relying on a second pump can be costly in the event of breakdown due to water overflow and total system failure. If you choose to run a sump tank with a pump, have a backup plan handy to avoid water loss.

Water pump – The size of the water pump should be big enough to handle recycling the water about 4 times per hour. 15% to 20% of the water in the grow bed will remain so only about 12 gallons will be displaced per cycle in a 15 gallon grow bed. To fill that 4 times in an hour you would need 4 x 15 = 60 gallons so you would need at least a 100 GPH pump at a 4 ft. pressure level. More than this is ok because the overflow will go straight into the fish tank for circulation and oxygenation. For this size of system a typical submersible water pump rated at 250 GPH will output 100 GPH when pushing water up 4 feet. This is still over-kill for a single 2'x4'x6" bed system but your overflow will be going directly back into the tank so it’s ok to use.

Because the pump will be placed directly into the fish tank, make sure it can handle small debris such as fish waste and unused fish food. For our system we'll be using a magnetic drive pump because it requires less moving parts and is designed for constant use without seals to wear out.

You can purchase your pump at http://www.aquaticeco.com or you can do a search to see if you can find a better deal.

Air pump – It is really tough to put too much oxygen into your system so going overboard on this part shouldn't be a concern. The minimum air output should be around 5 to 10 GPH for each gallon of water in your fish tank. Any pump will do that is rated for the size tank you'll be using in your system.

We are using a Fusion Air Pump 700 found here: http://www.thatpetplace.com/pet/prod/240194/product.web

Grow Bed Media – (Gravel/Rock/Clay pellets)
You can use gravel which is cheap but keep in mind that depending on the type of rock you use, it can affect the pH of your water and it may need constant adjustment which can be a shock on your fish.

We are using clay pellets for our grow bed because they are pH neutral and hold moisture well. They are also much lighter than gravel which means less work to reinforce your table because of weight. Clay pebbles can be purchased at most hydroponic shops or you can order online. Hydroton seems to be the cheapest brand on the internet. You should be able to order a 50 lb. bag for about $20 before shipping.

Plastic Plumbing, Hose and/or Tubing –

Most of these parts can be found at any hardware store such as Lowes, Home Depot, Ace Hardware, True Value or your local hydroponics store.

Plants

When using a gravel/rock filled grow bed with the ebb and flow method, you can grow just about any kind of plant you like. Seeds can be planted in the grow-bed but it is recommended that they be sprouted in a separate grow-bed or separate ready-made seedling pots. Coconut fiber works well as a growing medium and holds moisture while allowing air to reach the roots. It's also easy to clean off the roots when you are ready to transplant.

After about two to three weeks of growth your plants should be mature enough to transplant to the grow bed.

Just rinse the roots of any debris and plant them in the bed medium. Your plants may grow fast depending on how well your system is chemically balanced but they should grow even faster once your grow beds have had time to mature.

If you plan on growing through the winter keep in mind that growth rates will slow down with colder temperatures and you may want to grow only plants and fish that do well in cold weather during this time.

You can plant your seeds directly in your grow-bed media if you wish although I find it easier to sprout them first. Transplanting also makes your plants stronger with healthier root systems.

Just as in any garden your plants may suffer from mineral deficiencies but don't worry, they are easy to deal with. Seaweed extracts are a great way to add nutrients that are lacking in your aquaponics system and for the most part come without additives that might be harmful to the fish and bacteria. You can also use powdered minerals but use caution especially if you've never used them before. Most problems with fish are caused by shock or stress often caused by changes in the chemistry of the water.

Using good quality feed with lots of minerals is not only good for the fish but for the plants as well which means less or even no supplementation will be required.

Happy Fish = Happy Plants!

Plant growth rates from an aquaponics system are much faster than those planted in soil because the plants have all the water and nutrients they need. Even on a regular watering cycle, plants grown in-ground will use up water faster on a hot day and may not get enough liquid to combat the heat leading to burning and wilting. That in combination with a depleted soil composition can hamper the growth of any plant (except for weeds of course).

Aquaponic plants get watered constantly on autopilot with mineral and nutrient rich food. When setup properly, some types of plants in an aquaponics system will yield up to 20 times more food up to four times faster than traditional in-ground gardening methods. That means you can see a difference in the growth of your plants in as little as a day!

Here are some plants that grow well in an aquaponics system:

Leafy Greens:	**Vegetables:**	**Herbs:**	**Root Vegetables:**
Lettuce	Tomatoes	Chives	Radish
Spinach	Squash	Cilantro	Carrots
Swiss Chard	Peppers	Parsley	Ginger
Watercress	Beans	Dill	Garlic
Cabbage	Cucumbers	Mint	Onion
Kale	Peas	Basil	Shallot
Okra	Celery		Arrowroot
	Zucchini		Parsnip
			(12" deep grow bed recommended)

Take care and use best practices when harvesting your plants. Use clean hands and tools touching only the food part of the plant. Use gloves when handling the roots and gravel to avoid contamination.

For more info on plant safety, download and read this PDF (also from the College of Tropical Agriculture in Hawaii).

http://www.ctahr.hawaii.edu/oc/freepubs/pdf/FST-38.pdf

Fish

There are many different species of fish that will work well in an aquaponics system. In fact, just about any type of fresh-water fish will work as long as you can provide the right temperature and food for your chosen species of fish. You can grow edible fish for protein if you plan to eat them or if you don't like fish you can choose something like Carp or more decorative versions such as Koi or even Goldfish. Most people choose a fish that's available locally and compatible to local lakes and streams. Here are just a few of the more popular types you can use in aquaponics:

Tilapia

Tilapia is an extremely popular fish for aquaponics because they grow fast and can withstand poor water conditions. They also are flaky and mild tasting as a food.

They do require warm water so they are better suited for tropical climates above 60 ºF. Most tilapia variations cannot survive below 50 ºF. Tilapia fish consume floating aquatic plants, such as duckweed, most "undesirable" submerged plants, and most forms of algae.

More: http://en.wikipedia.org/wiki/Tilapia

Trout

Trout can handle much cooler temperatures and are most comfortable between 50 º and 60 ºF. Young trout are referred to as troutlet, troutling or fry. They are distributed naturally throughout North America, northern Asia and Europe. Trout generally feed on other fish, and soft bodied aquatic invertebrates, such as flies, mayflies, caddis flies, stoneflies, mollusks and dragonflies. Adult trout will devour smaller fish up to 1/3 their length. Trout may feed on shrimp, mealworms, bloodworms, insects, small animal parts.

As a group, trout are somewhat bony, but the flesh is generally considered to be tasty. The flavor of the flesh is heavily influenced by the diet of the fish. For example, trout that have been feeding on crustaceans tend to be more flavorful than those feeding primarily on insect life.

More: http://en.wikipedia.org/wiki/Trout

Catfish

Channel catfish are native to the Nearctic eco zone, being well distributed in Lower Canada and the eastern and northern United States, as well as parts of northern Mexico.

Channel catfish possess very keen senses of smell and taste. At the pits of their nostrils (nares) are very sensitive, odor-sensing organs with a very high concentration of olfactory receptors. This combination of exceptional senses of taste and smell allows the channel catfish to find food in dark, stained, or muddy water with relative ease.

Channel catfish are omnivores and can be caught using a variety of natural and prepared baits, including crickets, night crawlers, minnows, shad, crawfish, frogs, bullheads, sunfish, and suckers.

Channel fish are best kept in water with a temperature of 70-85°F but can accept a wide variety of temperatures without taking damage.

More: http://en.wikipedia.org/wiki/Channel_catfish

Carp are various species of oily freshwater fish of the family Cyprinidae, a very large group of fish native to Europe and Asia.

Carp have long been an important food fish to humans, as well as popular ornamental fishes such as the various goldfish breeds and the domesticated common carp variety known as koi. As a result, carp have been introduced to various locations, though with mixed results. Several species of carp are listed as invasive species by the U.S. Department of Agriculture, and worldwide large sums of money are spent on carp control. In Asia, the farming of carp continues to surpass the total amount of farmed fish volume of intensively sea-farmed species such as salmon and tuna.

Carp, along with many of their cyprinid relatives, are popular ornamental aquarium and pond fish. The two most notable ornamental carps are goldfish and koi. Goldfish and koi have advantages over most other ornamental fishes, in that they are tolerant of cold (they can survive in water temperatures as low as 40 ºF, can survive at low oxygen levels, and can tolerate low water quality.

There are lots of varieties that will work for aquaponics but the best fish to use in your system for your climate is likely to be the species that are popular in your local lakes and streams.

Sourcing fish can be a challenge depending on where you live. There really aren’t many stores online that carry a variety of stock fish. Local hatcheries usually specialize in a single type of fish.

Other species that can work well in your tank are fresh water mussels, prawns and crayfish.

The amount of fish you can use in your system depend on the number of grow beds and the amount of water you plan to use. A *very* general rule of thumb is to provide 4 gallons of water per pound of fish and about 5 to ten fish per grow bed. This does depend heavily on the type of fish you plan to use, the size of your fish and the size of your grow bed so experimentation is required to determine what is going to work best for your system.

Building your Aquaponics System

Safety First
Always take care when working with water, electricity, children and pets. Always plug electrical appliances into GFI protected outlets. Enclose open water with fencing and never leave water accessible to children.

Before we get started building it's a good idea to consider how you are going to create and maintain the environment that will allow you to grow fish and plants.

Climate – Aquaponics can work well anywhere in the world as long as you provide the right temperatures, nutrients and sunlight. If you live in a tropical zone, keeping fish and plants year round is easy without the use of climate control. If you live in a geographical location where you have seasons, you may need to enclose your system in a greenhouse or indoors to extend your growing season or even keep it all winter long.

If you do plan on an indoor system just make sure your plants are getting enough sunlight through your windows.

During the cold months plant growth will be slowed or halted depending on how well you keep your environment suited for optimum results. Some fish can handle colder temperatures and you can keep them year round as well but keep in mind that if you don't have plant growth, then you will need to provide a different means of filtering the water and keeping it safe for your fish.

Size and Scale – Aquaponics systems are very scalable in that you can add more components over time to increase production. To begin with, a simple system with one tank and one grow-bed will fit well within a 8 to 10 square foot area. With a typical 3 bed layout you may need up to 12 square feet depending you how you place your grow beds but you shouldn't need any more than that unless you really want to go big. In that case you would probably build an advanced greenhouse facility that could accommodate larger or even commercial systems.

Maintaining Water Levels – Over time your system will lose water through evaporation. How much it loses is dependant upon your climate and humidity. Overall however you can expect to have to add water from time to time. For smaller systems, adding cold chlorinated tap water in large amounts could shock your fish. You may want to keep a 5 gallon bucket handy that has already acclimatized and dechlorinated over several days and use this water to refill as necessary. There is nothing you have to do to prepare the water except let it sit in the open air.

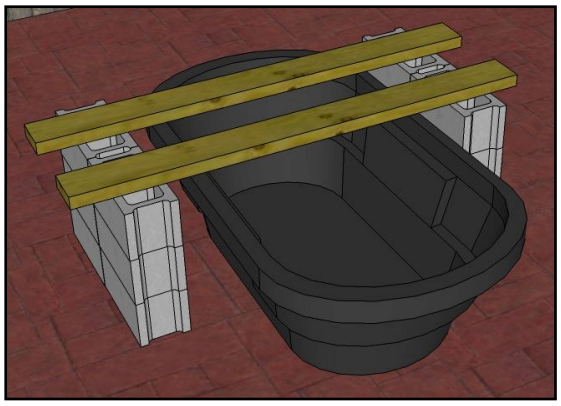
Larger systems (160 gallons or more) shouldn’t have any trouble with tap water being added slowly over time. A simple way to allow your system to do this on autopilot is to attach your water line to a float valve such as the kind you would find in a swamp cooler or toilet tank. In a one-tank system your water level will fluctuate and you’ll have to adjust the valve so that it doesn’t fill your tank too much during the flood stage and then overflow after draining.

System Assembly

Simple layout for easy setup and maintenance

Layout – To save on space, our system places the grow bed over half the fish tank. This way, you have easy access to the grow bed because it is placed at waist level while still allowing easy access to your fish. Plumbing requirements are also kept to a minimum.

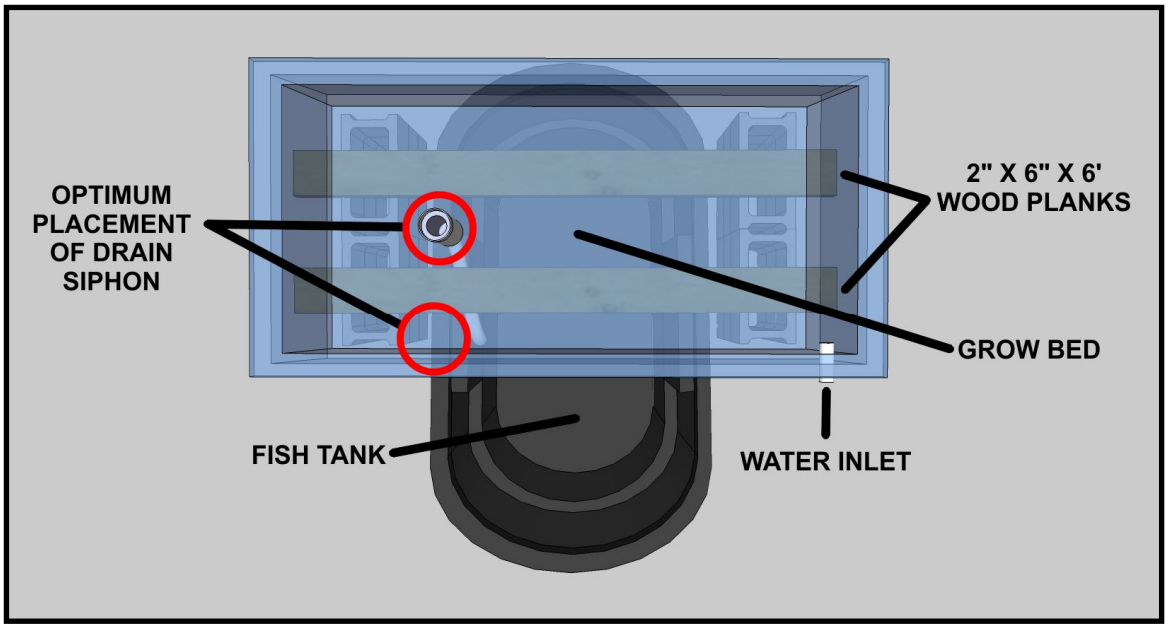
Placing the grow bed over the fish tank also provides shade for the fish and water. Sunlight directly on the water will promote the growth of algae which is not good for the fish or the plants.



Placing the grow bed directly on top of the tank can cause structural failure so we recommend using cinder blocks for support. You could use reinforced wooden table if you wish but cinder blocks are tough enough to support the weight of any size grow bed/s especially if you plan on using gravel as your plant medium. Depending on the structural strength of your grow bed you may need to use wood supports to span the cinder blocks under the grow bed.

You can use 2” x 4” x 6’ lumber or in our example we used 2” x 6” x 6’ pieces. When choosing a place for your system it’s a good idea to have a little room all around the grow bed just in case you need to get back there for maintenance, harvesting/planting, or cleaning so avoid placing it directly in a corner or against a wall.

Once you have the fish tank in place you can position the grow bed over the cinderblock supports. The best place to install the water inlet is on the side facing the open water tank. The drain siphon assembly should be placed at the other end of the bed either in the middle or toward the same side as the water inlet.



Ideally the drain should be positioned at the opposite end of the bed where the water comes in; either between the supports or near the wall.

It’s extremely important during this process that you make your grow bed and fish tank as level as possible (especially if you have more than one.) The water-return relies on gravity and if your bed is off by even a little, it could greatly affect the performance of your water circulation system. It’s better to make sure everything is level now rather than having to drain your water to make adjustments later.

Plumbing Installation

The easiest type of plumbing to install is flexible tubing. You can use PVC if you don't have a source for all the flex components but cutting and cementing can be time consuming depending on the complexity of your system.

The components you'll need:

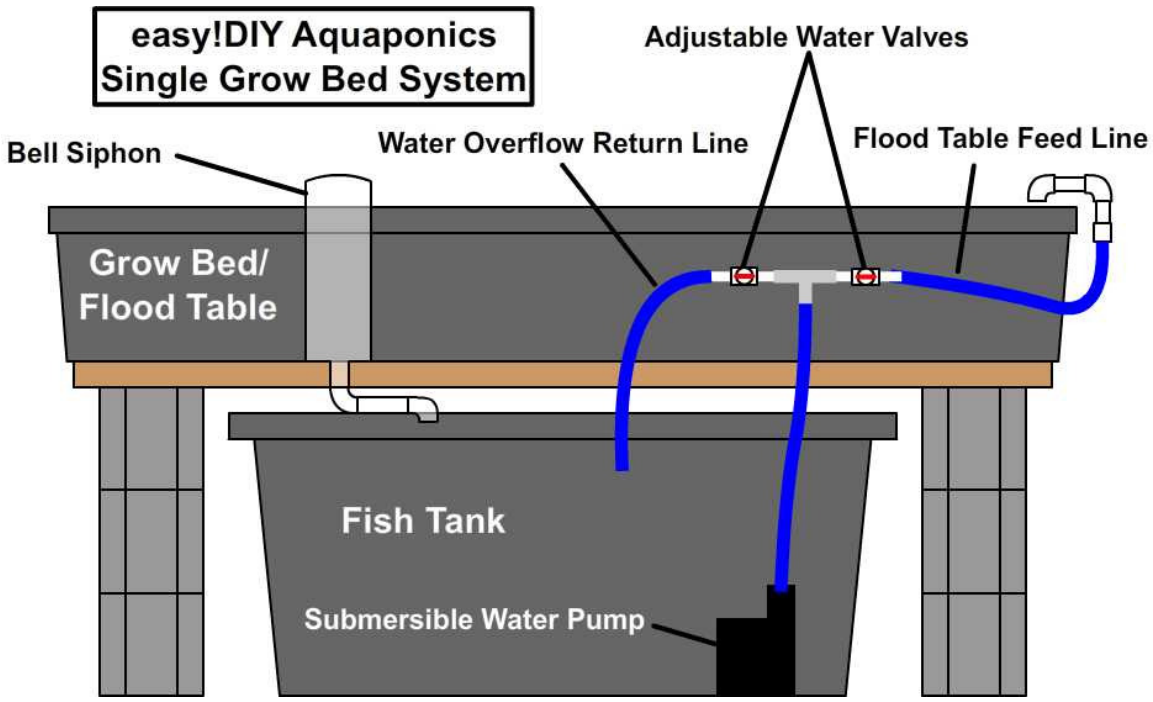
Flexible Plastic Tubing – This will be used for the line coming from the pump to the grow bed. Use any size you like as long as you can fit the correct size adapters to the pump, valves and bulkhead fittings.

Barbed Connectors and Water Valves – These are various types of connectors such as Tee, Elbow and Straight connectors that are barbed for use with flexible tubing. The water valves control the flow into the grow-bed and return line. All of these parts can be sourced from your local hardware store (as ½" PVC), hydroponics store or purchased online by doing a search for "hydroponic valves" or "hydroponic fittings".

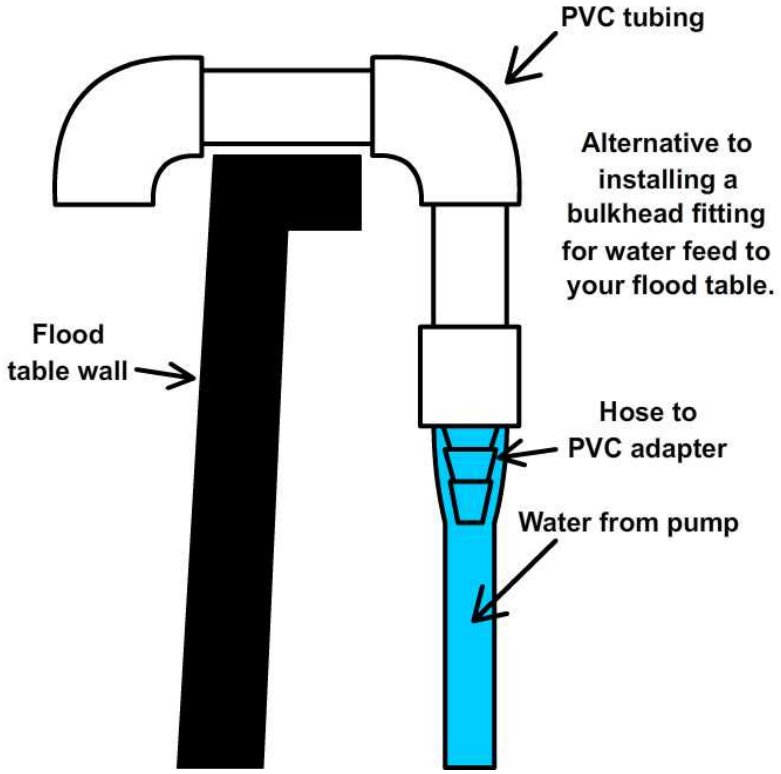
Bell Siphon PVC – You will need a 6" section of 1" PVC for the standpipe and 8" sections of 2" and 4" PVC. (All of these will be cut to size later.) You will also need a 2" top cap for the bell and a 12" length of 7/16" OD vinyl tubing for the air return.

Bulkhead Fittings – These are for the water feed-line into the grow bed and the drain system. Make sure the sizes fit with the plastic tubing you are using.

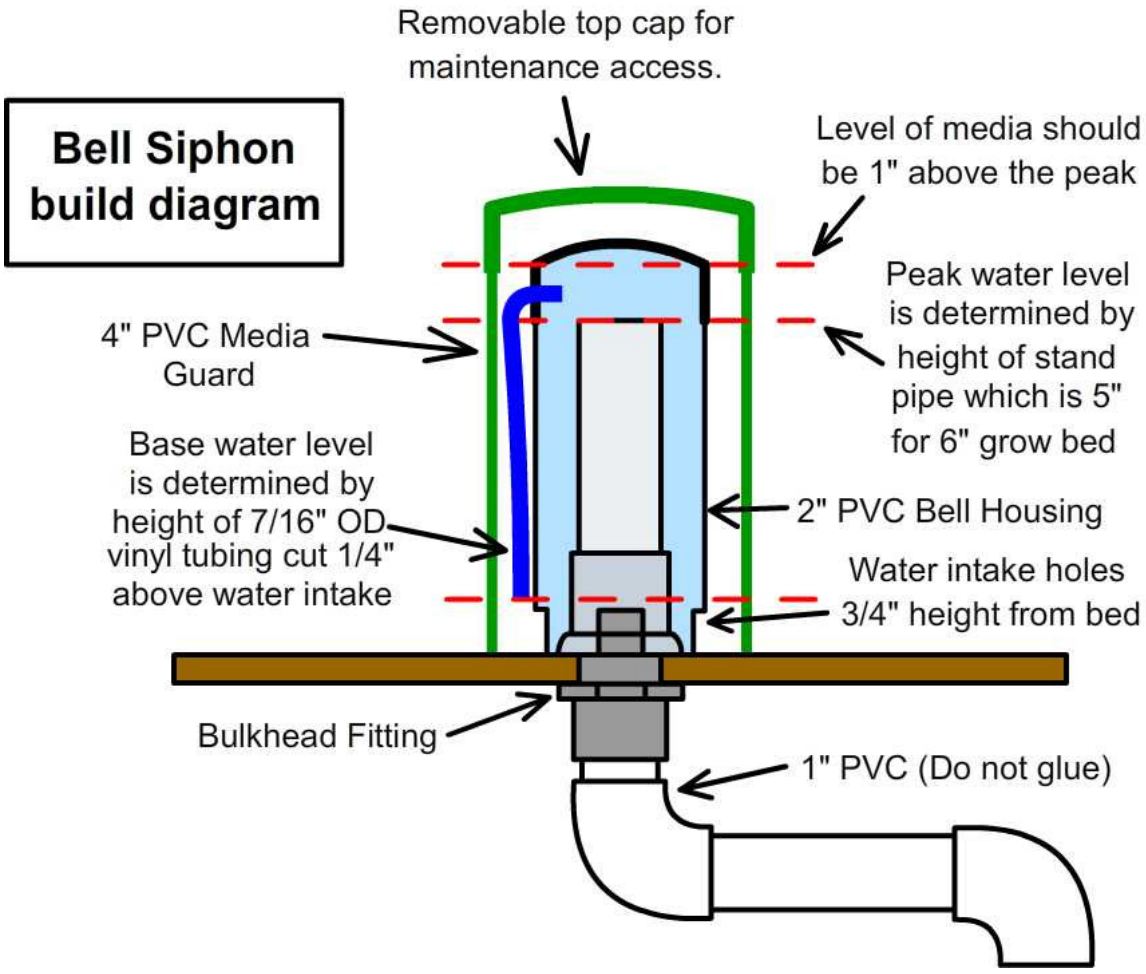
Return line assembly – 1 ½" PVC pipe and elbows for the return line to the fish tank.



(Diagram of the water delivery system)



Assembling the Bell Siphon



There are 5 parts to the Siphon Assembly

1. **Bulkhead Fitting**
2. **Stand Pipe**
3. **Bell Siphon**
4. **Media Guard**
5. **Drain Assembly**

Bulkhead Fitting – The first step is to install the bulkhead fitting into the grow bed. We are using a PVC bulkhead fitting with a threaded 1" PVC adapter connected to the 1" OD stand pipe.

Cut a hole in the bottom of the flood table to the size necessary for the bulk fitting. The one we are using requires a 1 ¾" hole but yours may be different so make sure before you cut because this cannot be undone!

Stand Pipe – Next, install the fitting and the PVC adapters as needed. Do not glue any of the PVC parts together because it may be necessary to make adjustments later. Just make sure the fitting is tight to avoid leaks after any adjustments are made. Cut the height of the stand pipe so that it reaches a top height of 5" from the base of the grow bed to the water inlet at the top. This does not mean that the PVC pipe itself is 5", but the whole assembly sitting above the floor of the grow bed which includes the bulkhead fitting and threaded adapter. This height sets the peak water level for the grow bed.

Bell Siphon – The bell assembly is 2" PVC with a top cap cemented in place. The completed bell should be approximately 6" (including cap) or the height of the grow bed.

Cut ¾" length slits in the bottom for the water to drain through. Drill a hole in the side of the bell cap appropriate for the vinyl tubing and cut it so that it reaches down the tube just ¼" from the slits at the bottom.

It’s important that the line is above the drain holes otherwise air would never enter the tube to break the siphon allowing the bed to fill again.

Secure the tubing to the bell housing with a zip-tie but do not pinch or kink the line.

Media Guard – The last step is to create the media shield which keeps large debris away from the drain assembly. Perforate the tube with holes using a hand drill or drill press or use a hand saw to cut slits in the pipe. There’s no science to this process, all you need is enough material taken away to allow water through while keeping the media out. Place 3” cap on top but do not cement it in place or install a threaded end-cap with removable lid. Drill a small breather hole in the top of the lid so that air can penetrate the chamber.

Drain Assembly – To complete the lower half of the drain assembly, install a small section of 1” PVC in the bottom of the bulkhead fitting. Attached to that is a 90° elbow with a 6” to 12” section of 1” PVC to another 90° elbow. This section also does not need to be cemented because you will want to make adjustments later when tweaking the siphon and drain system.

Water Circulation System

Install a hose adapter into your pump system that will allow you to connect the size of hose you are using and connect enough hose to reach your bulkhead inlet fitting.

Within this section of hose you will need to install a Tee which feed two valves which will regulate the water flow. One valve will control the water running into the grow bed while the other will regulate water returning back into the fish tank. The reason for the return line into the fish tank is so that we don't put too much back pressure on the pump and lets it run at full power as it was designed for. This also helps circulate the water keeping it well oxygenated for the fish and plants.

Adding Working Components

There are 4 parts to this process and each part should be completed in order.

1. **Grow Media**
2. **Water and Chemicals**
3. **Plants and Nutrients**
4. **Fish and Waste**

(For this part we've created a startup schedule for your aquaponics system that you can download from the membership site to help make this critical step an easy process.)

Grow Bed Media – In our ***easy! DIY*** kit, we are using Hydroton clay pellets which are quite a bit more expensive than rock or gravel, but it is pH neutral making it much easier to manage water chemical levels. Clay holds moisture well keeping the plant roots well hydrated. It's also much lighter and easier to manage. When adding water to your system, you may find that it quickly becomes discolored and "dirty". You can choose to wash the pellets if you wish or you can simply let it run through your system and settle in the grow beds.

If you do choose to use gravel or rock, make sure your table support and grow bed can handle the added weight. One of the easiest ways to do this is to use 2"x4" lumber laid upright rather than flat in the same way floor joists are used to support the wood flooring surface above it.

Water – Once your system is completely built, it's ready for a water test. Fill up the grow bed near capacity which should be almost 5" for a 6" grow bed. Check the bulkhead fittings for leaks. Fill up the fish tank enough to get the pump going and start circulating the water into the grow-bed. Check the plumbing for leaks.

This is a good time to adjust the fill rate for the water flowing into the grow bed. Adjust the valve so that the flow is more than a trickle but less than wide open.

Running the water too fast or too slow will affect the performance of your siphon system so experiment with the flow rate until your bed drains and cuts off the siphon properly when emptied. You may also need to adjust the elbow beneath the drain to where the water flow is enough to start the siphon once the bed fills to capacity.

Your grow bed/s should cycle the water approximately twice every hour. If you have any leaks or plumbing issues, now is the time to fix it. When you are satisfied with the function and timing of your system you can add bacteria. If you have access to water from a local lake or river adding this to your system will help boost the cycling process naturally.

To test your cycling process without experimenting on fish, you can add ammonia which will feed the bacteria and make it grow. Simply add a teaspoon of pure ammonia to your tank once every 3 to 4 days but don't let it spike above 1 ppm.

Run your system for a few weeks this way and test. If you system is reading below 1 ppm, it means your system is cycling it properly. Just remember that you want to add fish at the low point of the cycle when your ammonia levels are reading zero or close to it so wait a few days before adding fish.

Make sure your ammonia is pure ammonium hydroxide and water in a ratio of 1 part ammonia to 3 parts water.

Any other chemicals in your ammonia will harm your ecosystem and may require a complete scrub-down of all system parts including your grow bed media. This can be very time consuming so always check your source to ensure purity.

Tap water in most homes will most likely have been treated with chlorine. Running the system for 24 to 48 hours will remove any detrimental effects any residual chlorine would have to your system. You can use this time to prepare your water by testing and adjusting the pH as necessary. If you do have to add chemicals, it's good idea to circulate your water for another day or two after treating it before you add plants and fish.

You will see your water levels drop due to evaporation so it's important to have water on hand that you can add as needed. Keep a 5 gallon bucket of water handy that's had at least 48 hours to blow off any chlorine and adjust to outside temperatures. Always add water to the fish tank and not to the grow bed so that you don't disturb the ecology within the media.

If you have an automatic fill valve filling your tank, make sure that the water trickles in as little as possible so that the water change is gradual and doesn't shock the fish. This method is best used on larger systems with 500 gallons or more circulating through the grow beds and tank/s.

Any changes made to the water chemistry needs to be gradual.

Raising or lowering the pH of your water takes time. After you add chemicals, let your system circulate for a day and then test again. Follow this procedure gradually until the water is considered stable. You may need to add a lot of chemicals or you may not need to add anything but this is the time that most of your adjustments will take place. Once you have your ecosystem running for a while, it will often adjust itself as necessary to adapt to these various changes naturally.

Don't be surprised if this step takes a few weeks to complete. Patience is the key and will save you a lot of headache and problems in the future if you take the time to understand the process, test often and make small changes as necessary.

Plants – Once your water is ready you can begin adding plants. The easiest way to introduce plants to your grow bed are as seedlings. You can often buy garden ready plants from your local garden store or start your own by planting the seeds in seed pots.

They should be ready to transplant after a couple of weeks growth. Just rinse off the roots, displace the grow-bed media just as you would if it were dirt and bury the plant up to the first set of leaves. After you have your bed filled with the desired amount of plants, water them twice a day for the next two days until the plants have settled.

Because there are no nitrates to be found in the water to feed your plants, you will need to add plant food until your fish are ready.

One of the easiest ways to do this is to add seaweed extract such as Maxicrop or Seasol to your water.

Fish – The last step is to add fish. A good ratio for healthy fish is 5 to 10 gallons of water per pound of fish. This all depends on what your ecosystem is naturally adjusted to handle. As long as you make changes slowly, your aquaponics system will automatically adjust as needed.

Before you add your fish, test your water to make sure your temperature and ph levels are within limits. Your nitrate readings should also be less than one or not detectable. If they are at 1 or more allow your system to continue cycling until it drops back to zero.

If you are going to be introducing small fish or fingerlings to your system, place the bag of fish intact, inside the tank water allowing the temperature to adjust. This is a gradual change and should be completed in about 30 to 45 minutes.

After the temperatures are matched, and to make sure that you don't shock your fingerlings, add a cup of water to the fish bag ever 10 min. or so for about an hour. This will help acclimatize your fish to their new environment by adjusting any pH and Oxygen differentials.

When your water is ready, tip your bag into the tank water and let your fish swim out into the tank.

If your system is cycling properly, you should have bacteria in your grow beds to help process the fish effluent. You may see spikes in ammonia but they should return to undetectable levels in a few days.

Chemicals and Nutrients

One of the most important things you can do to keep your fish happy and your plants growing is to test the chemistry of your water. There are 3 things you need to test for and keep in balance.

- Water pH
- Dissolved Oxygen (DO)
- Ammonia/Nitrites/Nitrates

You can test your water either with a liquid chemical kit or test strips. Chemical kits cost more but are preferred because of their accuracy. Test strips will work and are cheaper but not as accurate so if you want to take less risk, use a liquid chemical test kit. Otherwise, test strips are better than nothing.

It’s a good idea to keep a log of your test results so that you can track your system over time. Write down when you added chemicals, how much and the water test results. Use the one we’ve created for you or make your own.

There are over-the-counter chemicals that you can buy specifically for aquariums that will work for your aquaponics system. Just make sure they do not have additives that would be harmful to your plants.

Note: Many of these chemicals can be extremely harmful if used or handled improperly. Always follow instructions for proper handling. Use safety gear such as rubber gloves and safety goggles.

Water pH – Testing the pH of your water will determine whether it is Acidic or Alkaline. Too much acid is bad for the fish and too much Alkalinity will kill the plants. A pH level of 7 is neutral and is best for the fish and plants both although a range between 6.8 and 8 is acceptable. Any less than a pH of 7.0 and your bacteria will not grow which will increase your ammonia levels. Leaving you system in this state for too long will have a detrimental cascading effect on your fish and ultimately your entire system.

Most of your changes to the water pH will occur before you add fish and plants. If you need to adjust pH afterward then do so slowly. Any quick change over a few percentage points (.2 plus or minus) will be hazardous to your fish. If you constantly have to adjust your pH, something in your system is causing it and should be eliminated.

If your pH gets too low (becomes acidic) use pH increase equivalents such as sodium bicarbonate (baking soda), Calcium Carbonate powder or (ground egg shells, sea shells, or snail shells), Potassium Hydroxide, Potassium Carbonate, Potassium Silicate, Phosphoric Acid or Sodium Phosphate.

Calcium carbonate is good to use because it will dissolve until your pH hits 7.4 where it will remain until it's depleted.

If you pH gets too high (becomes alkaline) use pH decrease equivalents such as vinegar, citric acid or iron sulfates. You can also use stronger pH equivalents such as nitric, hydrochloric and sulfuric acids. Just remember to make small changes or it will shock your fish. They have a much more difficult time dealing with radical pH changes than they do with a slightly high or low pH level that they're already accustomed to.

Again, many of these chemicals are corrosive and dangerous to handle so follow instructions and use safety gear.

Keep in mind that smaller crushed particles act quicker to change pH levels while larger particles dissolve over time and affect your system gradually.

Your water pH will fluctuate by a few 10ths during the Nitrogen cycle so if you don't see any drastic changes, it may be best to just leave it alone and let nature balance your system, especially once it's been established and running for a few months.

Dissolved Oxygen – One of the most common reasons for fish death besides too much ammonia is lack of oxygen. The target for DO in the water is about 4 ppm. Keeping the water circulating may be sufficient to keep the oxygen level up but the easiest way to ensure there is always enough is to use an air pump common to aquarium fish tanks. Keeping the water well oxygenated is also necessary for the nitrification process. There are testing kits available for DO but if you have an Air Pump you should be fine.

Ammonia/Nitrites/Nitrates – Ammonia is toxic not only to fish but to plants as well but it needs to be present in your system in order to produce bacteria. That's why media filled grow beds work so well because the surfaces of the clay pellets or rocks is a natural habitat for these types of bacteria. When ammonia is introduced to the system (through fish effluent), bacteria such as the Nitrosomonas species will naturally grow and convert the ammonium to nitrites (NO_2^-). Another form of bacteria (Nitrobacter sp.), will then convert the nitrites into nitrates (NO_3^-).

Any level above 5 ppm for ammonia is very toxic and must be managed. Ideally your water should test at 1 ppm or not detectable. If it gets too high to manage with the normal cycle, change the water out 1/3 at a time per day until ammonia levels reach 1 ppm or less.

Nitrite reading should also be at 1 ppm or less. Nitrate readings however are much more tolerable by the fish (more by some species than others) so to be on the safe side, it should be kept under 20 ppm.

It is very important that your pH levels are under control or your bacteria will not be able to grow and you could see spikes in your ammonia levels. The optimum pH range for Nitrosomonas is 7.8 to 8 while the optimum pH for Nitrobacter is 7.3 to 7.5. Bacteria growth will slow below 7.0 and stop at 6.5.

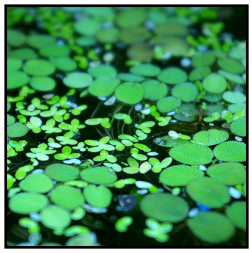
Plant Food – Plant food only needs to be used until your bacteria have developed to where it will convert ammonia. This is usually only necessary during the startup process between the time you plant your seedlings and add your fish. Any type of plant food used in hydroponic gardens should work well as long as it's free of chemicals harmful to fish. Seaweed concentrate is generally considered to be safe for fish and has plenty of nutrients for just about any type of plant you wish to grow.

Add the recommended amount of seaweed extract for the amount of water in your tank and grow beds. Continue to add about ½ to 1 oz. per day for the next 4 to 6 weeks.

Fish Food – When feeding your fish you want to keep them well fed but don't overfeed. Any food that doesn't get eaten will add ammonia to your system and you don't your water to become toxic. If your fish don't eat all the food within a few minutes, adjust the amount. Uneaten food will decompose and create toxicity. If you do add too much fish food, simply remove the uneaten waste. Feed your fish at least once a day.

If you wish to raise fry (newborn fish) or fingerlings (small to medium), keep them separated from the larger adult fish. You can keep them in a basket within the main tank, or keep them in a separate tank.

Fry eat micro worms, brine shrimp or soft foods while fingerlings will eat flake fish food. Most mid to adult fish will eat pellets, worms and insects.



Duckweed is a popular plant for aquaponics because it's easy to grow and great for fish food. You can easily add a (duckweed only) grow bed to your system using the deep water culture method. Just keep in mind that although it's healthy for the fish with plenty of nutrients and protein, it does consume more nutrients from the water than most plants. Those interested in growing fish only can grow duckweed instead of vegetables.

The easiest way to simplify the feed process is to buy fish food specific for the age or size of your fish. And excellent online source for fish food and other supplies can be found at Nelson and Pade, Inc. here:

www.aquaponics.com

Nitrifying Bacteria – When ammonia starts to show up in your system, bacteria will begin to grow in your clay/gravel bed but this process can take a month or two to level off and stabilize. You can give your system a boost in the mean time by adding the nitrifying bacteria gradually to your water if you see spikes in ammonia levels.

Worms – One of the best ways to increase the health of your system, believe it or not, is to add worms to your grow-bed media. The worms will eat the fish waste and produce worm castings which the plants love.

Minerals – Most of all the minerals and nutrients your plants need will come from the nitrates and supplements provided by the plant food (Seaweed Concentrate) until your system has become it's own independent ecosystem. Some of the minerals that may need to be supplemented are Iron, calcium and potassium. Iron deficiencies can be addressed by adding chelated Iron directly to the water.

Conclusion

Growing your own food can be very rewarding! When you face challenges with your aquaponics system, keep at it. It's worth it in the end. As you gain experience you may lose fish and/or plants and can be very discouraging but remember that it's just part of the learning process.

As you work on your own aquaponics system I would encourage you to get to network with other enthusiasts in your area. Use the message boards online and get to know your local hydroponics and aquarium suppliers to help you solve any problems that may arise.

http://www.aqaupoonicscommunity.com is an excellent resource for ongoing information and news involving the aquaponics community.

Keep to the maintenance schedule and keep your system balanced. Feed your fish well, keep them happy and your plants will follow.

Thank you for reading and I wish you the best of luck with your own aquaponics adventure!

Visit http://members.easydiyaquaponics.com often for updates, videos, articles and additional resources.