

Endless Food Source



HOW TO FEED YOUR
ENTIRE FAMILY FOR LESS
THAN 10 BUCKS A MONTH

Table of Contents

The Growing Problem	4
House of Cards	5
Why YOU Must Become a “Farmer”	6
The System of Abundance.....	8
Advantages of Aquaponics:	9
Infinite Flexibility.....	9
Basic Aquaponic System Components	11
Fish Tank.....	11
Plant Trough (Runway)	12
Air and Water Pumps	13
Types of Aquaponic Systems.....	15
Media Bed.....	15
Raft	15
Nutrient Film Technique (NFT)	15
Operation Modes.....	16
Ebb and Flow (Flood and Drain)	16
Constant flow	17
6. The IKEA Shelf Starter System	18
Why Start Small?	18
Materials Needed:.....	19
The Framework.....	19
The Drain Pipe.....	20
The Pumping System	22

Installation	23
Add Media, Plants, and Water	25
7. Peripherals.....	29
Timers	29
Test Equipment.....	29
Some things to consider about both bacterium when cycling a system:	33

The Growing Problem

Throughout human history, food shortages, crop devastation, and famine have been the rule, rather than the exception... until the 20th Century.

In the span of a few short decades, advances in technology, agriculture, and transportation have made it possible for citizens living in the developed world to stop focusing their time and energy on finding food. In fact, nutrition has become so abundant that America is facing an obesity epidemic. In many aspects, these advances have led to the greatest period of economic development that mankind has ever seen...

But there's a dark side to all of these advances, one that we're only just now beginning to fully understand. Industrialized agriculture, with its dependence on petroleum, genetically modified crops (GMOs), and government subsidies is putting out food supply at great risk...

The frightening truth is that the average American lacks the skills, experience, and resources to grow their own food.

Houston, we have a growing problem...

As a nation, we've become entirely dependent on grocery stores and complex supply chains for our food. Although we have absolutely zero control or influence over our food supply, we've nevertheless become extremely comfortable with this situation. Fat and happy, you might say.

Most Americans have completely failed to realize how vulnerable we've become to even a minor "food shock."

Conflict in the Middle East, financial collapses, or even a simple trucker's strike could wreak havoc on our food supply. Every year, our politicians threaten to block one bloated "Farm Bill" or another that would cause the price of a gallon of milk to

skyrocket to \$8. While the price of milk may get headlines, the skyrocketing cost of milk would only be the tip of the iceberg -- an iceberg capable of shutting down America's food supply network.

House of Cards

Here's what no politician will ever tell you: In 2008, the United States came incredibly close to a massive food shortage, much like the one experienced in the Great Depression or worse. As much as I hate to say it, our food supply is no more secure today than it was then.

Why? You may think the extended drought in the nation's breadbasket is the greatest threat to America's food supply, but it's not. The shocking truth is that it has less to do with food production than it does with oil, finance, and the value of the dollar.

Most people don't know this, but grocery stores keep only 3 to 5 days of inventory in stock. You see, most Americans believe there's a massive warehouse in the back of every grocery store, crammed with an immense stockpile of food and supplies. If you've ever worked in a grocery store, you know that this isn't true...

We see it every time a hurricane threatens a populated coastal area. Crowds pile into the grocery stores and empty the shelves in a matter of minutes. There's scarcely a can of cat food left on the shelves.



If the dollar fails... or a financial collapse occurs on Wall Street... or if the fires burning in the Middle East ignite the powder keg, the grocery supply chain could break down overnight and panic-buying will begin.

Why YOU Must Become a “Farmer”

Now that you’ve discovered, as so many other patriots have, that America’s food supply chain is only a couple of days away from a collapse at any moment, what can you do about it?



There is only one way to protect your loved ones from disruptions in the grocery supply chain, and that’s taking responsibility for your own food supply. You can do this by storing canned food and water, but eating canned food day after day is by no means ideal.

What if, instead of feeding your family genetically modified junk food (GMOs) shipped in from places like China, you could feed them fresh-caught tilapia, with a side of fresh picked fruits and vegetables?

According to most Americans, it would be nearly impossible to provide this quantity of food without a few acres of land and spending several hours in the garden every day. Either that, or you would have to spend every day at the local farmers market and spend a fortune on food that you can't verify if its genetically modified or not...

However, there is a way to take control of your food supply. Don't worry; you don't have to become a farmer, rancher, or even a traditional gardener. In this report, you're going to learn how to build an incredibly efficient food system, one that produces an abundance of fresh fruit, vegetables, and even animal protein. And this food machine is no larger than the size of your kitchen table.

The System of Abundance

Of course, there's a reason that many farmers still farm, despite the droughts, crop failures, and low profit margins. It's the same reason many of you like to work out in the garden: Fresh air.

Fresh air is beautiful thing, but that's about the only real benefit of traditional farming, a little fresh air. Many farmers have discovered a new method that's much easier and 10X more productive, and it doesn't require acres of land and massive irrigation. It's called "Aquaponics."



Aquaponics is the combination of hydroponics (growing plants in a soil-less, nutrient rich solution) and aquaculture (raising fish). It takes the best of both these worlds, and produces a far superior vegetable yield in a fraction of the time. This without using any chemicals, AND remarkably using less energy than a light bulb. It is electric and therefore can be powered by backup power systems. With a small-attached solar panel, the system can be produce fresh fish for protein and organic vegetables "off-the-grid" in anyone's backyard. Additionally, Aquaponics uses 1/10 the amount of water that conventional gardening does.

Advantages of Aquaponics:

- Aquaponics uses 90% less water than a conventional garden.
- Aquaponics uses a tiny amount of energy, less than a light bulb.
- Aquaponics can produce up to 10 times more vegetables in the same area and time as a garden.
- Labor required is reduced as much as 40% compared to traditional gardening

Infinite Flexibility

Ask 10 people how to build an Aquaponic system, you may well get 10 differing opinions.

The reason for this is simple: Aquaponic systems are infinitely flexible -- they can be as small as a microwave or as big as an 18-wheeler -- because they're so easy to scale once you understand the basics.

Thus, you can begin with a small, inexpensive system that supplements your normal grocery needs, and build it up as you get a better understanding of the techniques involved.



For simplicity sake, we will discuss a very basic system, one that's remarkably simple and very easy to construct. The parts of this system include:

- 1 fish tank
- 1 plant trough (with fittings)
- 1 air pump
- 1 water pump
- Plastic tubing
- Air stones

In addition to discussing each of these components, I will also address the three basic methods of operating aquaponic systems, as well as walk you through a simple build-out using parts that you can buy at your local home improvement store.

Basic Aquaponic System Components

One of the best things about aquaponic gardening is that literally all of the components are readily available at your local Walmart-type store. Most hardware stores will have all of the parts you need as well, even the submersible pump that will circulate the nutrient-rich water through your system.

Fish Tank

Many different containers are used for fish tanks. Some include blue plastic barrels, (IBC Intermediate Bulk Container), farming stock tanks, Rubbermaid type stock tanks, whiskey ½ barrels, and even pre-formed poly containers designed for wire drawers (like I used in my example system in Chapter 6). Never use metal stock tanks, as the zinc coating used in manufacture is toxic to the fish.

The fish tank size greatly determines the amount of fish you can have in your system. Conservative estimates are about one pound of fish per seven gallons of water. One pound per five gallons is standard. Note these weights are full grown size, and your fish will be different sizes. It might be helpful to picture a full grown fish that you would see at a grocery store to get an idea of fish sizes.

Thus conservatively, a 150-gallon fish tank could easily house about 22 pounds of fish. A standard population would be closer to 30. The significance here is that the more fish you have, the more nutrients are produced. The downside is the more fish you have, the more susceptible your fish are to disease and nitrite spikes. It is always good to start small, learn the science of Aquaponics and then expand your system.

When you first introduce fish to your system, they tend to jump out of their new surroundings. Be sure and cover the tank with netting or other material. Your Aquaponic water at no time should

be exposed to direct sunlight. Sunlight kills bacteria! More on this later.

When scoping the fish tank, note that it will not be filled to the top, and when the plant trough is filled, the water level will drop that amount. Fish must have at least two feet of water above them at all times.



Plant Trough (Runway)

Your plant trough size will be largely determined by your fish tank volume and fish population. In general, a fully populated one hundred and fifty gallon tank will support two 6 x 3 grow beds (36 sq. ft.). A fully populated 300 gallon tank will support two 8 x 4 grow beds (64 sq. ft.). These are general values and results are affected by changing factors such as stocking density, types of plants, temperature, time of year, etc.

Your plant troughs should not be more than four feet wide. This is so you can reach the plants in the middle of the trough for trimming and harvesting. If possible, it is also desirable to have the plant trough off the ground for easy access and to help protect the crop from insects and critters.

As with the fish tank, the water must always be protected from direct sunlight. More on this topic will be discussed later.

When scoping the plant troughs, note that when it is filled, the water level in the fish tank will drop that amount. Fish must have at least two feet of water above them at all times.

Air and Water Pumps

Two types of pumps are needed on an Aquaponic system: An air pump, and a water pump. While the size of either of these is determined by the specific Aquaponic system size, a basic aquarium sized water pump and multi-port air pump is all that is needed.

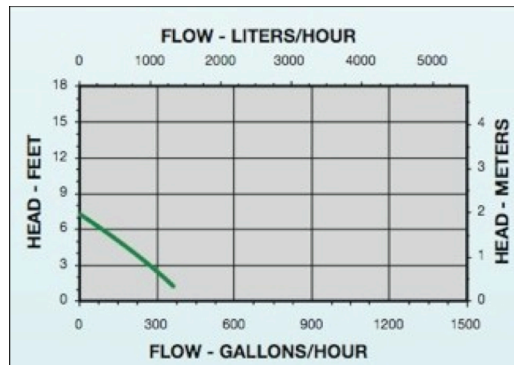
Generally speaking, a two-port aquarium pump is sufficient for a 150-gallon tank and a four port is recommended for a 300-gallon pump. Run your air lines to opposite sides of the tank and be sure to extend the end of the air line to the bottom of the tank for maximum aeration.

The air pump on the system must never be turned off. Fish require sufficient oxygen levels and can perish in a matter of hours if there is an interruption. This is especially true in hot weather. Even after the airflow is restored, fish may die days later due to gill damage.

The size of your water pump is determined by the tank volume and the height needed to move the water. Too big a water pump will fill the plant trough too quickly; too small will not fill it at all. Your plant trough should have an overflow pipe, which will begin to drain when your preset water level is reached.

In general, a three hundred gallon fish tank could support a 300 gallon per hour (GPH) water pump. The amount of water pumped will also be determined by the height the water is being

pumped. This is called head (per feet); the higher the level to pump, the less flow per hour.



Air Stones and Tubing

Two types of tubing are used with an Aquaponic system; one for aeration, the other for water distribution.

DO (dissolved oxygen) is of paramount importance to your fish. The water surface is one of the main sites where oxygen is transferred to the water. Air stones aid in this exchange. When connected to the end of the aeration tubing, oxygen is blended down into the water and carbon dioxide is released out to the air. Aeration tubing is generally about $\frac{1}{4}$ " in diameter and runs from the air pump to the fish tank. At the tank end of the tubing an air stone is attached. It is important to position the air stone at the bottom of the tank to aid in water oxygenation. There are many types of air stones on the market and are a question of personal preference.

Tubing used for water distribution is generally $\frac{1}{2}$ " and runs from the fish tank to the plant trough. It is important that the tubing is black as sunlight will promote algae growth, and will kill the beneficial bacteria. If the plant trough overhangs the fish tank, a short tube is desirable as it allows the water to splash and thus increase the oxygen supply to the fish.

Types of Aquaponic Systems

The three main types of Aquaponic systems used in backyard systems are Media based, Raft, and NFT. The differences are mainly in how the plants are anchored and nutrients delivered. The fish tank is usually the same for each.

Media Bed

Media based systems utilize some sort of inert material to hold up plants in the grow bed. These may include river rock, granite, expanded clay, or other material. A consideration for this type of system is the weight. Depending upon the type of media used, it can be quite heavy. The plants are anchored directly into the media, which holds them firmly in place. Water flow characteristics must also be considered and will be addressed later.

Raft

Raft systems, sometimes called deep rafts, use large floating sheets that are placed directly on the water. They have holes drilled in them to accommodate small baskets in which the plants are placed. As the plant develops, the roots grow through holes in the basket and are exposed directly to the nutrient rich water.

Nutrient Film Technique (NFT)

There are many variations with the nutrient film technique but they basically all use long channels in which to grow plants. These channels have holes in the top in which baskets are placed, similar to the raft system. A thin film of nutrient rich water is pumped through the channels. The concept here is that the root tips absorb the nutrients, while the remainder of the root is exposed to air (oxygen).

Operation Modes

Ebb and Flow (Flood and Drain)

Ebb and Flow is one method used to distribute water (and thus nutrients) to the plant trough. At defined intervals, water is pumped through the system for a specific amount of time. Generally either a timer or auto siphon is used to accomplish this.

A timer, attached to the water pump, can be set at any interval desired, and turned off at night to conserve energy and heat (desirable in the winter). A common setting for Aquaponic systems is “ON” for 15 minutes, “OFF” for the remainder of the hour. When in off mode, water drains back slowly into the fish tank. The principle here is that nutrients are allowed to be absorbed by the roots during the flood stage, and absorb oxygen when the water is drained. “Splashing” water back into the fish tank supports extra oxygen to be added to the water.

Auto siphons such as Bell, Loop, J and U bend, and No holes overflow are another method used to achieve the ebb and flow effect. They can be a bit more difficult to operate and dependent upon the amount and flow rate of water being pumped. As the plant trough fills up to a pre-determined level, water tension within the auto siphon is broken and thus the water is drained back into the tank. This process is repeated after the plant trough is filled again. Auto siphons are not generally available for purchase and must be constructed to fit the system.

Nutrient distribution is efficient with ebb and flow system as the nutrient water is distributed throughout the system with each flood cycle. This is true with each type of Aquaponic system.

Constant flow

As the name implies, the constant flow mode involves pumping water from the fish tank to the plant trough constantly. The plant roots are always submerged in water. Although a constant flow system is the simplest to construct, root rot can become an issue if sufficient oxygenation of the water does not occur. The advantage to constant flow is that the pump is in a constant state, and the roots have continuous access to the nutrient-rich water.

Another consideration with constant flow is nutrient distribution. Unlike with ebb and flow, the water will seek the easiest path in the plant trough, and remain on that path. This creates dead zones and plants in those zones will not receive proper nutrition. The solution is to have the water fill the plant trough from the opposite end of the water intake. Then the water must travel the course of the bed to drain into the fish tank.

6. The IKEA Shelf Starter System

As I explained earlier, there are literally hundreds of aquaponic designs out there. With a quick online search you can get an idea of what types of containers are being used to design these systems.

As you will see, there are very few containers designed specifically for aquaponics gardening. Thus, most systems are constructed with repurposed materials. The system I will show you is no different.

In fact, it uses a shelving system that you can purchase at IKEA for \$20 to house your fish and plants. The beauty of this system is its simplicity and its compact size.



Why Start Small?

Although your overall goal is to create a garden that can sustain your family throughout a major food crisis, it's best to learn the basics with a small-scale system.

From there, you can easily design a larger indoor or outdoor system that will provide for all of your food needs. You have to learn to crawl before you can run a marathon.

This system will teach you how to cycle your system, test your water, and successfully grow a surprising volume of produce in a compact area. As you will see once your first crop comes in,

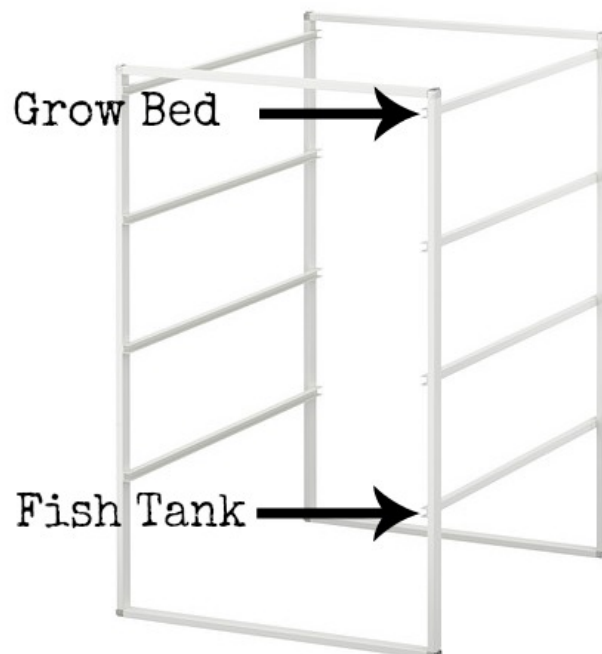
plants in a properly cycled aquaponic system plants grow and fruit prodigiously.

Materials Needed:

- ❖ 1 Antonious Frame (from IKEA)
- ❖ 2 Antonious wire baskets
- ❖ 1 Antonious plastic drawer (7 gal)
- ❖ 1 Antonious plastic drawer (13 gal)
- ❖ 1 Submersible aquarium pump 160gph
- ❖ 1 - 10-foot section of ½" diameter PVC pipe
- ❖ 1 - ½" diameter T fitting
- ❖ 2 - ½" diameter 90° elbow fittings
- ❖ 1 - ½" diameter ball valve
- ❖ 1 - ½" diameter male adaptor
- ❖ 1 - ½" diameter female adaptor
- ❖ 1 - Tube silicon caulk
- ❖ Zip ties

The Framework

Many of the aquaponic system designs that you'll find online require considerable time, effort, and expertise, not to mention tools. One great thing about this design is that you don't have to be handy to put it together. You simply follow the directions provided by the manufacturer.



Once you've constructed the Antonious frame, you'll see that there are 4 slots for drawers. For our purposes, we'll only be using 2 slots (top and bottom).

These wire drawers will support your 7 gallon grow bed (on top) and your 13 gallon fish tank (on the bottom).

The Drain Pipe

Before you can add your media, water, and fish, you must install all of the necessary plumbing elements. These will keep the water flowing from your fish tank to your grow bed and back.

For this design, you'll be using your submersible pump to push the water up to the grow bed (more on this in the next section) and allowing gravity to drain the water back into the fish tank.

To achieve this, you'll need to install a simple drainpipe that determines the water level in your grow bed. As the water entering from the pump reaches your desired water level, it will drain back down to your fish tank automatically.

Installation

- 1.** First, drill a 0.5" hole in the center of your grow bed that your pipe can just barely fit through. You'll want it to be snug.
- 2.** Next, place a rubber O-ring on your male PVC adapter and push the threaded side through the hole. Thread the female adapter on the underside of the grow bed and tighten firmly to create a watertight seal.

Just to ensure that your seal is water tight, run a bead of silicon caulk around the male adapter where it and the O-ring make contact with the plastic grow bed.

3. Next, measure from the bottom of the grow bed to the top of the male adapter, and cut a section of PVC pipe that will extend the top of your drain pipe to at least 1 inch.

4. Last, you'll need to create what's called a "media guard" to ensure that your air stones, rocks, and plants down get caught in your drainpipe and create clogs.

The simplest way to do this is to use wire mesh to construct a cylinder around your drainpipe. You can also drill holes into a section of larger diameter pipe and place that over your drain pipe.

As long as the wire guard stands taller than your grow media, your drain pipe will remain debris-free and your grow media won't end up in your fish tank.



The Pumping System

Even if you have zero plumbing experience, you can not only easily build this plumbing system, but also customize the design to your own preferences -- as long as you understand which function each component serves.

As you already know, the primary objective of your pump system is to move the nutrient-rich waters in the fish tank up to the grow beds. You can get as fancy as you want with elbows and zip ties to route the pipes around your system as you desire, as long as the submersible pump connects to the top of your grow bed.

The only other component that I recommend adding to this setup is a T-connector and a ball valve. In fact, I highly recommend this addition for two reasons:

First, most pumps will have only one speed, which may be a little too fast for your drain pipe to keep up with (causing your grow bed to overflow). Thus, you can adjust the flow by diverting the water back into your fish tank.

Second, the diverted water picks up oxygen as it falls back into the tank, and this oxygenation and circulation is good for your fish.



Installation

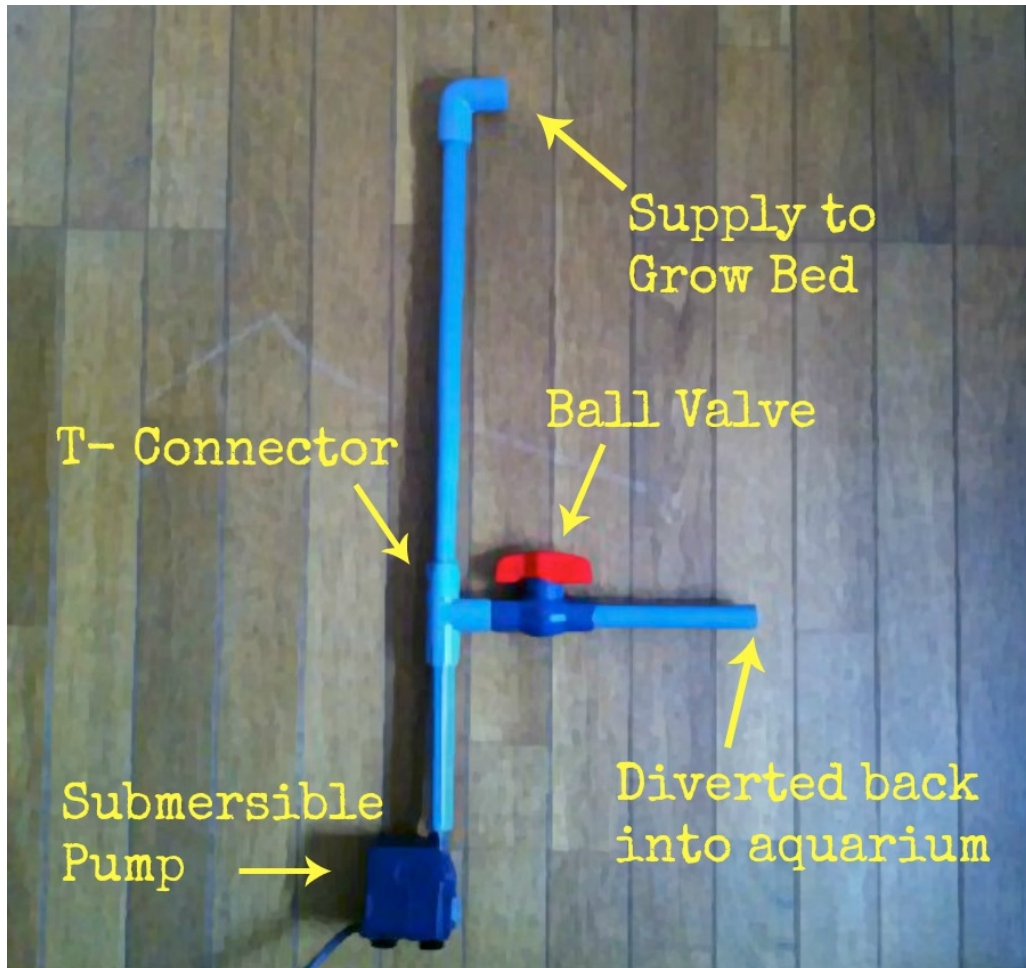
The only cutting you'll need to do for this installation is simply to cut your pieces of ½" PVC pipe to length. This can be done with a fine-toothed handsaw, jigsaw, or sawzall tool.

1. The first section of pipe will connect your submersible pump to the T-connector. Measure the distance from the top of the pump's nozzle to 2 inches above where the water line will be in your tank.
2. Connect your T-Connect (PVC glue is recommended) and connect the ball valve at the proper height. (see photo nearby).
3. Measure from the top of the T-Connector to 1-inch above the lip of your grow bed and cut your pipe to the proper length.
4. Last, attach a 90° elbow to the top of your pipe, and add one more small section 2-4 inches in length to direct the water into your grow bed.

Once you've confirmed that everything is working properly (e.g., no leaks), use zip-ties to attach the plumbing pieces to the frame.

On the next page, you'll see a diagram of an early prototype for this setup. In later versions (like the one on the previous page), you can see that more elbow joints were added to make the plumbing follow the contours of the shelving unit.

For illustration purposes, however, this photo makes it easy to identify all of the important pieces:



Add Media, Plants, and Water

Now for the really fun part. You get to add the living elements to your system.

Grow Media



Start with your grow media, i.e. the rocks and/or stones that will hold your plants in place, allowing water to pass through to root systems. Some of the most popular grow media are: Lava rocks, washed large gravel (avoid limestone), river stones, shale, etc.

Your primary considerations should be:

- 1) The media you've selected won't harm your plants or fish. You don't want add dirty gravel to your system, or a limestone that may suddenly alter the pH level of your water.
- 2) That your media won't fit through your filter and get into your drain pipe.

Add Plants

Most common fruits and vegetable varieties grow extremely well in an aquaponic system, with the exception of some tubers. I recommend starting with seedlings, rather than seeds.

Remember to rinse all seedlings thoroughly, removing all potting soil from the root systems before planting them in your grow media.

When planting in your grow beds, plant everything densely. Because the plants are receiving their nutrients from the water, rather than soil, you can plant things a lot closer together than you would in a traditional garden bed.

Try and make use of areas where plant growth can expand and extend. If your system is located near a shed or wall or fence, erect something for the plants to grow up, and plant climbers like beans peas, tomatoes, cucumbers etc. so that they can grow up things.



Cycle Your System

TIP: Avoid the simple beginner mistake of adding your fish too early, before your system has had a chance to cycle properly.

As your system begins to run for the first time, the nitrifying bacteria may not have “kicked into gear.” It takes some time for them to reproduce and get acclimated. Thus, ammonia and nitrite levels can spike into the toxic range and kill your fish.

To solve this problem, aquaponic gardeners “cycle” their systems by adding ammonia to their systems to kick-start the nitrifying bacteria before adding fish (read more about the Nitrogen Cycle on page 31).

There are several options to add ammonia safely. You can simply start adding fish feed, which breaks down into ammonia. Or you can add small amounts of household ammonia.

One of the most common ways to kick-start your system off is a little gross: Many gardeners find that the quickest/easiest way to get the nitrifying bacteria going is to add human urine to the system. Yes, it’s gross, but it works. The ammonia-eating bacteria respond quickly and create the balance that fuels your aquaponic system.

Add Fish

Lastly, once you’ve tested the water in your system and determined that it’s safe for fish (more on that in the next chapter), add your fish.

I recommend that you begin with a few very cheap fingerling fish, because as a new aquaponic gardener, you may kill them. In other words, don’t run out and buy a \$100 koi.

Goldfish are very hearty and cheap, perfect for beginners. If you want to start with an edible fish, call around and find some catfish or tilapia fingerlings.



7. Peripherals

Timers

Timers are used in Aquaponics to schedule the water pump and auxiliary lighting. As mentioned previously, the water pump is turned off and on at pre-determined times to induce the ebb and flow cycle. The lighting schedule is also set in this fashion.

Test Equipment

There are several parameters to be concerned about with Aquaponics. These must be tested for to insure a healthy Aquaponic system. There are basically four types of testing.

Test Strips – These are strips that contain a test pad for each test. They are dipped into the Aquaponic water and tested against a color chart to determine result values.

Reagents – These are liquid tests in which a few drops of the test solution are added to Aquaponic water and then tested against a color chart to determine result values.

Electronic Test Equipment – These tests can be very expensive and subject to malfunction. They are convenient to use, but do not cover all tests needed.

Human Observation – This is where one really wants to get. Using your sense of smell, sight, and hearing, many tests can be conducted without relying on external tests. Aquaponics should never smell badly, bubbles should pop crisply, fish should swim and feed enthusiastically and never list to one side or the other, plants should be perky and well colored, etc.

Most testing occurs during the cycling process. This is the period when the fish are producing ammonia and the bacteria are trying to process as much of it as possible with the numbers they have.

If the ammonia overwhelms the bacteria, the system dies. Therefore, knowing how much ammonia, nitrites, and chlorine is imperative at this time. Alkalinity, pH, and oxygen all contribute to the system condition.

Ammonia - Fish excrete ammonia in the normal process of digesting food. In large bodies of water this is fine as it dilutes the ammonia. In an Aquaponic system, it must be managed, as it is very toxic to the fish, bacteria, and plants. Decomposing food also creates ammonia.

Nitrites – Nitrites are compounds formed during the nitrification process of ammonia becoming Nitrate. Nitrites are toxic to both the fish and plants and must be processed into Nitrates. Nitrites interfere with the ability of the fish's blood to take up oxygen.

Nitrates - Fish give off ammonia, which is converted to nitrites (both toxic) and then to nitrates (non-toxic), which the plants consume from the water. The water is then returned to the fish tank cleaned of excess nutrients and freshly oxygenated. Fish and plants are fine with high levels of nitrates in their water.

pH - The pH scale runs from 0 to 14. On this scale, 7 is neutral (neither acid nor alkaline). Values below 7 are acid and above are alkaline. pH swings of just a couple of units can seriously affect fish health. Additionally, it directly impacts a plants ability to absorb both micro- and macro- nutrients. Fish prefer pH levels around 8 and plants prefer slightly acidic levels around 6. 7.0-7.2 is considered a good compromise for the plants, fish, and bacteria.

Chlorine

Chlorine gas is added by many municipal water supplies to kill bacteria in the water. This gas must be removed (off-gassed) before adding fish or bacteria to the Aquaponic water. Simply

bubbling the water over night or letting it set will off-gas the chlorine.

Alkalinity

Testing the alkalinity levels in an Aquaponic system reveals the water's ability to neutralize acids. Alkalinity refers to the quantity and type of compounds present in the water that shift the pH above 7.0.

Dissolved Oxygen (DO)

Sufficient oxygen levels are critical to the health of most fish. Additionally, nitrifying bacteria are aerobic and will multiply much faster under highly oxygenated conditions.

Thermometer

During hot and cold seasons, an underwater thermometer is imperative. Many fish species are very sensitive to high and low temperature fluctuations. In general, temperatures between 60° and 85° F are desirable to most fish. Fluctuations in water temperature will affect nitrifying bacteria also.

Manage your water temperature by adding a clarifier and bio-filter, and cutting the rafts to suit each crop. Several different raft configurations can be constructed and used at switched out at various times of the year to accommodate crop changes.



The Nitrogen Cycle

As you know, fish excrete toxic ammonia, which is broken down into nitrites, and then nitrates. This is accomplished by two remarkable, naturally occurring bacteria known as Nitrosomonas and Nitrobacter.

Nitrosomonas consumes toxic ammonia and converts it to nitrites. Nitrites too are toxic to fish, plants, and bacteria. Nitrobacter, a slower growing bacterium, consumes nitrites and converts them to nitrate. Plants love nitrates and absorb them readily. This is a wonderful thing because if this second bacteria were present before nitrites were available, they would be killed by the ammonia.

This in a nutshell is the Nitrogen Cycle. When the fish are producing an amount of ammonia that can be sufficiently broken down into nitrites and nitrates, and consumed by the plants, the system is said to be “cycled.”

The Ammonia/Nitrite Spike

Because of these conditions, more often than not, there will be a “spike” in the amount of ammonia in the system before the first nitrifying bacteria can kick in and start breaking it down into nitrites. Once it does, there is a bigger problem, the second bacterium has not yet kicked in and now the water contains both toxic ammonia and nitrites. This is the most dangerous stage in the Aquaponic cycling process. If the second nitrifying bacterium has not had time to kick-in, an ammonia/nitrite spike occurs.

Under these conditions, a partial water change is required. This involves dumping 1/3 of the water and replacing it with “off-gassed” water. Use the dumped water to fertilize your garden or trees.

Some things to consider about both bacterium when cycling a system:

- The more surface area available for colonization of the nitrifying bacteria, the better. These can be media, a bio-filter, or other surface.
- Proper oxygen is essential (air stones are recommended in all systems)
- It is desirable to maintain a pH of around 7.0 to 7.2 as this range satisfies the plants, fish and bacteria.
- These nitrifying bacteria have long reproduction times compared to other bacterium. That is, Nitrosomonas sp. can double every 7 hours and Nitrobacter sp. every 13 hours. E. coli bacterium would have produced a population exceeding 35 trillion cells by this time.
- Optimum temperature for nitrifying bacteria is between 77° - 86° F.
- Growth rate is decreased by 50% at 64° F.
- Growth rate is decreased by 75% at 46° - 50° F.
- No activity will occur at 39° F.
- Nitrifying bacteria will die at 32° F.
- Nitrifying bacteria will die at 120° F

Nitrosomonas sp.

- Nitrosomonas sp. bacteria eat ammonia to grow and reproduce.

- The optimum pH range for Nitrosomonas sp. is 7.8 - 8.0.
- At pH below 7.0, Nitrosomonas sp. growth will slow and increases in ammonia may become evident. Nitrosomonas sp. growth is inhibited at pH 6.5. All nitrification is inhibited if the pH drops to 6.0 or less.

Nitrobacter sp.

- Nitrobacter sp. bacteria eat nitrites to grow and reproduce.
- Nitrobacter sp. is less tolerant of low temperatures than Nitrosomonas sp. In cold water systems, care must be taken to monitor the accumulation of nitrites.
- The optimum pH range for Nitrobacter sp. is 7.3 - 7.5

Note that the number of fish used to cycle your system should be much less what the system can bear. The idea here is to get the water sufficiently populated with nitrifying bacteria. If the fish tank is too populated, the ammonia and nitrite levels will spike, and likely kill your fish, bacteria, and plants (if present).

Do not to overfeed the fish. They will produce excessive ammonia and the uneaten food will fall to the bottom and increase ammonia.