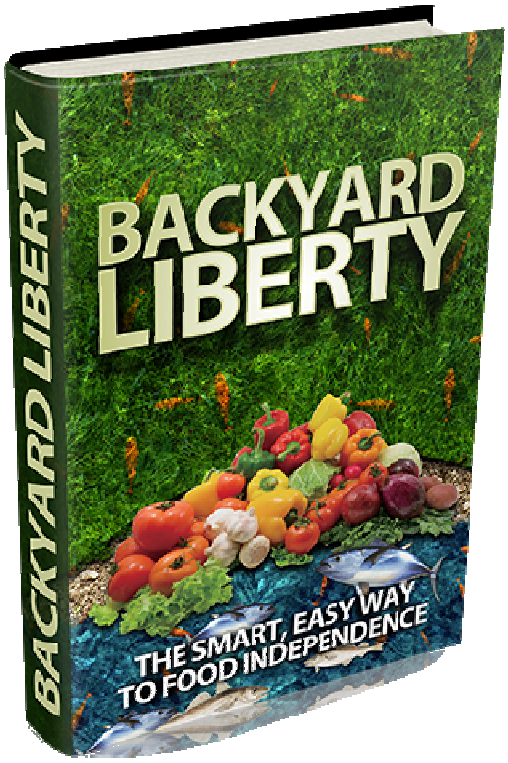
# BACKYARD LIBERTY




## THE SMART, EASY WAY TO FOOD INDEPENDENCE

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# INTRODUCTION

Mainstream America may be unwilling to accept the inevitable possibility of a crisis situation, but the truth is, it will eventually take place. Whether it's due to a national contamination of our food source, war, or other disruptions to "the norm", crisis scenarios have occurred all throughout history and you need to be prepared in the event that you're alive when it happens.

One of the most important things that you have to be aware of and prepared for in any type of crisis situation is how you will eat. As everyone will no doubt turn to looting, scavenging and any other possible means to get food, the available food supply will eventually be depleted and you will have to be able to create your own source of food. And this is where the practice of **Survival Aquaponics** comes into the picture.

As we've seen in the past in countries like Niger (2005) and Sahel (2010), food shortages can cause a great deal of damage to entire populations. With survival aquaponics, you will have the ability to completely produce your own **sustainable food source** utilizing resources that are currently readily available. The information found in this book could mean the difference between life and death in emergencies. While everyone else is struggling to find food, you will be well prepared.

Aquaponics is a fairly new concept for many people, including survivalist but it is gaining momentum very quickly. In this book, we will cover a wide range of topics including:

- Choosing the best fish and plants for survival aquaponics
- The health aspects of aquaponics
- How to build an aquaponics setup from scratch
- How to maintain your setup in any conditions

Whether you're an advanced survivalist or have just recently started researching survival techniques, you will benefit immensely from reading this book.

# 1. Why Survival Aquaponics?

***Survival Aquaponics*** is a form of ***Aquaponics***. Many people are looking to it as a means to grow food that is nutritious and fresh under the following circumstances:

- An end-of-the-world scenario
- A situation where the cost of food increases dramatically
- The current food supply is tainted
- Any other situation where our current system is disrupted

Many of these people are looking at aquaponics because they're looking at freeze-dried food or food with a long shelf life and they're thinking that they want more than just something that can be rehydrated and microwaved. These folks recognize that nutrients are important -- not just calories but nutrients, compounds called ***phytonutrients*** , that is, antioxidants and other chemical compounds that are available only in fresh green produce. They also include certain amino acids that degrade or are rapidly metabolized, and these things are only available in fresh green produce as well.

When people start looking at freeze-dried food and feeling unhappy about the nutritional value that they can offer, survival aquaponics can offer a solution to this problem.

Another thing that people are looking at is cost. People are looking for an inexpensive source of green produce if produce prices increase. This is a likely scenario in instances of:

- Inflation
- Disruptions to the transportation system if energy costs rise
- Disruption to the labor system
- If inputs like fertilizer, water and fuel become scarce or more highly valued

*It's of note that political instability influences all of these different scenarios.

When politically unstable areas of the world and environmentally degraded areas of the worldyou are examined, you find that the most expensive things in those culturesand societies, are typically weapons and food -- that is, what can you feed yourself and how can you defend yourself. The reality of every situation is that people always have and always will need to eat.

Another reason that people are looking at survival aquaponics is because they're interested in flavor and quality, of not just the food they eat, but the quality of the life they live. One overlooked aspect of many survival situations or a disrupted society and a disrupted lifestyle-type scenario is quality of life. People forget that morale and long-term outlook are influenced by luxury and comfort items. That is, **it's not just about surviving; it's about actually being happy**. It's about finding some joy in the things that you do. It's about enjoying your lot in life, enjoying your place,and a lot of that has to do with consuming the

things that you enjoy. Even the most avid meat eaters, on occasion, crave a salad. That's the body's way of saying it wants some of those nutrients.

Research has also shown that being exposed to plants is important for human psychology. Many studies have shown again and again that people like to be around plants and that plants are not just good for our psychology, but good for our bodies as well.

Another thing to consider is that greens have always been an important part of the human diet. Just cutting them out altogether can lead to some serious health effects. The biochemistry of plants provides unique compounds with a short shelf life and these are only found in green plant tissue.

Aquaponics is the combination of ***aquaculture*** (that is, fish farming) and ***hydroponics*** (that is, the growing of plants without soil).

## Aquaculture

Aquaculture or fish farming is a very old agricultural practice where fish are raised in tanks or ponds. They are fed and grown, just any other livestock. It's fairly intensive the way it's practiced today and it's not very sustainable. When fish are grown, lots of feed is put into the water and lots of waste nutrients are produced. These waste nutrients can be pretty toxic to other organisms and the fish themselves.

They require that the waste be cleaned, which is a very expensive and very intensive process. Because of this, the aquaculture industry is gaining a reputation for polluting more and more and being less and less sustainable.

## Hydroponics

Hydroponics is the soil-less production of plants. Instead of growing plants in dirt, or in the soil, you grow them in an artificial media or a substrate such as gravel. Hydroponics is a very productive form of agriculture that's used more and more for producing crops like cucumbers, tomatoes, and lettuce throughout the world. The reason it's growing is because it's very productive but it also offers very high levels of control.

Hydroponics does have its issues however.

- It consumes a lot of energy and
- Requires a lot of fertilizer to grow,
- The excess nutrients go to waste

## How Aquaponics Works

Both of these industries are very wasteful in their own right, and while the resources they consume are inexpensive, these resources are not used very efficiently.

So, when aquaponics is practiced, the waste from the fish is recycled through these hydroponic production techniques and the plants remove the waste from the water. Essentially what happens is the waste gets circulated in this water, it's captured by the media in the plant roots and it's broken down by

bacteria. In this regard, the bacteria are really the heart and soul of the system. The plants then remove the nutrients that the bacteria are creating from breaking down the waste and they use them to grow. And this process cleans the water, allowing the water to be re-circulated constantly.

In essence, the fish produce waste, which are nutrients for the plants. The plants remove waste, cleaning the water for the fish. It is a beautiful cycle where both of the crops benefit from each other. Essentially the negative aspects of both aquaculture and hydroponics individually become very complementary when they're combined. This can make aquaponics very sustainable, producing a great deal of produce with very little inputs, all by using those inputs efficiently.

So essentially the feed that goes into the fish, it's not wasted. It's cycled in the system and it's absorbed by plants which you take out and you eat. Everything that goes in gets used much more efficiently than any of the traditional individual systems like aquaculture or hydroponics.

Most of the fish waste in the system is in the form of feces (fish excrement). And it contains mostly organic compounds:

- Nitrogen,
- Potassium,
- Phosphorus
- All of the other secondary nutrients and micronutrients that plants need to grow

Now, when I say that they're organic, it means that they're attached to other molecules containing carbon that make it really hard for them to be absorbed in that particular state. They have to be broken apart by the bacteria.

Another thing that the fish produce is ***ammonia***, and this is inorganic nitrogen. This is nitrogen that's just floating around in the system but it's attached to some hydrogen, and it's very, very toxic. If you've ever used ammonia for cleaning, you know that it's a pretty strong stuff and it's pretty destructive. This makes it great for cleaning, but unsafe for fish to consume.

So these waste nutrients in the form of feces are organic. These organic compounds and ammonia are cycled through the system. And microbes living on the media, the surface of the system, and the tank's side, capture this waste and they break them down. So they're essentially performing all of the work.

As they break these compounds down, the nutrients become available to the plants. The process of making nitrogen available is called ***nitrification.*** This is the process of taking proteins and breaking them down to ammonia, and then taking ammonia and adding oxygen to it a couple of times to end up with ***nitrate.*** Nitrate is the primary plant nutrient in your system that you're going to want to keep an eye on.

The process of making these other nutrients available is called ***mineralization***. When we talk about mineralization, we're talking about potassium, phosphorous and a lot of the other plant nutrients that are in the system.

Almost all of these processes are called ***oxidation reactions***. This simply means that oxygen is used in the process. This is important to know because a lot of these reactions will consume the oxygen in your system.

All multicellular creatures need oxygen to survive. If we don't have oxygen, we die,and the same is true for fish and all the other organisms in aquaponic systems. Fish need oxygen and the microbes in the system need oxygen and the plants need oxygen. So knowing that these decomposition processes use up oxygen is important because you'll want to keep an eye on it to keep your oxygen levels really high. Too much stuff decomposing all at once leads to oxygen depletion, which can kill your fish and stress out your system.

Nitrification is the most important process in aquaponics to understand. And the reason for that is that the entire system is based on nitrification. It's essentially the oxidation of ammonia, as I mentioned before, and it's what drives the system. If nitrification isn't taking place, then ammonia builds up in the system and it kills the plants, it kills the bacteria, and it kills the fish. So it's very important to foster nitrification and to keep it going in the system.

As these nutrients are made available, the plants remove it from the water using their roots. Almost all of the compounds necessary for plant growth and development are available in fish waste, with the exception of a couple. And I'm going to talk about these more in detail later.

But the primary nutrients that will need to be supplemented on occasion are

- Potassium
- Magnesium
- Calcium
- Iron

All of these things can be supplemented, that is, put into the system with very simple and very inexpensive compounds that you can get at a hardware store.

There are many ways to grow plants in aquaponics, and a few of the methods are ***deep-water culture,*** often called ***DWC; nutrient film technique,*** called ***NFT, vertical hydroponic technique, media-bed technique***, and a few other random ones that we won't get into.

We're going to talk mostly about media-bed technique here because the system that we're going to build is a media-bed system. It's pretty generic but it works very well for home gardeners who are just looking to get into aquaponics and want a system that is easy to operate, easy to build and inexpensive to put together.

# 2. Why is Aquaponics Better Than Soil-Based Gardening?

Aquaponics has several advantages over conventional gardening.

## Efficiency

First, it uses less water, considerably less water in fact, than conventional gardening -- around a tenth of what is used in a conventional soil-based garden. That's important to people who are trying to conserve water or are considering living in a place in the future where water is a valuable resource that should be conserved.

In that regard too, systems can function as an interesting water-storage device. So instead of just putting your water in a tank and storing it there,unproductive until it's used, in aquaponic systems (because there's so little water loss) you can essentially store your water in a system that's working for you and for your family.

## Less Strenuous

Aquaponic systems can also be much less work. There's no weeding, tillage or soil preparation or amendment with aquaponic systems. Now, there is other work involved, but the backbreaking, bending-over work is typically not as much of a problem in aquaponic systems. So for folks that have back problems or just don't like spending a lot of time on their knees or bending over a row of crops, aquaponics systems at waist-height can be a very valuable and convenient means of growing their own food.

## Flexibility

Aquaponics is also very flexible in where it can be done. It can be done indoors or outdoors. It can be done in a variety of different scenarios from the country to the city. It can be done underground; it can be done on rooftops; it can be done just about anywhere where the system can be fit.

Now, there are some interesting things to consider for all of these different locations, and we'll talk about those a little bit later. But the good thing to know right now is that **you can do it almost anywhere**.

## Eco-Friendly

Aquaponics is also very nutrient-conservative, that is, you won't lose valuable nutrients to leeching or runoff or to weeds that you can't eat. These are really common in soil gardens where you're inputting a lot of nutrients but you're not getting out as much because you're losing a lot of that nutrition. It's either

dissolving in the water, being absorbed by weeds, or it's being blown away as the wind blows away your top soil.

So the nice thing about aquaponics is that it's very conservative with nutrients. You put in fish feed, and almost all of that nitrogen is consumed in the system. Almost all of those nutrients go into a crop that you in turn can consume.

Often times, aquaponics systems can actually produce more than soil gardening. On average, you can get 2-3x or more from your system than a traditional garden, per square foot. This is because in gardens you have to space crops apart, you'll lose a lot to weeds, and you have less control over the conditions. In addition,your crop plants are also competing for nutrients in the garden. In aquaponic systems you can control how much they compete and this leads to higher productivity. You can control the weeds, which leads to higher productivity. And you can just basically optimize conditions for plant growth.

The one caveat to this is that these systems can't just be turned on and run. They take time to gear up and get going because they are biological. But usually the benefits are well-worth the investment.

# 3. How is Survival Aquaponics Different From Aquaponics?

Survival aquaponics is a little bit different than normal aquaponics, not necessarily in practice as much as in consideration. Essentially, folks that want to practice survival aquaponics have to take into account a few different variables, including things like:

- Feed storage
- Energy use
- Simplicity of design
- Availability of parts

The point is thatsurvival aquaponics is somewhat different and you have to think carefully about what you want from the system when you're designing a survival aquaponic system.

## What to Consider for Survival Aquaponics

Survival aquaponics will have more of a focus on long-term needs -- that is, water and feed storage. Survival aquaponics practitioners must think about the different constraints that could be imposed by a survival scenario. The system needs to have an element of preparedness incorporated into the design. These include things like low energy requirements or being adapted to available energy sources.

Each system will be different depending on what the owner wants from it. If you're trying to operate it on solar panels, then that's a unique energy requirement or energy need that you have to tailor the system to.

Similarly, if you're trying to do it in an area where energy resources are intermittent or not reliable, that's something that you need to take into account too. All of these things, if they're thought about, can be addressed in the design itself.

### STORAGE

You also need to be thinking about feed storage because the primary input of the system is fish feed. You need to think about ways that you can store that feed in the long-term.

The same goes for seed storage -- that is, storing seed for use down the road. Now, you can do some of your own seed collection from the system itself if you wish, but some people find it more useful to store larger quantities of seed. And a survivalistcan never go wrong with having extra seed.

### DESIGN

For survival aquaponics, you need to consider having a simple, minimalistic design. Your goal should be minimizing the possibility of what's called in engineering, "***single point source failure***," that is, the dependency of a system on a single failure-prone part to function.

In any kind of survival plan, point source failure is your enemy. To avoid it, you must design redundant systems, that is, have spare parts, and be able to operate if one part of your plan fails.

The same thing goes for aquaponic systems. You don't want a bottleneck in your operation. Part of that includes having lots of spare parts on hand.

Knowing what you use in the system and knowing what's most likely to fail is an important part. And this is something that I'm going to talk about a bit more as we get into the design, operation and building of the aquaponic system. But this is something you need to be thinking about the entire time.

Another thing to consider is building your system as a series of modules, that is, systems that can be easily built and scaled up or down, systems that are easily combined, and systems that can be easily moved or operated.

It's also useful if you can build the system out of inexpensive parts that are commonly available anywhere in the world. If you can find parts in just about any city to build these systems, it becomes much easier to move systems or move your operation, or just build the system in the first place, especially if you're on a budget.

### SPACE EFFICIENCY

Space efficiency is also another thing to consider in survival aquaponic systems. Not everyone has a lot of space to operate these systems, so it's important to consider the space that you have and design a system that will fit it well. That is, if you've got lots of vertical space, then consider doing a vertical

system. If you have a lot of floor space, then you can spread out and do a larger horizontal system. Whatever your space constraints are, you can design a system that will suit them very well.

***Vertical growing*** is another thing to be thinking about for a lot of these systems. It's an effective means of space conservation and allows you to utilize walls instead of horizontal space. Walls are very inexpensive real estate, especially in cities. If you're growing in a greenhouse or you're considering growing in a greenhouse, growing vertically can also be a more effective use of greenhouse space.

#### SUSTAINABILITY

Your system also has to be biologically sustainable. If something goes down and you're unable to get new fish for your system, you want to design a system where you have multiple generations of fish, that is, you've got older fish that are having babies. So as you harvest fish, they'll be replenishing the population. It will be constantly replenished as fish are removed..

In the same way, you want plants that produce seed that you can take and plant down the road as well. And you want a really robust microbiology that can withstand stress and that will survive power outages and that will survive low-water levels, and other system stresses

#### FOOD PRODUCTION CAPABILITY

You also need a system that produces nutrition-dense food consistently and in adequate quantities. This can be the really hard part because you never quite know what the production potential of the system is until you're running it, and until you learn to optimize it yourself. It requires harvesting at intervals so that you don't harvest everything at once. You always want something in the system. It is important toalways want to have a backup. You always want to have something that you can fall back on if something else fails.

## USING AQUAPONICS FOR DRINKING WATER

As I mentioned before, water conservation and storage is an important part of most survival aquaponic systems. You're designing a system that is productive and is producing crops but is still a water-storage system. Aquaponic systems usually lose between 1% and 2% of their system volume daily. Compared to hydroponics and compared to aquaculture, this is a very small amount.

For larger systems, you can grow crops and fish without losing too much water on a daily basis. This allows you to have an extra source of drinking water if you're ever in need.

Because these systems are more productive than soil gardening, this is kind of a nice way to replace your soil gardening while having a water-storage system integrated into your house or integrated into your property.

So in healthy systems, the solution can be potable. Essentially if the system is really healthy, if your fish are healthy, if nothing is too far off, you can drink the water directly out of your system, although of course, I recommend that water from the system should always be filtered. You just never know what's in it.

If you really want to drink and feel safe drinking the water from your system, you have to figure out a way to protect it from birds, from mammals, from other things that poop in your water because that's going to be the primary way that your water can be fouled. We'll talk about that a little bit later as well.

Figure 1 Submersible pumps

Other waste processing capabilities can be built into these systems but it can be fairly complicated. So if you're looking for a way to recycle human waste or animal waste or other waste products, whether they're agricultural or industrial, these types of systems can be modified and changed to accomplish that task. Things can be added to them or subtracted from them to make them more capable of processing that waste. If that's something that you're interested in, there are all sorts of information online and in a variety of different books and journal articles.

The thing to remember through all of this is that plants are very efficient at nutrient removal. In fact, they're more efficient than most mechanical processes. So when you think about the large corporations that invest millions of dollars in equipment to remove, say, nitrogen from aquaculture effluent, plants are doing that much more efficiently at a fraction of the cost. And the nice thing for you and I is that plants are very inexpensive to grow and they're readily available to all of us.

# 4. Safety Concerns

There are a few safety precautions that you should take into account before you embark on building our own aquaponic system.

## Drowning

A lot of these tanks can be fairly deep and because they're filled with water, children especially, can get curious, climb up there to look at the system or the fish and fall in. So if you have children in your area or if you have children yourself, you want to figure out a way to exclude them from the system, whether that's putting a screen on the top or putting a rack around the system, essentially just thinking about how you can protect your children from falling in and getting hurt.

It's also true with animals, but people drowning is the primary concern, so make sure you're thinking about that as you build your system. Everyone will have to do something different to make sure that their children are protected.

## ELECTROCUTION

Electrocution is another concern. Remember that electricity and water do not mix. You only want to use pumps and equipment that are rated for this use, that is, submersible pumps, with the UL rating that are recommended and advertised as being submersible. You want to keep your system water away from outlets and use ground fault interrupter outlets if possible. They have a ***GFCI*** logo on them.

## LABOR

Manual handling can be another concern because some of the media used in these systems to replace soil can be really heavy. So you want to be really careful when you're loading your gravel or your rock or your *hydroton* or whatever it may be you end up using, making sure that you're lifting with your knees and you're not overstressing your back or other parts of your body. Be thoughtful about the manual labor involved in this build.

There's a lot that we can do to reduce this risk with system design. And of course, once the system is built, if you do have back problems, harvesting the lettuce and harvesting the other crops become much simpler because they are raised up off the ground.

## TANKS BREAKING

Collapse of tanks can be an issue, or tanks falling over. It's a minimal concern but it is possible. So as you build your tanks, depending on the media that you use, you're going to want to make sure that everything is well-supported and can withstand being bumped into, moved around, and placed on solid footings.

## TOXIC SUBSTANCES

Toxic substances are also a concern. We're going to be using an Intermediate Bulk Container, or ***IBC tank***. These tanks are really inexpensive. They're industrial tanks for moving around all sorts of liquids and they're used to move them all over the world.

A lot of the time though, you're not sure what liquids were moved in them. From the very beginning, if you can find an IBC that's advertised as only containing food-grade or food products, then you're off to a good start and you don't have to worry as much about it. But you want to make sure you know what that IBC has moved.

Typically, IBC tanks that moved food can only move food afterwards. More often they are only single-use IBCs. So you want to look at the label on the IBC tank that you find and make sure that it was used to move a natural product.

For instance, the IBCs that I use often contained lactic acid. Lactic acid is made from fermentation and it’s a fairly natural compound. This means we're able to clean those tanks with soap and water and be fairly confident that whatever substances are in them, are not toxic and are not going to kill our plants. Make sure you always clean those IBCs with soap and water regardless of what they contained.

# 5. THE HARDWARE INTRODUCTION

Before you get started, you need to know what's required to build your aquaponic system. Hardware-wise, there are a lot of different options and what you choose really depends on what you want from the system and what you're willing to spend. There are two main camps: **retail** and **do-it-yourself**.

Aquaponics has a really long history of do-it-yourselfers building systems, innovating and building all sorts of interesting things uniquely suited to their needs,to their space, and to their budget.

Retail sales are kind of a new and emerging area of aquaponics.. Many people now are producing turnkey, plug-and-play systems that you can buy directly off the shelf. They come with everything you need to get started. However, they cost a lot more money, typically.

Before you begin, you want to think about what you need and the budget that you have to build with. If you have plenty of money, retail options can be a very quick and very trouble-free way to get started. However, if you are budget-limited or if you have some very unique requirements, be it the space, the inputs, what you want from the system or what the intended use is, then do-it-yourself is probably a better option.

## TANKS

For do-it-yourselfers in aquaponics, **barrels** have long been the staple of aquaponic systems. A lot of people have used barrels from the very early days to build their systems because they're cheap, they're readily available anywhere in the world, and they're very easy to work with. They're usually made from high-density polyethylene which lends itself very well to being cut and melted and drilled.

**IBC tanks** are another staple of the aquaponic world. In fact, most of the systems of the early days used either barrels or IBC tanks in one way or another. To this day, many people continue to use IBC tanks.

Figure 2 Barrels

IBC, again, stands for intermediate bulk container, and these tanks can be found just about anywhere in the world because manufacturers of food products and chemicals use them to ship their products all over the world.

You can usually find IBC tanks in a few different forms. You'll find them new, and new they're fairly expensive, usually around USD300 to USD350. You can also find them used, and usually single-use tanks in the $100-$150 range and you can find multiple tanks that have been used multiple times, usually for $100 or less, depending on where you're at.

Again, the important thing to remember is to only use tanks that have been used for food or natural products that you know are safe for fish. If you have any questions about the products that were contained in the tanks, go online and do a little research to find out whether it's toxic and how to clean it best.

Figure 3 Discarded bathtub

The same goes for barrels because they're often used for a variety of different chemicals and food products. Research before you start so you don't end up with a bunch of dead fish later on.

Another thing that people use are **discarded bathtubs and hot tubs**, and these have quite a following in a lot of different areas, especially where people can find discarded bathtubs for very cheap. Lots of times, bathtubs can be piled up at local dumps especially if they're fiberglass or cast iron, and they can make very nice fish tanks as well as grow beds.

**Swimming pools** have also been used on occasion. Although they’re a fairly expensive thing to convert over to aquaponics projects, it's not out of the question. If you have a swimming pool and you're not using it very often, it might be worth considering.In a similar vein, a lot of folks have also used the little kiddie pools like the ones you can find at Wal-Mart, primarily  because they are very inexpensive. They're usually made from vinyl and are used as both grow beds and fish tanks. So, all different types of swimming pools can be used for these systems.

When you start getting into the commercial sphere or large family systems, you'll find that many people use liner-based tanks. They'll frame the tank out of wood, usually using OSB or plywood and a 2x4 framework to build the tank, and then they'll take a vinyl liner to line the inside of the tank.

Essentially it's building a tank out of wood, which is very inexpensive, and a plastic sheet, which is also very inexpensive. This building technique can give you a lot of volume for very little money. It's a great way to go if you're looking for an affordable, efficient way to build larger tanks.

Figure 4 OSB and Plywood

## PLUMBING

You're also going to need the plumbing hardware. This includes pumps, pipes and usually lots of joints and valves. All of these things are going to be really important once you start building your system primarily because they're how you're going to be moving water from point A to point B.

Most systems can be designed so that water gravity-drains back to the main tank or the feed tank. So return lines are important but the feed lines are as well.

Pumps are something that everyone will have to have in one form or another, and there's a variety of pumps offered online that are very high quality and very inexpensive. Depending on what kind of electricity you're going to be operating on, (solar panels and DC electrical systems or AC electrical systems), your needs will be different. But the nice thing is that there are a lot of pumps out there to choose from and a lot of them are very affordable.

## MEDIA

You're also going to need a media type, and you have several options.

Figure 5 Granite and Gravel

If you have plenty of money to spend, something like ***hydroton*** is a very valuable and proven media. If you don't have as much money but you want something that works just as well, you can use granite or gravel. Just be aware that they may be a little less user-friendly as far as weight, and digging in these types of media. I don't always recommend gravel because gravel will clog very easily. Three quarter-inch of granite is what I would officially recommend.

The big thing to remember is you want something that has high surface area for your microbes to live on, but something that doesn't clog easily. And you also want something that doesn't have a lot of ***carbonates*** in it.

An easy way to tell if a rock has carbonates in it is to get a bowl of vinegar and drop a couple of pieces of the rock in the vinegar. If they bubble a lot, you know that there's a lot of carbonate in the rock and you don't want to use it. If they don't bubble, then you know the rock is good to use in your system. If you do use rock that bubbles, you're going to have a very difficult time managing ***ph*** down the road.

# 6. THE FISH

There are a lot of options when it comes to fish for aquaponics. Almost any freshwater fish can be cultured and many of them already are.

What I would recommend is to focus on freshwater fish that are tolerant of poor water quality. These are fish like the **carps,tilapias** and other freshwater fish that can handle muddy water or water with lots of solids floating.

Figure 6 Carps

## TILAPIA

In North America, one of the most common fishes to be cultured is **tilapia**. There are lots of different types of tilapia but the most common ones are:

- Nile Tilapia
- White Tilapia
- Blue Tilapia

Oreochromis ***Aureus*** is from Israel. The Nile Tilapia is from the Nile River. And these fish have been hybridized and crossed to such an extent that no one really has any kind of pure stock these days. They're all crossed.

They’re great fish for a number of reasons. One, they're omnivorous, so you don't have to feed them a really high-protein diet if you don't want to. You can feed them vegetable matterwhich in a survival situation can be a great asset. You can feed them anything from lawn clippings to insects from your bug zapper, to commercial fish feeds. And they get along pretty darn well. This has made them really popular with hobbyists and it's led to them spreading throughout a number of aquaponic systems all through North America.

Figure 7 Tilapia

If you're looking for a fish like tilapia, probably the best place to find them is from another hobbyist or from a commercial fish hatchery.

Now, with a fish like tilapia, you want to be really careful because in many areas, they're illegal, especially in the South. So you want to check with your local state Game and Fish Department and your state agencies to make sure that you're allowed to have the fish in your area before you go out and find them and introduce them. It's just better to not have the government snooping in your business bydoing your research before you get a hold of the fish and making sure that you're using something that's okay.

## CATFISH

Some other fish that people really like in North America are **catfish** and specifically, ***Channel catfish***. Youou can get channel catfish from commercial hatcheries, and catfish are really nice. They typically feed on the bottom and they need fairly high-protein feed.

Figure 8 Channel catfish

So there are a few other options. You can feed them live food, you can feed them insects. They're fairly good generalists, which means you can feed them lots of different types of food but they're going to need higher protein content than tilapia.

So those are two fish you can look into right off the bat that are usually available. Someone in your area is probably already growing them. And I would recommend talking to other hobbyists first before you start talking to other fish hatcheries.

## OTHER FISH

Other fish to look into that a lot of people are using are **yellow perch**. More and more people are getting into them. I would not recommend them for hobby systems. They're just very hard to manage. They're very hard to train, and not as forgiving as tilapia or catfish when it comes to poor water quality.

Another fish that a lot of people use is **rainbow trout**. Many people really like rainbow trout. For beginners, they're a harder fish because they require a well-cycled system that has lots of really good clean water in it, and they require cooler temperatures. So if you live in a really cold climate where your system is going to be pretty cool for most of the yearor your air or water temperatures are going to be pretty low, trout is a fish that's definitely worth looking into.

Now, with trout you're either going to have to be feeding live feed (that means high-protein animals that you're feeding – insects, minnows, etc.), or you're going to have to be feeding a high-protein feed of some sort.

Figure 9 Goldfish

This type of fish is going to require that you stockpile bags of high high-protein feed to feed them. And they're going to require a lot more maintenance and care as far as just keeping an eye on water quality because they are a little less forgiving than some of the other fish.

Some other folks are also playing with fish like **bluegill**, and of course, everyone uses **goldfish** at one time or another. Goldfish and **Koi** are decorative fish but they're great fish to start with because they're very forgiving and they're very pretty. So if you don't plan on eating your fish right off the bat, Koi and goldfish can be a great option.

### Matching Fish to Climate

With all of these fish, you want to match the fish to the climate. So depending on what fish you're interested in, you want to make sure that that fish can survive in your climate. If you live in a very hot place or a warm place, then a fish that requires cold water isn't the right choice. You want to look for a fish that requires warmer water.

Any region where your water is always going to be warm, tilapia is going to be the perfect fish for you just because it likes warm water and it's super tolerant. It's more forgiving of really poor water quality. You can have pretty murky water, water with low oxygen and water with high levels of ammonia comparatively, and tilapia will do great. They're also nice because they can filter feed in addition to feeding on solid food.

So that's the right-off-the-bat recommendation for anyone in a warmer climate. Anyone in a cooler climate, definitely look at trout, look at Koi and look at catfish, as these willall be fish that will serve you well. They do, however, require that you feed them a commercial feed, for the most part.

## 6A. What Fish Need

Before you pick your fish, you have to know what your system is going to deliver in terms of water quality. Fish need a few different things. They need the obvious: they need water to survive, but that water needs to be a certain temperature. It needs to have certain oxygen content. It has to be a certain level of cleanliness and it has to have low concentrations of toxins such as ammonia (which fish actually produce themselves) in the water.

So before you pick your fish, you want to know what your system is going to look like. And if you're building just a standard IBC system, right off the bat you can count on your system being a little bit dirtier than it will be down the road. In that case, I would recommend starting with a more tolerant fish species like a Koi, goldfish, or a tilapia.

### Water Quality

You need to pay really careful attention to your water quality. You want to make sure that your water stays relatively clear, and you want to make sure that there's lots of oxygen. And you can do that by keeping your water temperatures low if you have cold water-loving fish, and by circulating lots of water through your grow beds. Your grow beds are going to filter the water, but they're also going to help oxygenate it or put oxygen in the water for your fish.

You also want to circulate it a lot because most of your nitrification (turning ammonia into nitrate) happens in your grow beds. So if you don't have circulation, ammonia builds up to the point where it becomes toxic to your fish and you'll start to see them die.

You want to be thoughtful about your water quality and you want to keep tabs on it. The best way to do that is just with a thermometer. With a thermometer you'll be able to tell if your water is in the right range for your fish, and each fish have their own temperature range. So you should consider that up before you begin.

With a test kit, you can measure how much toxic compounds there isaren your water in the form of nitrites and ammonia. Your kit will test the levels of:

- Ammonia
- Nitrite
- Nitrate

Figure 10 Murky water

Another thing you can do is just do a visual check of the water. If your water is really murky, it means you probably have a bacterial or an algal bloom in your system.

## ALGAE

For fish like tilapia and fish like goldfish, they handle algae blooms really well. In areas where you're allowed to grow carp, which are great fish, they handle algae blooms pretty well as well.

Figure 11 Bloom algae

But most of the other fish don't really like algae, so you want to keep your algae in your system to a minimum. And if you're growing something like trout, you don't want any algae at all, if possible

You can check the algae just by sticking your hand in the water or sticking a newspaper in the water and seeing how deep it can go before you can't read it anymore or seeing how deep your hand goes before you can see it anymore. If you're paying attention, ou'll get a good feel for how murky your water is pretty quickly.

If it's really murky, then you need to cut back on your feed. If it's not too murky, then you know you're feeding it at about the right rate, and you probably don't have too many algae or bacterial bloom issues.

So those are the biggies with fish.

- Temperature
- Ammonia
- Nitrite
- Nitrate
- Algae

As long as your temperature is in the right range, you're circulating a lot of water to give good oxygen to your fish, and not overfeeding and making your water really dirty, it's possible to raise pretty good, healthy fish.

## 6B. Fish for Survival Aquaponics

When choosing the perfect fish for survival aquaponics, you need to take into account a few different things. First of all, you have to know what you can offer your fish population as feed down the road. If you anticipate a situation where bags of commercial feed won't be available, and all you have available is something you can rustle up yourself, then you're going to have to figure out a fish that's omnivorous, that can feed on a lot of different things and can adapt to different feed sources.

### South

For folks in the South, I will always recommend tilapia, specifically Nile tilapia or a Nile-cross tilapia. These are commonly known as blue tilapia, white tilapia or some other common name, but they're not hard to find and in a lot of places they're already available in the wild. You can go out with a fishing pole and catch them.

If that's not how you want to do it, you can always bum some off of someone who already has a system and is already growing this fish. And there are a lot of them out there. All you have to do is hop on one

of the aquaponics forums online and you can find people who are willing to give you fingerlings or smaller fish to stock your first system with.

Figure 12 Nile Tilapia (Blue Tilapia)

## NORTH

If you're on the North and your water temperatures are going to be fairly cold, then I will always recommend carp, if you can grow them, specifically common carp.

Common carp is a great fish. It's really tolerant of colder waters and it eats almost anything. Anyone who lives in a state where carp are invasive, know that these fish are very difficult to kill and they can grow very quickly. They also reproduce really well, which brings me to my second point: You don't want to just think about how to feed your fish; you want to also think about how they'll reproduce.

Figure 13 Common Carp

You want to pick a fish that reproduces readily in your system. If you're growing tilapia, you'll quickly find out that they have lots of babies. And even though they'll consume a lot of their own young, a lot of them will still grow to adulthood.

Here's one of the reasons that tilapia makes such a great fish for these systems: You don't really ever have to buy fingerlings so long as you're only harvesting your fish as the population replenishes itself. Essentially, tilapia form really great self-sustaining populations.

Other fish that do well, for colder waters, in addition to carp, will be goldfish and Koi. Koi and carp reproduce very similarly. They need a little bit more work than tilapia. So before you adopt carp or Koi, you want to look into how to breed them and figure out how you're going to do that if that's important to you.

Goldfish breed pretty readily. All you have to do is supply substrate for them and usually if you treat them right, if you give them the right amount of sunlight, they'll have no problems having babies on their own.

So thinking about reproduction is also another important part of these systems, because you don't want a system that you can't replenish your fish stocks in.

If you do have someone around that's happy to supply you with fingerlings, then reproduction isn't even a question. And if you don't anticipate that source going away, and if things get dicey, then there's no point in worrying about breeding your own fish. You can always just buy them from your supplier.

## 6C. Finding Fish to Stock

### Legal

Finding a fish for your system can be very easy or very difficult depending on where you live. The first thing to do is go to your state Game and Fish website and check out what fish you're allowed to own in your area. If you're in the North and you want to have tilapia, sometimes it's very simple. All you have to have is an aquarium permit from your state Game and Fish office.

In other states, you don't even need that to have tilapia. That's just because tilapia are a warm water fish and they're not too worried about a warm water fish surviving in cold northern streams.

Now, if you're in the South, there's a lot more rigmarole to go through to own certain fish. If you're owning fish that are already native, game fish for instance, like channel catfish, trout, crappie bluegill – those types of fish types, oftentimes you just have to fill out a couple of forms with your Game and Fish Department before you can own them.

If you want to own invasive fish (in the North these would be things like common carp and in the South this might be something like tilapia), you're going to have a lot harder time getting permission to own that fish, which will make it a lot harder to find them to stock in your system.

So that's the first step, find out what fish you're allowed to have.

## Certified Hatcheries

The second is to go to your state Game and Fish website and find out where the certified hatcheries are in your area. If you're in an area where there's lot of fish breeders and lots of hatcheries, it might be very easy to get your hands on small quantities of fish to stock in your system. And this can be a very good way to go because oftentimes, the Game and Fish Department will know which fish hatcheries are disease-free. If you can start your system with fish that are healthy and in really good shape and disease-free, you're going to be starting off on the right foot right off the bat.

So after you've checked out local hatcheries, if there's none in your area or there's none that can offer you fish at a reasonable price, try finding out if there's anyone else in your area that's doing a similar thing, that has an aquaponic system or a backyard pond or any of the above and can supply you with fish. Make sure that you ask a lot of questions about fish disease, because you don't want diseased fish in your system right off the bat. If you have diseased fish at the very beginning, you'll probably struggle with disease in your fish population for a long time. So it's very important to find disease-free fish.

If the person you're asking has a pond and he's offering you fish but they sound like they've got a disease, pass on that offer and find someone else. If it sounds like he hasn't had any disease issues for a while, then usually it's okay to take fish and put them in your system.

Sometimes if you do have fish and you put them in your system and they look like they're having problems right off the bat, it's just the stress of introduction. It's not always an issue with fish disease so keep that in mind.

## Catching Fish

If you can't find anyone in your area who can give you some small quantities of fish, then maybe you want to collect them from the wild. To do this, if it's a game fish, you will need a collection permit from your Game and Fish Department for your state. Once you have a collection permit, you're allowed to go out in the wild and harvest live fish, bring them home and stock them in your tanks and do it all legally.

These are all different ways that you can get your hands on fish. If you are looking for fish from other aquaponic practitioners, I would recommend going on some of the online forums and just asking folks in your area.

# 6D. Introducing Fish to the System

The important thing to remember about introducing fish to an aquaponic system is to have your system all set up and cycled before you even begin to think about adding fish. This is really important, especially with beginning aquaponic systems.

If your system is not cycled, that means if you don't have bacteria growing in your beds and processing the wastes, processing the proteins and ammonia in your system, essentially what you'll end up with is a lot of dead fish who have died of ammonia poisoning.

So you want to make sure you cycle your system before you even start. So make sure you look at the cycling section of this book before you go any further with putting fish in your tanks.

Cycling takes 6 weeks and for impatient folks it's hard to wait that long but it's always worth it. You're going to save a lot of fish's lives by holding off for the cycling period before you introduce fish.

## How to Add Fish

Introducing fish to the system is pretty easy. Start with smaller quantities. The actual process of putting them in the water is important too. You want to make sure that the fish are going from one temperature to the next, seamlessly, and that there's not too much of a difference between the water that you transport them in and the water that they go into.

What I like to do is put fish in bags or 5-gallon buckets, and hang the buckets or the bags in the water so that the temperatures can equalize before I release the fish. So long as you let the temperatures equalize, the fish will be perfectly happy transitioning from the bags or buckets they're transported in into the new system.

A lot of people like to start with ***feeder goldfish*** that they get at the local pet store or something like that as a way to test the system just to make sure that everything is okay before they put in more valuable fish. So throw in a fish or two and see how they do in the system for several days. You want to be monitoring your water during this time.

Monitoring for ammonia is the most important thing with new systems, as ammonia spikes can oftentimes be initiated by putting fish in the system. The moment they're in there, they start excreting ammonia- they start pooping, and they start producing all of these wastes that can poison the water if the bacteria can't keep up. So you want to make sure that your ammonia is being processed, and that your fish stay healthy in that introduction period.

## Feeding Fish

You also want to keep an eye on your feeding. A common mistake that people make in the beginning is feeding their fish too much. Fish are not warm-blooded animals. That means they consume a lot less

energy keeping warm. So don't feed them like you would feed a hamster or a dog or a horse. Feed fish in very low quantities.

So to start **you should never feed more than the fish can consume in the course of a minute or so**. If there's food left over after a minute, then you're feeding too much. You always want to scoop excess feed off the surface of the water. This is the primary mistake that beginning aquaponic practitioners make when they're starting a system. They always overfeed, and they always feed immediately.

Remember, your fish can go for several days without eating at all, and it doesn't hurt them -- they're perfectly happy that way. So right after you put the fish in the system, it's always best to wait for a day or two before you start feeding.

Throughout the entire process, make sure you keep an eye on the health of your fish. How they feed and how they behave in the water will always tell you something's wrong long before your tests do.

## Breeding Fish

Fish breeding can be very complicated or very simple depending on the type of fish that you're using in your system. To get started, you have to understand that fish have a number of different egg-laying behaviors, and it varies widely from species to species. So, some fish scatter their eggs on gravel or on a substrate; some attach their eggs to weeds or rocks or branches, something like that; and some mouth brood.

An example of an *egg scatterer* would be something like trout. They lay their eggs on gravel essentially, in clear, fast-moving, well-oxygenated water. Fish that attach their eggs to weeds or rocks or branches, something like that, they actually kind of glue the eggs on to these underwater structures, and those are fish like carp or koi. Some also mouth brood.

Now, when we talk about tilapia, we're almost always talking about a mouthbrooder. So this means that the fish essentially lays the eggs, the male fish will swim over and fertilize the eggs, and then the female will actually kind of suck the eggs up into her mouth and just spin them around, keeping them oxygenated, keeping them moving inside of her mouth. And she'll stop feeding during the duration of that kind of incubation period until those eggs hatch, and after they hatch, she'll kind of just keep on circulating the fry in there until they reach a certain point in which she'll spit them out and they're on their own.

So before we get started, we need to know what fish you need to breed. Sexually mature males and females are required, so you can't put fingerlings in and expect them to breed, right? We always need to wait for our fish to mature before we think they're going to breed or before we prepare them for breeding.

Fish also need a conducive environment. When we say conducive environment, we're talking just about the things environmentally that the fish need in order to breed. These are things like a spawning substrate, whether it's gravel or whether it's branches or weeds. They need clean, oxygenated water, they need structure and cover, and they need other environmental things. So these are things like

certain light (amount of daylight), certain temperatures, pH -- all of these things contribute to causing a fish to spawn.

So you need to essentially research the fish that you're going to be working with and figure out what is required to help that particular fish spawn.

Sometimes they also need a little more help and this is one of the reasons why commercially produced fish like trout are often manually spawned. Essentially the folks will take their fish out and they'll squeeze the eggs out of the females and they'll squeeze the males and essentially fertilize the eggs by hand in buckets.

So it just kind of depends on the fish. Some fish will breed very easily and naturally in your tanks and some will essentially need a little more help, including sometimes, hormones. So if you are into really intense, manual procedures for getting your fish spawned, you want to do all of that research beforehand. You want to make sure that the fish that you're using in your system is an easy breeder, it's easy to cause to spawn. Now if you're not opposed to doing more work, then that's fine, but it's good to kind of know what you're getting into before you pick the fish that you plan on using.

Once you've supplied all of these things, you're also probably going to have to supply a separate breeding tank. Now, the reason for this is a lot of the time, breeding females and/or males that are preparing to breed will change their behavior. The males oftentimes become very aggressive. They'll begin chasing other fish around the tank and beating up on them. Similarly, the females will need more shelter. This also allows you to control which fish pairs are breeding. So if you separate one desirable male and one desirable female and those are the only two fish in the tank, then you know that that female is being bred by that male fish.

Similarly, if you throw several females in there and one male, you know that all of the offspring are coming from that male and coming from those females so there's no other fish that can be entering into the mix there. So that's an important thing to remember when you're beginning to separate fish and thinking about breeding some fish.

Having separate tanks also allows the adults to be more easily separated from the eggs and from the fry, and this is important because once the females start producing eggs, a lot of the time other fish will swoop in and try to eat them. The same thing goes for fry, essentially (that's the fish that hatch right out of the egg). When they're still that young, they're very susceptible to predation. That means the other fish can swoop in and eat them and kill them very easily. So to prevent that, we want to separate them and we want to keep an eye on our tanks so we can separate that fry out from the breeding pair as soon as they're produced.

It also reduces the aggression-related mortality, that is, the fish that die because a male fish is chasing them around, nipping at them, biting them, wounding them -- all of these things are kind of mating behaviors that a lot of fish exhibit. Separating them out, allows you to control which fish are breeding, protect the eggs and the fry, and it also reduces fish deaths.

Once the eggs are laid, you have a few different options. Now I'm going to assume that most folks will be using fairly easy breeders, initially. These are fish like tilapia, fish like koi or carp.

For mouthbreeders, you're going to either collect the eggs from the female and put them in incubation jars… Essentially you're going to chase a female around the tank with a net and she'll spit the eggs out. It's better if you can scoop her out into a bucket of water and allow her to spit the eggs out there so you can get all the eggs, and then you're going to have to put them in incubation jars. This is the intensive way to do it.

If you don't want to go with incubation jars, you can just let the female do it naturally, and this is what we do most of the time because it's very simple, it's very hands off, it's very easy. You don't get as many eggs or fry that way but by and large, it works pretty well and it doesn't take a whole lot more work.

You have two options here: you can either put them in incubation jars or allow the female to mouthbrood. Either way, you'll end up with fry so long as you do it correctly and so long as the water is clean and well-oxygenated and the right temperature.

There's almost always some egg separation from mouthbrooders in commercial systems. Now in home systems, I would say don't worry about it. Just let the female do what she does and then make sure you separate those fry. Net them out of the tank as soon as they begin to appear.

For substrate brooders, you're going to have to remove the substrate and the eggs to a separate tank.

This is fish like koi. If you're growing a fish like koi or carp, in the spring, once the water levels kind of pick up a little bit and the temperatures change a little bit, sometimes daylight helps too, they'll start to look for shallow water with a lot of kind of structure to breed in, and they're looking for tree branches or weeds, something to attach the eggs to.

Once your koi or your carp lay their eggs and once they're fertilized by the males in kind of the shallow areas that you'll have to create in your tank, a lot of folks will remove those eggs. One way that folks do this is they create what's called the *breeding mops*, and these are just basically bunches of string that float on the water surface. The fish will kind of mistake them for weeds and they'll lay their eggs in the mop.

Some people also use tree branches sunk in the tank. The fish will lay their eggs in these dense tree branches.

Then all you do is, once the eggs are laid and fertilized, you just take the whole mop out and you move it over to your fry and your fingerling tank. Same with the tree branches, you just take them out of the breeding tank and set them in the other tank, and those egg masses will adhere to the mop or adhere to the tree branches and they'll be really easily moved over.

Egg scatterers are a little bit more difficult to deal with. You'll probably have to do the spawning yourself and then construct egg trays to incubate them. I'm not going to get into egg scatterers too much because they're much more complicated as far as getting those eggs to incubate and hatch. If you're

interested in breeding some kind of an egg scatterer, then I recommended you look up online, just kind of do a little research and figure out how you're going to do it.

Once the eggs hatch, you're going to remove them to a separate fry tank if you haven't already. So if you have fry appearing in your tilapia tank, you're going to move them to a fry tank, or if you're doing carp or a koi, something like that, and you've already moved your mops or your tree branches over, then you're good to go. That tank will essentially function as a fry tank.

Once those eggs hatch, for the first several days, the fingerlings won't need to eat. Essentially they just feed off of the yolk inside of that egg. You'll see the little fish swimming around and will have this big kind of a jelly-like yolk sticking off of their bellies. And over the next couple of days that yolk will shrink and shrink and shrink and shrink until all of a sudden all you have left is a fry. At that point, they're going to start to eat, and they're very hungry. At this point you need to start supplying some kind of really high-protein feed.

It's important to have good filtration in your tanks because once you start putting in that feed, your water will sour or ammonia will be produced and all sorts of other funky compounds will be produced that can cause mold and can kill your fry. You need to make sure that you're providing high-protein feed but also that you're filtering that water very well so that feed doesn't sour your tank.

There's all sorts of feeds that you can use at this stage and I recommend something like fry powder. This is a commercial powder that you can use. Powdered high-protein feed, okay, so you can just take your normal fish feed and you can grind it down to a powder to feed.

Powdered feeds are a little bit more difficult with these fish because they're very hungry but they're very bad at finding food so a lot of that will be wasted. You've got to count on your filtration to clean that water for using any kind of a powder.

Other folks like to use egg yolks, they'll boil an egg and will just float that boiled egg yolk in the tank and the fish will feed on it. It's a good way to go but again, you have to have good filtration.

One thing that I really recommend is either live feed or some kind of, in that category as well, some kind of phytoplankton or some other kind of aquatic plant that the fish can feed on. An aquatic plant of some kind will help because it will be absorbing some of that ammonia and some of the waste being produced, but it's also good feed that doesn't spoil for your fish. Some people use zooplankton as well, that is, just referring to little aquatic animals (tiny, microscopic animals) and the fingerlings will love, your fry will love these kinds of food sources because they're high protein and they're live so they won't sour your water like adding a dead protein source will.

Phytoplankton just refers to algae, and if you're growing something like tilapia, then you're going to be growing something that can eat algae or other plant materials. And of course, duckweed always works very well for this purpose as well.

You can't rely entirely on these phytoplankton or duckweed for a food source. You're going to have to also supply high-protein feed. But actually using algae or duckweed can help keep your water nice and

clean and help your fish grow really nicely. And they're nice because they don't spoil and they actually help clean your water.

That's how you get a start. You'll see that your fingerlings will grow very quickly…or your fry will grow very quickly into fingerlings. At the fingerling stage, they're ready to be stocked in a tank, in a larger tank. As they grow, you're going to want to move them from tank to tank to tank to make sure that they have plenty of room to grow, they have plenty of feed, and they're not competing too heavily with each other. And you'll find out very soon that you can grow very quickly from fry stage to fingerling stage, and the bigger the fish gets, kind of oftentimes, what you see is, the slower it grows. As it grows, you can start using less and less protein in the feed and you'll still get pretty good growth rates.

That's a start on breeding. I highly recommend, depending on the fish variety that you choose, that you do a little bit more research because fish breeding can be a very complicated thing. Once you do it a couple of times, you'll be very comfortable with it, but it does take a little bit of research on the frontend to figure out how to make things work, how to get the best incubation and hatching, and how to get the most survivorship out of the fry that's coming out of your tank.

Just do a little research. And this is a good start here, but you'll want to continue to learn, to research the subject, and especially to research fish-specific techniques because fish are so very different, there's so many out there. Have fun and good luck!

# 7. Vegetables – What You Can Grow

There are many vegetables that are well-suited for aquaponic production. Practically anything that's grown on the ground can be grown in aquaponic systems. Usually the question is not *what can I grow* but *what is most appropriate*.

So if you're doing outside aquaponics, you want to grow plants that are well adapted to your climate and well adapted to your area. If you're doing indoor aquaponics, then you have a lot more freedom over what you can grow. If you're growing inside of a greenhouse or something like that, you want to pick a crop that will do well in the conditions that you're going to be growing them in. So think about your temperatures. Think about how much light you're going to be giving the crop, and pick a crop accordingly.

The most common aquaponic crops are **greens:**

- Lettuce
- Collard greens
- Kale
- Mustard greens
- Spinach

Figure 14 Lettuce and spinach

Some people grow some root crops, crops like beets, turnips, radishes, carrots, etcetera, and a lot of people like to try **fruiting crops** like tomatoes and cucumbers.

Tomatoes and cucumbers are a little bit harder to try right off the bat because they demand a lot more nutrition than leaf crops. So that's one thing to keep in mind. When you're just cycling your system up and you don't have a whole lot of nutrition in your system yet, you want to think about focusing more on leaf crops that demand fewer nutrients than fruiting crops and just transition into some of the more difficult fruiting crops as time progresses.

Another thing to keep in mind, especially when you're talking about fruiting crops, is **pollination**. If the crops are outside then they'll get pollinated naturally by insects, by pollinating insects. But if they're indoors, you'll have to hand-pollinate.

So if you're growing eggplant or cucumbers or melons of some sort, strawberries, tomatoes – any of those crops – indoors, you're going to have to be pollinating by hand, which can be pretty time-consuming but well worth it if you really like strawberries in the middle of winter.

Figure 15 Strawberries

The type of crop that you pick will vary. There are lots of different varieties of different crops and most of the time you can find good write-ups on them when you're buying your seed. You want to look for crops that are tolerant of heat if you live in the South or if you live in a place where the summers are hot.

If you are growing strawberries, you want to pick a strawberry that's ***day-neutral***. That means it's going to flower all year long and produce berries all year long.

For other crops, you just want to read the description, read how many days it takes for them to grow and then figure out if you're going to have enough time in your system to grow the crop to maturity.

Most of the seeds you can start outside of the system if you want. For crops like cucumbers and tomatoes and for crops like greens, oftentimes people will sprinkle them in their grow beds and grow them directly in their system.

You can do whatever pleases you most. I do recommend starting seeds outside of the system just to save space. It's nice to be able to use that space really efficiently and plant seedlings that you've grown outside of the system as you have room opening up for them.

Another thing to think about is what kind of crops you like to eat. You'd be amazed at how many people grow crops that they don't even enjoy eating. Tthink about the crops that you like to eat on a daily basis and focus on those. There are a lot of different varieties so you just want to pick the one that's most appropriate to your area. Sometimes the expert gardeners in your area can give you recommendations on what is the best crop to grow, and oftentimes they'll share their seeds with you as well.

Another thing to think about for survival aquaponic practitioners is the ability to save seeds. Not all crops have viable seeds, especially a lot of hybrids. This is something you want to pay close attention to when you're buying your seed. You want to make sure that the crop isn't a sterile hybrid.

And most hybrids are going to be very difficult to save seed from. So look into crops that are older -- ***heirloom crops***, crops that have a history of seed-saving -- and consider using them instead of some of the newer hybrids.

A lot of the newer hybrids will produce more food but you can't save seed for a lot of them. So if saving seed is important to you, make sure that you're getting a crop or seed that will produce seed and that you can save from year to year and be self-sustaining in that regard.

# 7A. What Plants Need

Before you start growing plants, you need to know what plants need. Plants need water, light and nutrients to grow and reproduce. Plants also need support, which you're going to be providing via your media bed and the media in it.

Aquaponic systems are designed to deliver the water and the nutrients to the plants in the form of fish waste. So whenever your pump is pumping to your media bed, you are essentially delivering organic material that will be broken down and turned into plant-available nutrients.

If plants aren't getting enough nutrition, then they won't be able to grow properly. And there's lots of ways that you can spot deficiencies in plants, but I will talk about those in the Troubleshooting section.

## Supplements

In the meantime, though, you need to know that plants will need to be supplemented some nutrients when they're in your system simply because fish feed doesn't contain all of these nutrients. These are nutrients like calcium, potassium and iron, and occasionally, magnesium.

All of these can be easily supplemented in a few different forms, including:

- ***agricultural lime*** to supplement calcium
- ***caustic lye*** to supplement potassium
- ***potassium chloride*** to supplement potassium
- ***chelated iron*** to supplement iron.
- ***epsom salts*** to supplement magnesium

The nice thing about all of these compounds is that you can usually find all of the materials you need to supplement your plant nutrition at your local hardware store or drugstore or dollar store. Beyond that, all the nutrition will be supplied in the form of fish feed and fish waste. And you'll be able to notice, right off the bat when you begin feeding, a difference in growth in your plants.

## OXYGEN

You need to deliver oxygen to the plant roots. So this is one of the things that are most often overlooked in beginning aquaponic systems. And it leads to a lot of plant death.

Plants need oxygen in the root zone just as they need oxygen up around their leaves. They're aerobic creatures and they need to have oxygen in order to breathe, essentially. If they don't have oxygen, it's called ***anaerobic conditions*** and it causes disease and plant roots to rot. And it stresses the plant out, and because the roots are unable to function properly, plant diseases are able to get in really easily and hurt your plants.

So you want to keep that in mind when you're designing your system. You don't want your water to stand in your bed for too long. You don't want water to sit around those roots and grow stagnant or not move for long periods of time. This is all going to lead to oxygen depletion and it's going to cause your roots to rot on a lot of your plants. You always want to be moving water. You always want there to be some oxygen exchange taking place or your plants will rot.

## POLLINATION

If you have fruiting plants, they will need to be pollinated. And this is another thing that's often overlooked. If you're growing indoors, you're going to have to hand-pollinate your plants in order to get fruit for a lot of different types of crop.

Some crops you don't need to pollinate, but many you do. And if you want to save seed, then you'll definitely have to pollinate in order to get viable seeds.

## NITRATES

So these are things to keep in mind when you're thinking about your system and thinking about the work that will be involved and also just thinking about monitoring your system. Remember that the plants are growing primarily in fish waste; the nutrients in your water. So if you're monitoring nitrate, you'll be able to tell very quickly whether or not your water is nutrient-rich or nutrient-poor.

High nitrate content means that you're producing a lot of nitrate, which is a good thing, but it means that your fish or your plants aren't taking it up fast enough. So you want to strike a balance between feeding your fish at rates that are going to produce nitrates, but not overfeeding, which will produce more nitrates than the plants can consume.

Nitrates aren't very harmful to your fish in small amounts. However, if you have a lot of nitrate in your water, you can end up with disease problems, algal blooms, and my biggest problems in high-nitrate systems are usually ***aphid infestations***.

Aphids really love nitrates so if you have really high nitrates in your system, you can oftentimes have really bad aphid outbreaks. These are all things to keep in mind.

## LIGHTING

You're also going to have to supply light to your system. Now, if you're growing outdoors, this problem is solved for you by the sun. But if you're growing indoors, you're going to have to supplement light somehow, unless you have a greenhouse or a really nice southern window.

There are lots of options when it comes to supplementing lighting and it really depends on what types of resources are available to you financially as well as energy-wise. If you have a lot of money but not a whole lot of electricity, look into LED lighting. It's very expensive but the electrical consumption is very low, about half that of any other lighting system.

There are lots of other lighting systems out there that can be bought at hydroponic stores or nursery supply stores including:

- ***Metal halide lightings***
- ***High intensity metal-based lightings***
- ***Fluorescent lights***

Figure 16 Metal halide lightings

One thing to remember if you're going with anything other than fluorescent or LED lighting is that they do produce a lot of heat. You will have to have some way to deal with this- or at least incorporate the additional heat into your growing plans.

If you plan on heating your house, then you can just treat your lights as a supplementary heating source. But these lights do consume a lot of electricity. So that's one thing to keep in mind when you're thinking about doing indoor aquaponics. There is a lot of electricity consumption there.

# 7B. How Nutrient Needs Change

One more thing about nutrients: Plants' nutrient needs vary depending on where they're at in their lifecycle. When plants are growing at first, they're not growing seeds, they're just growing leaves. This is called ***vegetative growth***. Crops like lettuce and kale go through vegetative growth for most of their useful lifespan. We like to use the results of their vegetative growth – their leaves.

However, we don't use the vegetative growth for other crops like tomatoes, cucumbers, strawberries. We want their fruits or their ***reproductive growth***.

As the crops transition from vegetative growth to reproductive growth, their nutrient needs change as well. This is important to remember when you're doing aquaponics because a lot of the time, fruiting crops demand more phosphorous and more potassium and some of these other nutrients once they start producing fruit.

So it might be useful for many aquaponic practitioners to supplement phosphorous and to supplement some of the other micronutrients, especially when their crops start fruiting. This is really easy to do. Some people use straight **seawater**. Some other people use **seaweed extract**, which is a really good way to supplement micronutrients.

Figure 17 Seaweed extract

Other folks will occasionally add **manure teas** or **compost teas** to their systems. It really just depends on what resources are available. But I will talk about diagnosing nutrient deficiencies and also how to supplement certain nutrients a little bit later in the Diagnosis and Supplementation portions of this book.

# 7C. STARTING PLANTS GERMINATION

Starting plants in aquaponic systems can be very simple. For crops like lettuce, kale and other greens, you can just sprinkle the seeds in the media itself. The seeds will fall down between the rocks and typically stick to the media somewhere down below the surface of the media.

The moisture in your gravel, hydroton, or whatever your media is, will germinate the seeds and you'll see them just sprouting up wherever they landed.

If you use this technique, oftentimes you have to go through and **thin plants out**. That means you have to pluck out preferably the smaller seedlings from the mass of seedlings so that the bigger, stronger ones have enough room to grow. And depending on when you plan on cutting the leaf, you might want to do this sooner or later and you might want to leave more or less space.

For instance, if you're growing heads, then you want to give them larger spacing so the plants can grow out and grow nice healthy heads. If you're planning to cut leaves when the plants are still really young, you can let them grow more densely.

## OTHER SEEDING OPTIONS

Other seed storing techniques include using some type of medium outside of the grow bed. So these can be ***jiffy pellets***, which are little pellets made of peat moss mined in Canada. It's scraped out of the ground and they form them into these little pellets. You drop your seed in the pellet and you let it fill up with water and that seed will germinate in the pellet. Then after the seedling has grown and those roots are well developed inside the pellet, you can transfer it to your system.

Other people will use ***vermicompost***, which is the compost that's left over after worms eat your kitchen scraps, lawn clippings, or whatever you're feeding to those worms. Other folks will just use other media like ***vermiculite*** or ***perlite*** or some of these other ones.

Figure 18 Jiffy pellets

I prefer using peat pellets, especially Jiffy pellets because they're contained in a little mesh bag. So usually that peat won't spread out into your system and make a mess.

All those other media can cause problems in your system as they break down and as they spread through the system.

The peat pellet option is also nice because it gives you more room in your grow bed. It lets you put in more seedlings as you need to. It doesn't force you to plant plants really densely right off the bat, and you're not wasting as much space on seedlings.

I really prefer the pellet method or using ***plug trays*** or some other means of planting the seeds outside of the system for most crops, and then transplanting them in as you need them.

### Germinating

To germinate your seeds, you're going to need a nice moist environment that's not too moist and you're going to need oxygen. You're usually going to need sunlight and of course, you're going to have to be supplying water fairly regularly.

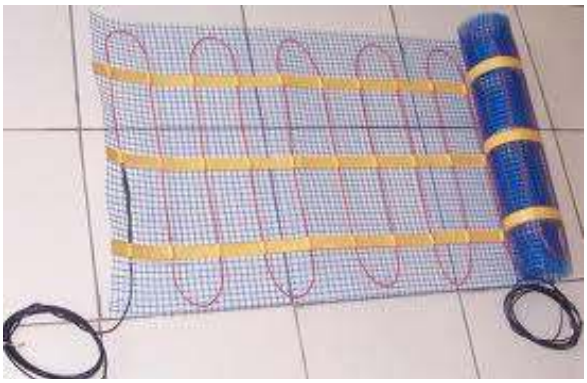


Figure 19 Heating mats

Most people find it a lot easier if they use ***heating mats***. These are little electrical mats that you plug into the wall and it can heat up your plug tray or whatever you're using to germinate and keep it nice and warm so that seed germinates a little bit faster and grows a little faster.

A lot of folks will also germinate their seeds under ***grow lights***. Little fluorescent lights can be used for this purpose. They're very inexpensive to operate, really inexpensive to purchase, and they can dramatically speed up your germination process and increase the success of your germination.

## 7D. Buying and Saving Seed

There are lots of different places you can get seeds. You can collect them yourself from your own plants, a friend's plants, from the wild, or you can buy them.

There are lots of really great retailers for plant seeds out there that will give you very good descriptions of how the crops grow, what they need and what kind of a time span you need to provide for the plants to grow. They'll also tell you how much light the plants need, which is important if you're growing in a

more shaded area. They'll tell you how big the plants will grow and they'll tell you how to space the plants.

Now, one thing to remember when you're planting your plants is that you're always going to plant a little bit tighter in aquaponic systems. But that's a side note.

In reality, buying seeds is very easy and there are lots of opportunities to do so. Look for crops that are common to your area and try some of the online seed banks as well if you're looking for more heirloom seed varieties. There's lots of seed banks out there where people will share seeds and essentially will gather it up in the fall and then send it in to be redistributed among other folks.

So depending on what you want and depending on how much money you want to spend, there are tons of options as far as getting a hold of seed.

## STORING SEED

Naturally if you're saving seed yourself, you won't need to buy seed because you'll be able to collect it every year. So the important thing to remember if you're saving your own seed is store it properly. You can store seed in ***mason jars*** or in packets but you want to keep it in a cool, fairly dry place and you want to keep it out of direct light. And of course, if the seed gets wet, oftentimes it's easily ruined.

You also want to keep your seed away from vermin, rats, mice, and other insects and animals that might destroy your seed while it's in storage.

Mason jars are a great way to store seed because they seal really well and they're fairly insect- and rodent-proof.


Figure 20 Mason jars

If you're storing in seed packets, I would recommend steel containers like stainless steel, small stainless steel garbage cans with lids, or filing cabinets. Some people like to use library card files because they can get them really cheaply from equipment sales, schools, or from old libraries.

These are all options. Saving seed is a great way to go, especially in a survival aquaponic system,simply because you know how the crop has performed before and you can replicate that performance. Over time you'll find that you develop plants that perform especially well in your system. If you save seeds from year to year, you end up with crops that are very well adapted to your system and very well adapted to your area.

# 8. The Bacteria

The bacteria are really the most important part of the system, but it's often the most overlooked part as well.

Bacteria grow on the surfaces of the tanks, on the surfaces of the media, and are suspended in the water. They really do all of the work in the system by converting waste materials into plant-available nutrients.

They also help keep the water clean. They also help protect your fish and your plant health when you have a healthy bacterial ecology going. The best way to do this is to keep good, oxygenated water to prevent overfeeding and to make sure that you're cycling your water quickly. And you want to make sure that plants and fish always look healthy. They'll always be a good clue as to how healthy your bacterial populations are.

## Nitrifying Bacteria

You have several types of bacteria in your system and several different classes that do different things. The most important ones though, are the ***nitrifying bacteria***. These are the bacteria that we always talk about that are converting ammonia to nitrite and converting nitrite to nitrate. And there are a couple different types of bacteria that do each conversion.

So keeping these bacteria healthy and keeping those populations high is very important. One way you can do that is keeping your water well-oxygenated and keeping your pH from dropping too low, at least at first.

Keeping a pH around 7 keeps the bacteria healthy and makes it easier for them to convert ammonia into nitrate. Also, keeping your temperatures stable is going to ensure that they don't have too much environmental flux to deal with.

These bacteria are also really sensitive to UV light. So if you go out and take a shovel out and you overturn your gravel and expose your gravel or your rock or your hydroton or whatever your media is, to sunlight, oftentimes you can kill the bacteria. So that's something to keep in mind as you are taking care of your system, as you're doing some of that maintenance work that's required.

You also don't want to harvest all of your plants immediately. You want to harvest them successively because a lot of these nitrifying bacteria will colonize your plant roots, and that ends up being a really valuable habitat for these little bacteria.

Beyond that, you just want to make sure that things are staying well-oxygenated as these bacteria need oxygen to survive. If it grows anaerobic, often times you'll see your bacterial population crash.

## MINERALIZING BACTERIA

The other bacteria in your system are ***mineralizing bacteria***. These are just other bacteria that basically are decomposers. They take waste and they break it down to smaller and smaller parts. These bacteria are  well suited to your system environment and they're a little bit harder to kill and less sensitive than the nitrifying bacteria. But you still want to make sure that you're giving them what they need and being sensitive to your bacteria's needs because it's the one element of these systems that people forget about. Oftentimes folks will go out and they'll turn over their gravel and then they'll wonder why their system crashes and their fish dies. It's all because of bacteria. Everything comes back to having really healthy bacterial populations, so if you disturb and disrupt this population, you can hurt the whole system

There are all sorts of other bacteria in your system beyond decomposers, beyond nitrifiers, that do all sorts of great things. By and large, they just keep your system good and healthy. They interact with plant roots and they interact with your fish positively.

## PATHOGENIC BACTERIA

There are also ***pathogenic bacteria***. This is bacteria that will kill your fish and attack your plants. If you have a healthy ecology in your system, not overfeeding, and being careful about your system maintenance, then these bacteria usually won't have a chance to take over and really start impacting your system's health.

So as long as your system is healthy and your nitrifiers and mineralizers are in good shape, you don't have to worry too much about pathogens.

# 8B. Starting Your System Bacteria

Getting your bacteria started in your system can be very simple. A lot of people will take water from an established system such as an aquarium or another aquaponic system that they know is safe and that there aren't any disease problems with, and they'll introduce it to their system. This is a really great way to accelerate the ***break-in period*** or ***cycling period*** on your system and ***inoculate*** your system. Inoculating or Cycling refers to the process of getting all of the good bacteria into your system and reproducing.

## Inoculants

In addition to getting this water from existing sources, you can also buy ***inoculants*** over the internet or from lawn-and-garden stores. Some hydroponic shops will also supply some of these bacteria.

I don't recommend inoculants typically because the inoculant arrives in a bottle and these are very sensitive bacteria and I'm not entirely convinced that they survive the transportation process.

Also a lot of the inoculants that are sold as ***nitrifying inoculants*** contain bacteria that do nitrify but they're not really native to these types of systems and they don't stick around for a long period of time. They're a great way to get a little bump in nitrification but in the long-term, you'll find that bacterial species will adapt to your system specifically and will begin to grow and reproduce on their own, and really these are the bacteria that you want.

If you don't want to introduce water from an aquarium or from someone else's aquaponic system and you don't want to use an inoculant, you can just wait. The bacteria that you need will colonize your system naturally, with very little help from you.

However, you do need to supply food for them so you're going to have to put a little ammonia into that system and there's a lot of ways to do that. You want to be patient if you just choose to let natural colonization take place. You want to be patient, you want to make sure that you're maintaining your system flow, and you have to provide a little bit of food for them in the form of ammonia.

It will usually take about six weeks for those bacterial species to start showing up. And once they start showing up, you'll see an instant bump in your ammonia reduction process. You'll see ammonia dip, you'll see nitrites spike, and then in a little while later you'll see your nitrites dip and your nitrates spike. So you just have to be patient, wait around six weeks, and the bacteria will find their way into your system on their own.

# 9. Worms

A lot of people introduce red worms to their systems. Some folks use earthworms, some use some other variety of worms, but I recommend ***red worms***. These are *Eisenia Fetida.* They're red wigglers and they're great at composting.

Figure 21 Red Worms (Eisenia Fetida)

These worms can be purchased over the internet or from lawn-and-garden stores. They are not very cold-tolerant though, so they won't survive during the winter. So if you're going to introduce them to your beds, I recommend removing them before winter, otherwise don't expect them to be alive in the spring.

When you buy these worms, they'll come in a box. You can just open that box up and dump those worms in and they'll work their way into your media.

## Why Worms are Important

The reason they're important in these systems is that they can really help with your solids mineralization. If you recall from a previous chapter, mineralization is just breaking down organic solids into smaller constituents. It's breaking down these big chunks of fish poop and turning them into plant-available nutrients.

Red worms are like little ***bioreactors***. That means they speed up these processes dramatically. And the nice thing about them is that solids go in and very small particulates (little itty bitty tiny pieces of poop) come out of them. Most of what's left after the worm eats it can easily be washed around by the water. It's very small. It's broken down further faster and you end up with healthier plants and faster nutrient cycling.

This is really important in these systems because one problem with media-bed systems is that they can clog really easily and you end up with kind of anaerobic beds, beds that stink a little bit, and they end up having lots of solids stuck down in the nooks and the crannies of the media. So by using worms, you can reduce that and keep your flow going really well. You can keep the water movement and percolation through the media going well and you can reduce some of the oxygen depletion issues that come with many media beds.

Introducing worms to your media beds can be a really great thing if you want a healthy system really fast. You'll find that they also help with all of your other bacterial establishment issues.

I highly recommend red worms specifically for use in these systems. Once they're in there, they make themselves at home and they reproduce really rapidly. So they will form a self-sustaining population very quickly.

Not only do they move around in the media beds, they move around in the system as a whole. You'll find them just about everywhere that the water flows. In healthy systems, you'll have such high oxygen content that the worms will survive regardless of how much water they're in.

In many of my systems, I find that the worms survive in places that I wouldn't expect them to. If they end up in the fish tank, it's not a problem. The fish eat them. It's supplementary protein. So everything in the system cycles very nicely and worms can really help keep that cycle in good shape and keep your nutrients breaking down and keep your media beds free of solids.

## 10. Additional Animals

Many other people will choose to integrate other animals into their aquaponic systems. This is essentially just adding another waste loop or adding another input to the system. You'll see folks that have put ducks and chickens in their systems. What this does is introduce all of the waste material from the chickens and the ducks to the system and gives it a little bit of bump in nutrients.

So it's a nice thing you can do to complicate your ecosystem. Remember that any time we make our ecosystem a little more diverse we can get a little more power out of it.

In instances where ducks and chickens are incorporated, you see oftentimes a little more nutrient content to the water. Usually with that comes more algal blooms but these are something that we can deal with when the time comes. See the troubleshooting section for more information on that.

Other folks will integrate larger animals into their systems like goats, hogs, or other larger size animals. Some will introduce waste from livestock into their systems. While this can be a practice that bumps up the nutrients in the system, I don't recommend it for systems where there's going to be exposure of the

water to humans. If you don't have the facility, time, or you don't take a lot of care washing your produce, this can introduce some dangerous pathogens to the system.

But in systems where you wash everything, it's not a bad way to go. This is called ***waste-fed aquaculture*** and is the norm throughout the developing world. A lot of people use waste, either human or livestock, to feed ponds which cause algal blooms, which the fish then feed on. The fish graze on the algae in the ponds.

It's a very sustainable way to use waste from animals to produce fish. And usually the fish is fairly safe until you start introducing human waste and waste from animals that might have problems with *E. coli*.

With all of these things, you can usually get around the safety issues by cleaning the fish well, making sure that all of your surfaces are sterile, and by washing everything you eat.

While I don't recommend the introduction of livestock to these systems by and large, simply for the health concerns, it is a possibility and it can add a little more power to the system itself.

# 11. Additional Plants – Water Plants

## Duckweed

Some folks choose to integrate additional plants as well. One plant that's commonly used is ***duckweed***. Duckweed is a great crop that grows very rapidly and it can be used as human and livestock feed.

If you're growing duckweed in systems where you have omnivorous fish like tilapia, it's also a great supplementary feed source for the tilapia.

The thing to remember with duckweed though is that it produces a lot when you weigh it fresh, when you measure it's wet weight. When you actually dry it out and weigh it, it's not as impressive. So when you're calculating your feed inputs and you're calculating the fish you'll get from the amount of feed you put in, you have to be careful with duckweed to be considering it by dry weight.

Figure 22 Duckweed

That being said, duckweed has a lot of protein content, it grows very quickly, and it really is good at stripping nutrients from waters. It's great feed for fish, ducks, hogs, chickens and other livestock, and it can be a nice little addition to the system especially if you have problems with algae blooms. The reason for this is that the duckweed will grow on the surface and does a great job of shading the water underneath it. So as

the duckweed grows and shades the water beneath it, it basically chokes out the energy source for the algae.

## Water Hyacinth

Another plant that's used is ***water hyacinth***. Water hyacinth is a great crop. It is not legal in many places because it is an invasive water plant. However, it can be very useful for shading as I mentioned before, and fish like tilapia love it. It too is not a bad input for a lot of these livestock feeds. It grows very quickly and it can grow vegetatively.

Figure 23 Water hyacinth

There are a few other plants similar to water hyacinths that are also used, and there's lots of information online about different plants and their uses in these types of systems.

Remember though, every time you introduce another plant to your system, you're taking nutrients that could be used for crop growth. So unless you intend to feed a lot to livestock, unless you don't intend to eat as much yourself, make sure you're not adding too much water hyacinth, duckweed, water lettuce or other extra inputs at the expense of your crop plants.

# 12. Location and Environment

Location and environment are very important concerns when you're thinking about locating or building an aquaponic system. If you live in a place where the winters are cold, you want to consider what you will do over the winter to keep your system alive. Because it requires a lot of time to get these systems developed, you want to try and keep your system going as opposed to just letting it die over the winter. You can overwinter these systems but it's fairly hard on them and it's difficult to do.

## Temperature

The first climate consideration you want take into account is **temperature**. When you're thinking about putting your aquaponic system in a given location, make sure that there aren't wide temperature fluctuations from morning to afternoon to evening. Some qualifications you should look for in the location are:

- Not in a place where the wind rushes through
- Not in a place that's shaded
- Location should be protected fairly well

## Sunlight

You also want to think about **sunlight**. The easiest way to figure out whether your location is a good place to build or not is to go out in the morning, in the afternoon and in the evening and see how much light there is.

If you're thinking about locating in a greenhouse or building a greenhouse for your system, you want to go out in the dead of winter, preferably around the winter solstice and see where the sun tracks across the sky. If there's anything to the south of the location, track where the shadow of that object moves along the ground as the sun goes from its morning positions through its midday to its evening positions.

Wherever that shadow tracks, that's the beginning of where you want to consider building for a location. This is basically just to make sure that your system will be getting plenty of sunlight even during the winter. It's one thing that a lot of people fail to take into account before they build. And before you invest money and time and energy, you want to make sure you picked a good location.

If you're not going to build a greenhouse during the summer, you want to think about being able to either move your system indoors or use artificial lighting. I guess if you're going to move it indoors, you're going to need artificial lighting.

## INDOORS

So if you're going to be able to move your system indoors, it's going to have to be a smaller, lighter system. These systems are harder to build and usually they're not as productive as larger systems. So a lot of people shy away from them. They're also a little less stable.

If you're going to go that route, you're also going to have to use a lightweight media as well, something like ***hydroton***, which is fairly light. You can drain your grow beds and drain some of the water out of your fish tanks and kind of drag your tanks around a little bit.

But again, it's very difficult to design systems that will allow that kind of modularity. So think about either building inside if you have a long, cold winter, and using artificial lighting. Another option is you can build another system and basically move your media and your fish over at the end of the fall.

If you are growing inside, you're going to need to be using artificial lighting. There are several different options available and there are lots of resources online for figuring out what kind of lighting is best for you. You can choose anything from some of the traditional lighting to some of the newer stuff like LEDs which are making a big splash in the world of artificial lighting because of their low energy use and their efficiency.

However, every time you use newer, fancier stuff, it's always going to cost you more. Lights such as LEDs can be really expensive.

## HEATING GREENHOUSES

If you're growing during the winter and you're thinking about using a greenhouse, you're going to have to figure out a way to heat it. Greenhouses can be really good in a lot of ways. They're great at prolonging your season, at keeping your temperatures higher. They're great at keeping your crops growing through the coldest months of the year. But they're energy hogs. They consume a lot of heat and it takes a lot of heat to keep them going.

Now, depending on the system that you have and the fish that you're using, you may choose to go with something that's more of a ***high tunnel***, that is, a greenhouse without much, if any, heat.

If you're growing trout and you live in a place where it doesn't freeze for most of the winter, then you can get away with something like this, and essentially be growing fish in a high tunnel or a greenhouse with very little heat requirements.

However, if you do live in a place where you need a lot of heat especially in the middle of the night, to keep your greenhouse warm, you're going to have to figure out a way to heat it.

Some people will use heat from animals or compost. While this can provide small amounts of heat, it requires a lot to actually heat a greenhouse, especially in the dead of winter.

Other folks will use wood-burning furnaces but the industry norm is natural gas. And oftentimes the cost of hooking up natural gas can be cost-prohibitive for many folks.

Also for folks interested in survival applications, something that's more sustainable that uses a resource that's more readily available and is probably wiser. For folks that really want a sustainable system that will function no matter what, look around you and see what kind of resources you have.

If you have a lot of wood, then maybe a wood-burning stove is optimal. If you have a lot of sunlight like in the southern United States, then you can use solar heat and solar energy to run your greenhouse. It's really just going to depend on your location and what kind of assets you have as far as energy and heat.

If you are growing in a greenhouse or indoors, you don't have to worry about a lot of things like hail, massive amounts of rain or inclement weather. This is one of the huge advantages to growing inside.

## Other Locations

If you're growing outside, then all of these things become a concern. You need to start thinking about how you can protect your system from things like hail and other forms of inclement weather.

If you're thinking about growing in a confined space, then picking the right location is very important. You have to think about accessing your system, you have to think about harvesting every day, you have to think about caring for the fish, and just doing general maintenance, so you don't want to cram it into a corner somewhere. You want to find a place where it's easy to get around the system, to access every part of it, and a place where the system isn't in a way.

For apartments, it is possible to build small aquaponic systems that can sit on a patio or sit indoors in a fairly small space. There are many designs out there that can be used for this purpose. So if you have any questions about this, I'd encourage you to spend some time online researching small or micro systems.

If you are interested in rooftop production, there are aquaponic systems that work great for this application as well. The big concern with rooftop applications is the weight because many roofs are not rated for really heavy loads, and water is really heavy. So with these types of systems, you're just limited in the technique you use. You'll be forced to either use ***NFT*** or a ***vertical technique***, both of which are very lightweight and will allow essentially very lightweight plant production on top of the roof. The weight of the fish tanks can be spread out over the entire surface of the roof.

Another thing to think about is make sure you have access to energy and that it's reliable. Also, if you leave for a prolonged period of time, will your system be protected? Do you go and have to worry about vandalism? Do you have to worry about animals? Do you have to worry about thieves of the two-foot and the four-foot variety making up with your fish?

I've known a lot of folks who have lost fish to raccoons, herons and to other people. So you have to think about the security of your system and you have to locate your system in a place where you're comfortable leaving it unattended.

Oftentimes you'll probably have to leave for a weekend or something like that. Having a system that is well designed will allow you to walk away and come back to a functioning system that is still going.

# 13. What You Will Need To Get Started

***IBC*** aquaponic systems are a great way to get started in aquaponics. The required components are readily available, they're inexpensive, and there is literally tons of information on the internet regarding IBC systems. Almost everyone at some point in their aquaponic career has worked with an IBC or an IBC system.

So, before we get started, let's talk about what you're going to need. You're going to need an IBC, preferably a food-grade IBC. You can find these from depots that resell used IBCs, used barrels, and used containers. Oftentimes you can find them for a fairly good price. I would search your area, look on Craigslist, look in the wanted ads, and search online to find someone near you who sells them.

Oftentimes they can be had for between $100 and $200, although I've been able to find them before for as low as $50.

So search your area, try and find one that's transported food or a food-grade product. Also, make sure you have the supplies on hand to rinse the IBC out once you have it.

## Pump

You're also going to need a **pump**. And pumps are one of the subjects which you could talk all day about but what you want to pay attention to on a pump is **head height** and **gallons per hour (GPH)**. These are two ratings that pumps will always have listed on the box or listed by the manufacturer.

So for this project we're going to use a submersible pump, which is simply a pump that sits in the water. The hose will hook directly to the pump and it will pump water up through the hose to your grow bed.

I would recommend looking online for the *EcoPlus* brand name. These are pumps that I have used in the past and I find that they work very well and have a long lifespan.

Figure 24 Ecoplus Submersible pump

The *Ecoplus 396* and the *Ecoplus 285*are both models that are appropriate for this particular application. Both have good head heights. That means they're able to pump water high off the ground or from the surface of the water that they're submerged in, and they both have good gallon-per-hour ratings, which means they'll move a lot of volume

Figure 25 3/4 inch black polyethylene tubing

Now, there's a tradeoff in pumps. As your height increases, you're going to be moving less and less volume. So you want to do the math and you want to look at the charts on the pumps themselves to make sure that if you're lifting water two feet, you're still getting a good flow. Or if you're lifting water 5 feet, you're still getting adequate flow.

Both of these pumps are fairly oversized for this application but I anticipate that as you get into this project, you'll want to add more grow beds and as you do that, you're going to need more volume. So look for those particular pump types. They'll serve you well.

## PLUMBING

We're also going to need 5 to 6 feet of **3/4-inch black polyethylene tubing**. This tubing is readily available at any Ace Hardware, Lowe's or Home Depot. Pretty much any hardware store will have it and it should very inexpensive, less than a dollar per foot.

You're going to need three **barbed 3/4-inch L fittings**. These are fittings that essentially are pushed into the black *poly* pipe. You're going to use a heat gun to heat the pipe up to receive that fitting.

Figure 26 3/4 inch L fitting

I will note too that all of these 1-inch *poly* tubing components can be switched out for 3/4-inch poly tubing if that's all your local hardware store has.

We're also going to need **three feet of 2-inch PVC pipe**. This can be had inexpensively also at your local hardware store. And this too should cost less than $1 per foot.

You're going to need one **2-inch female-threaded-to-female-slip coupling**. So these are couplings that you can push the 2-inch PVC pipe into one end and on the other end, it has a threaded fitting.

You're going to also want one **female-slip-to-male-threaded coupling**. And we're going to use this to screw into the female side of the other coupling. Both of these should be readily available at your hardware store.

We're going to need one **10-inch piece of 4-inch or 6-inch PVC pipe**. It doesn't really matter which one and it can be thin-walled pipe, such as septic pipe. Just look for something inexpensive. Oftentimes you can find this type of pipe too in waste from irrigation systems.

You're going to need one **3/4-inch Lbarbed-to-male-threaded fitting**. This would be available in the irrigation aisle along with the barbed L's that I previously mentioned. You'll be able to find it at Lowe's, Home Depot or any other hardware store.

You're going to need one **T with a female-threaded fitting to slip on either side**. This is going to receive 1-inch PVC pipe. And this is going to form a pipe system that runs around the outside of our grow bed to irrigate our grow bed.

As part of this, we're going to need around **15 feet of 1-inch PVC**. So this is 1 ½ sticks of 1-inch PVC at your local hardware store. 1-inch PVC is usually $7 to $8 per 10-foot stick. And you can cut it down if you need to, to fit it into your car- just buy a couple of extra slip couplings to fit it back together.

Figure 27 PVC pipes

**Four 1-inch L's slip-to-slip PVC couplings** will also be required. And this is to form the corners on the tubing that's going to go around the grow bed.

You're also going to need a little **Teflon tape**. And Teflon tape is available on the plumbing aisle. It usually comes in a little blue roll and it's a fine film-like tape that's going to help us screw our 2-inch couplings together.

Figure 28 Teflon tape

## TOOLS

For tools, you're going to need a **drill** (can be cordless or with a cord – it doesn't really matter), an **angle grinder** with a cutting disk or a **reciprocating saw**, a **jigsaw** (which is optional), a **permanent marker**, a **tape measure**, a **½-inch drill bit** or a **spade bit** (either one will work). Spade bits are a little bit easier to work with for this particular type of plastic.

Figure 29 Tools

And a **2 ¼-inch hole saw** or a **jigsaw**. Now, we're going to use this 2 ¼-inch hole saw to drill the hole for our 2-inch couplings. You can also do with just a regular drill bit and a jigsaw but it's a fairly tight radius. So if you haven't used a jigsaw before, I would recommend investing in a hole saw. You can find a hole saw in your local hardware store.

You're going to need a **pipe cutter**. Now, I recommend using a pipe cutter as opposed to a reciprocating saw. You can cut PVC pipes with a reciprocating saw but you have to be very careful and you have to go slowly. So if you don't feel confident in your ability to cut pipe with a reciprocating saw, please invest in a pipe cutter. They're usually $7 or $8 at your local hardware store.

You're going to need **PVC pipe weld** or **PVC glue**. And you're going to be gluing some of your 2-inch pipe into your 2-inch coupling, so you're going to need a very small amount of PCV glue. This stuff can be kind of expensive. It's usually $4 to $5 for a fairly small bottle. So don't invest in a big bottle of PVC glue. Just use a smaller one.

Oftentimes people will have some PVC pipe weld lying around their house too, so make sure you raid your maintenance closets before you go out and buy any.

You're also going to need a **heat gun** or a **blow dryer** to heat up your *poly* pipe. So you can use a blow dryer for this application if you don't have a heat gun.

I would also recommend that you use **safety goggles** and **gloves** just to make sure you don't cut yourself on the burrs from the plastic, and to make sure that you don't get anything in your eyes.

Figure 30 Safety goggles and gloves

## 14A. 2X4'S AND MEDIA

You're going to need two more additional items. You're going to need some lengths of 2x4, preferably **two 10-foot 2x4's** that you can cut in half. You're also going to need **media** for your beds. The media is probably the most difficult part of this system to choose. You have a lot of different options.

### MEDIA

If you don't have a whole lot of money to spend, then I would recommend that you look at **¾-inch crushed granite**. You can get it at almost any landscaping or rock yard in your area.

For folks that want to save even more money, you can wash your own gravel by going and getting some road-based, washed gravel from your local rock yard or construction supply company.

These are kind of the low-end options, and they work fairly well but the drawbacks are that they're very heavy. And if you're using gravel, oftentimes you'll end up with some solids problems. So look into ¾-inch crushed granite. And if you decide to go that route, plan on reinforcing your system to handle the extra weight.

Figure 31 Crushed granite

If you have a little more money to spend and you want a system that doesn't weigh a ton, look into **expanded shale**. Now, this is a shale rock that's mined, and then it's put into an oven at a really high heat, which causes it to expand, to pop out, almost like popcorn. It's lightweight, it's got a very high biological surface area and it works really well. It's easy on your hands. This is one other drawback to the 3/4-inch crushed granite. It's hard to work with. It's kind of sharp and jagged and it's difficult to move around with bare hands.

If you plan on spending a little bit more money and going to expanded shale, you'll find that it's a lot easier to work with and it's much easier on your hands.

Now, the "Lexus" option here is **hydroton**. This is an expanded clay pellet. They are round, little terracotta-colored clay balls. These are really nice because they are lightweight and they move very easily. They are very easy to work with on your hands.

Figure 32 Hydroton

The one drawback to these is that they occasionally float, and that they're quite expensive. So unless you've got a bit of money to spend, I would recommend either expanded shale or a ¾-inch crushed granite for your media.

There are also a few other media products out there but these are kind of the main ones for this particular system build. So after you put your budget together, figure out what you can afford and go from there.

All of these media will work. There are pros and cons to each one. I'll assume that you're going to work with expanded shale; kind of the middle-of-the-road product as far as cost goes.

If you go to the rock yard to purchase any kind of gravel or rock, they're going to sell it by the cubic yard. Whether it is hydroton, ¾-inch crushed granite, gravel or expanded shale, we're going to need around half of a yard for this project.

# 14. Self-Sustaining Aquaponic Systems

A lot of people ask about making a self-sufficient aquaponic system. That means they are looking at raising duckweed in their system and using other animals and plants in a way that they hardly have to put anything into their system. They say, "Well, if I grow enough duckweed, then I can feed that to the fish, then I'm essentially getting fish for free. I don't have to buy feed."

There's some error to that argument because every time you take nutrients out of the system, you have to put an equivalent amount or even more into the system. So the whole perfectly self-sustaining closed-loop aquaponic system is a bit of a myth. However, you can create very efficient aquaponic systems that use your nutrient inputs really efficiently, as well as energy inputs.

## Solar Power

One thing that a lot of people do to try and make their systems more self-sustaining and more self-sufficient is using solar. Many folks think that using solar energy will make it so that they can walk away and go on vacation for a week and not have to worry about their system..

Unfortunately, it's not quite there yet. There's a lot of promise in regards to using solar panels to run pumps. There are some nice things about this arrangement. Plants are only really consuming water during the day when there's photosynthesis taking place. Just cycling water during the day should supply the plants with plenty of water when they need it.

The nice thing about solar panels is that they're only running during the day. If you have the ability to install panels and a controller, and you just want to run your pump while you have daylight, that's definitely something to look into.

If you want to install batteries and run occasionally through the night as well, you can definitely do that. Just irrigating less and running less volume during the night will help you conserve that energy and get the most out of it as far as solar goes. The same goes for wind. You can use wind to generate energy to run pumps.

Again, though, we're talking serious investment when it comes to solar and wind power systems. So you need to do a cost-benefit analysis and decide whether it's worth it for you to install a wind generator or solar panels and battery banks in order to run your aquaponic system.

I know folks who found that it is essentially something that they want and they'll install panels and they'll wind turbines and they will run their systems on them. But by and large, most people find that it's cost-prohibitive.

## FEEDERS

You can also install ***auto-feeders***. This kind of gives your system a little bit of self-sufficiency. It allows you to go away for a while.

There are a few different kinds of auto-feeders out there, and some of them are good and some of them are bad. I don't recommend auto-feeders by and large. However, if you need to leave and you want the auto-feeder to babysit your fish for you, they could be a good investment.

There are automatic feeders which run on a computer or a timer, and usually these are electric. And then there are also on-demand feeders, and there are two different types: ***demand feeders***, basically resemble a cone that you fill with feed and there's a little ball at the bottom that covers up the hole in the bottom of this feed bin. There's a little wire that descends out of the water and when the fish get hungry, they can just swim over and bump that wire with their nose and it will drop feed pellets into the water for them.

A lot of folks used to use these and a lot of people still use these feeders in pond production, primarily because there's a tendency with demand feeders to overfeed the fish. So that's something you want to keep an eye on. The fish will get greedy, and they'll take more feed than they can possibly eat. And then your water goes sour and you have some bad problems that result.

Demand feeders are cheap. That's the one nice thing about them. They don't cost a whole lot of money. But at the same time, you have to monitor them a lot more and make sure that the fish aren't giving themselves too much feed.

Automated feeders, on the other hand, usually run on some kind of electricity. Some of them are spring-loaded. There are a lot of different options out there. These are a lot more expensive but they're a bit more precise as well. You can set how much feed is being delivered to your fish daily. And if you're

underfeeding your fish, then you don't usually have to worry about feeding too much and the pellets rotting and ruining your water.

The one drawback to these feeders is that they automate the system a great deal. And while that's a benefit at times, at other times it's a bad thing. The reason for that is a lot of the time; your system's health will be mirrored in the behavior of your fish. So when your fish are feeding really well, you know that your system is healthy. And when they're not feeding very well, when they're kind of holding back, when they're swimming sluggishly, you know that something is wrong.

So these feeders reduce the amount of time that you spend observing your fish, interacting with your fish, and they don't help you really figure out how well your fish are feeding, because a lot of the time you won't be around to observe it.

I'm a big fan of hand feeding myself, and this is called ***feeding to satiation*** and it basically just describes feeding the fish until they stop eating. And then you stop feeding them. And if you keep track of how much you're feeding them regularly, pretty soon you'll know how much they can consume.

In aquaponic systems, you want to feed them to that point and then you want to back it off a little bit. So you want to be feeding them about three quarters of their maximum feeding rate when they're in their tanks.

And then of course, if you have a lot of nitrate, if you have an ammonia spike, if you have any other nutrient issues in your system, you want to cut back on feeding immediately. But demand and auto feeders can be pretty darn useful in that regard.

There are other things that people do to make their systems more sustainable including insulating their tanks, including shading things and putting them in greenhouses. All of these things help protect the system in case you need to step away from it. And they can also help make the system more independent in some situations.

So all of this stuff is worth considering and it's worth thinking about. However, I will say that if you do have to leave for a long period of time, it makes sense and it's usually worth it to have someone just come check on your system. Having someone on the scene who knows what they're doing, who can just do basic things like turn on and off valves and stop feeding or increase feeding or fish dead fish out of your system, this is always a really good thing.

If something dies while you're gone and it just lies there floating in your tank, it can throw the entire tank off. And if you've got an auto-feeder, the ammonia spike from a dead rotten fish in your system combined with excess feed can really make your system break down in a hurry.

So it's worth it to have someone come in and just check your system if you plan on being away for a week. This will also allow them to do water testing. You're going to have to do water testing really regularly anyway. So training someone how to do this so that someone you rely on can come and take care of your system while you're gone is usually worth it.

# 15. Water Catchment Treatment

Water is one part of aquaponic systems that you want to pay a lot of attention to. We've already talked about the importance of testing regularly to make sure that your ammonia isn't getting too high and that your nitrates are in a reasonable range, but you also want to make sure that the water you're starting with is really high quality stuff. A lot of various people's water is very basic. That means, it has a high pH, and it has a high pH because when it's pumped out of the ground, it's being pumped through things like limestone and other minerals that put carbonates in the water.

Carbonates can be good substances because they keep water within a certain pH range. But for the purpose of growing plants, they can often be frustrating because they'll keep the pH high enough that it's hard to grow really vibrant, healthy crops. And the reason for that is just nutrient availability which I will talk about later in the Deficiency portion of this book.

However, getting started, you need to be thinking very carefully about the water you're using. If you come from an area where either there's a lot of mineral in your water where there's scale or you've seen carbonates build up on your faucet, then you know that you need to maybe look into finding a different source for your water.

In areas where there's a lot of rainfall, one of the easiest ways to get high-quality carbonate-free water is through collecting rain. A lot of aquaponics folks do this and they'll install cisterns or they use rain barrels to catch water in order to keep their system running.

It's a great way to get water that's free of a lot of the chemicals that they put into water to treat the water. And when you're just getting started it's going to accelerate your break-in cycle because you're not dealing with water that's of poor quality. You're starting with good stuff that you can build upon.

Now, the one issue with this is that a lot of the time, there can be contamination from bird feces. The birds land on your house and they hang out in your gutters and they poop up there and waste gets in the water.

This is one concern with rainwater-fed systems. You just have to make sure that you're being wise about washing your vegetables and wise about rinsing off your fish before you eat them -- all of the basic food safety precautions that you should be taking anyways.

Figure 33 RO filter

So if you don't already have rain barrels and a water catchment system in place, I would highly recommend looking into one, especially if you come from an area with basic soils, where there's a lot of carbonate or scale or mineral in your water.

There is another option, it's more expensive. It's installing a reverse osmosis filter, oftentimes called an ***RO filter***. You can find these online for aquarium setups.

They're usually $300 or $400 for a decent one that will produce 20 gallons a day to top your system off. And these filters essentially can remove a lot of the contaminants in the water that remove some of the other stuff that you really don't want in your system. And it allows you to use tap water to replenish your system volume as it's lost to evaporation.

Those are two options for getting good water to start your system with. Both are worth considering. In the end, it will just depend on what your budget allows, where you live, and what kind of rainfall you get.

## 16. Air and Water Pumps

There are many different kinds of pumps out there. Whether you're interested in pumping airor pumping water, there are tons of options. And at times, it can be pretty confusing.

For water pumps, there are two basic types. You have ***in-line pumps*** and you have ***submersible pumps***. For this project, we're going to be using submersible pumps but in the future, you might want to look into in-line pumps.

On most of my larger systems, I use in-line pumps simply because they last longer, they're easier to maintain, and they’re easier to clean out and take care of. They also can be quite a bit more powerful because they're made in larger sizes than most submersible pumps.

Submersible pumps usually have casing filled with oil or some kind of coolant to keep the pump lubricated and cool. Or they're water-cooled, meaning that they're cooled by the liquid that they sit in.

Pumps that are outside are usually air-cooled. These are your in-line pumps.

While submersibles sit in the water, in-lines sit out of the water, and there's usually a pipe going into them and a pipe coming out of them. With these pumps, there is an electric motor that pumps the water from the inflow through the outflow, and it's all exposed to the air.

If these pumps get wet, oftentimes it can destroy them. So you need to be really careful using in-line pumps in wet areas.

Depending on the application you're interested in, if you're looking at doing a larger system, then an in-line pump is probably the way to go.

A lot of people play with alternate or cheaper sources for in-line pumps including using dishwasher and washer pumps and other miscellaneous pumps that they salvage from pieces of machinery or from things like dishwashers.

It's worth looking around and there's lots of information online as far as what kind of pumps are out there and what the best pump is for your system. Again, when you're picking out a pump, you want to keep in mind the energy consumption, that is, how many *amps* it's drawing when it's operating. You want to keep in mind what the head high height is, that is, how high it can pump water. And you want to keep in mind the volume of water that the pump can move.


Figure 34 Venturi pump

Every pump will have a tradeoff between volume and height. At higher heights, there's less volume. At lower heights, there's more volume. So you'll want to look that up for each pump before you purchase it just to make sure that it's right for your application.

There are also ***air pumps.*** A lot of folks use these in raft systems and in other systems where oxygen depletion can be a problem. In this system, we're not going to be stocking it so densely that we need an air pump. Natural aeration will work just fine.

If you're moving a lot of water, oftentimes you can replace an air pump with increased circulation or what's called a ***Venturi pump***.

And most pumps now come with Venturi fittings, especially if you're buying them from a hydroponics store. Most submersible pumps will have Venturi fittings, which basically sucks air into the pump and spits it out with the outflow. This is kind of a nice way to integrate aeration into your system without investing in an air pump itself.

Now, if you are going to build a large raft system or a system that needs an air pump, there are a lot of them on the market. You have everything from blowers that have several horsepower all the way down to teeny tiny little half-amp air blowers that you can integrate into aquarium setups or micro systems.

So by and large, they're not a necessary part of aquaponic systems but they're out there and they're inexpensive if you ever need an air pump.

One other combination of water pumps and air pumps is something called an ***airlift pump***, and these are very energy-conservative pumps that work for very low head heights. So if you're just trying to lift water

a couple of feet, then airlifts might work. And what they do is they're a pipe that a bubble is blown into. And as the bubble rises, it carries water above it. So if you're introducing bubbles fast enough, it essentially forms a pump that pushes water up to the very top of the pipe.

There are a lot of designs online for air pumps and there are a lot of theories regarding them. By and large, they can be useful mechanisms but they are not usually as effective as most people think they are and they're very disappointing at higher head heights.

## 16A. How Deep Should My Tank Beds Be?

Grow beds and fish tanks vary dramatically in the depth. There are some rules of thumb. For most grow beds, you want to have between 8 and 14 inches of depth. 12 inches is kind of the norm.

For this system, we're going to make a grow bed that's about 8 inches deep.

Fish tanks can vary in depth as well depending on the fish that's being grown and depending on what the user wants. If you're a short person and you don't really want to lean out over a tank to reach down deep with a net to get a fish out, then it's a good thing to make your fish tank a little bit shallower.

Similarly, if you're a tall person, then having a taller tank makes sense. Depending on the fish you're growing as well, you want to have deeper or shallower tanks.

For bottom-dwelling fish, having more shallow tanks allows you to watch them more. Now, the thing to remember, though, is as your tank gets shallower, you lose volume. So for something like an IBC, if you take a few inches off, then you lose a few gallons of volume. So you want to conserve your volume as much as possible. Don't make fish tanks any shallower than you have to.

Similarly, with grow beds, there's a lot of range where plants will grow just fine. They like the deeper beds but again, do whatever is best for your particular design.

## 17. Two Ways to Increase System Efficiency

There are a few things that you can do to make your system more efficient. Probably the easiest thing is to insulate your building, insulate your greenhouse, and/or insulate your tanks.

During the winter you'll be losing a lot of heat, especially because warm water evaporates really quickly. So you'll be losing water and you'll be losing the energy it took to heat that water.

One thing you can do is insulate your building so you minimize your heat loss. And insulate your tanks so that you minimize the loss of heat from your water.

Another thing that you can do is simply run your pump on a timer. In many systems you can plug the pump into a timer that you plug into the wall. You set the timer to run only at certain times, like say, during the day, and then every 15 minutes during the night. This keeps the plants happy because you're delivering water when they need it but you reduce the amount of time that your pump is running.

*Note: I only recommend this for submersible pumps and small pumps. Larger pumps (like larger in-line pumps that are half a horse or larger) do not like hard starts. They don't like to start up and turn off, start up and turn off. For pumps like that, it's just better to run them continuously. And you'll save money in the long run.

But for submersibles, you can run them on a timer and you can save quite a lot of money on electricity by doing so.

# 18. Water Quality

Water quality is really important in aquaponic systems. I know I've already talked about it a little bit but I'm going to talk about it some more.

Starting with good quality water is really important, hence, collecting rain or using water from an RO filter. If you have no other options, you can start with tap water, but definitely let it set for a while before you start cycling in order to get all the chlorine and chloramines out of it.

## Cycling

Once you start cycling, especially if you're doing a fishless cycle to start, most of those compounds (like chlorine and choramines) will be broken down by the time it comes time to put fish into the system. So you don't have to worry about the things that are added to the water so much as the compounds like carbonates that are already in the water.

So it's worth starting off with really high quality pure water to make sure that you get a good start and to make sure that you're not disadvantaging yourself down the road.

With water, you want to maintain a certain temperature. So once you build your system, before you start your fishless cycling, start taking water temperature readings so you know what range you're going to be dealing with.

Cycling takes six weeks or so, so you've got plenty of time to pick out what fish will be right for that particular temperature range. Usually if you know the temperature ranges there are certain fish that live wild in your area and that are probably appropriate for your system.

## OXYGEN

Dissolved oxygen (DO) is another thing that needs to be thought about when you're designing your system. You don't necessarily need to monitor it but it's a good thing to be considering.

Dissolved oxygen just describes the amount of oxygen that's dissolved in the water. This is the oxygen that's available to the fish to breathe, to the microbes to do their things, and to the plant roots. And it's really important to maintain high oxygen content in your water, otherwise you'll have fish die, you'll have roots rot, and your microbes will be pretty unhappy as well.

To keep DO high, you must maintain a good water flow. You keep the water moving and you keep it splashing around, and this increases the amount of surface area of the waterand the amount of oxygen that that water is exposed to.

Your grow bed will help with this tremendously. The water coming out of your grow bed will be very high in dissolved oxygen and the water going to it will usually be a little bit lower.

Another thing you can do is prevent your water from getting too hot. So if it's an extremely hot summer and you go out and you notice that your water is in the 70’s and it's going up, usually it's good to shade your system or shade your tanks to try and prevent that water temperature from rising.

The thing with dissolved oxygen is that as the water temperature increases, the amount of oxygen that can be dissolved in it decreases. So that's why in areas where it gets really hot, where the lakes get really warm, you'll see fish gasping at the surface of the water or you'll even see fish kills. That's because the water gets so warm that it can't hold oxygen very well and the fish essentially suffocate.

So you want to try and keep your water temperatures down within a reasonable range, a range that your fish like, preferably at the lower end of the range that your fish like to live at.

## MONITORING PH LEVELS

pH is another thing that you'll have to test on a regular basis. And the reason for this is that plant nutrients are only available in a certain pH range. Normally, people try to run their pH in hydroponic systems in the high 5’s and the low 6’s.

When you start your system, your pH will likely be fairly high. However, once your nitrifying bacteria get started, your pH will begin to drop and you'll see it drop pretty consistently over time. And that's a good thing. It means that your biology is working for you, that things are doing exactly what they should be doing.

If your pH doesn’t drop, you may see nutrient deficiencies and most likely it means that you have carbonates in your water., If this is the case,you're adding too many carbonates to your water and they are preventing your pH from dropping down into a healthy range.

Once the system is really well-established, if you have a system that shows a pH drop, that's a good thing. But you need to keep in mind that when the pH gets too low, you'll also have to be raising it to prevent your microbes from crashing.

Most of the nitrifying bacteria do not like the lower pH range or it takes them a very long time to get accustomed to it. So if the pH shifts very rapidly, your nitrifying bacteria stop working and you can have an ammonia spike, and then you can have fish die because of excess ammonia.

So you want to keep an eye on pH and make sure it's not moving up or down too quickly. And once it does consistently move down into the low 6's, you're going to want to raise it, preferably with a plant nutrient, a base that contains a plant nutrient which I'll talk about a little bit later.

Generally, you want to keep your dissolved oxygen as high as possible, you want to keep your pH somewhere between 6.4 and 7.5 if possible, and you want to keep your ammonia below 1 part per million.

So, when you first start fishless cycling, which I will talk about later, you'll see your ammonia spike up above one part per million. But as time goes on, you just want to keep an eye on it and make sure as your nitrifying bacteria kick in and as it drops down below 1, you want to just make sure it stays there. If it bumps up, it either means you're overfeeding or it means that your bacteria have stopped nitrifying, or oxidizing that ammonia.

Both of those things are bad and both of them can be fixed, but you need to catch them early. So it's important to always be monitoring your water.

All of these things are important not just for the system integrity but also for the long-term use and for keeping your system in good condition to be used down the road. If you do have to drink it, if you do have to use that wateras a resource,keeping these variables under control can make sure that you have good healthy water down the road as well. You don't water with high ammonia content and you don't want water with high nitrogen content. And you definitely don't want water that has things rotting in it.

So keeping the oxygen high, keeping your pH in the right range, and not overfeeding are part of monitoring that can lead to a healthy system and can help you get the most out of your resources.

# 19. FISH FEED

There are all sorts of fish feeds out there and there are all sorts of alternative fish feeds that you can use in your aquaponic system. I highly recommend high-quality feeds like *Silver Cup* because your fish will eat them and produce waste and you'll have less sludge buildup in your system.

When you're looking at feed for fish, you want to look first at the brand name. You want to make sure it's a good quality brand. You want to look at the protein content, that is, how much protein the feed contains. Higher protein content will lead to increased nitrogen in your system.

And you want to pick the protein content that's appropriate for your fish. Some fish like less protein. Some fish like more.

You also want to look at the fat content, crude fat content, and how much filler is used in the feed. So once you've got a good idea of what a good ratio is for your particular fish, you'll have a better idea of what the best feed is for your situation.

Avoid feeds that use protein sources like feather meal, simply because these types of proteinshow up in analysis but the fish can't really digest them, so they just end up being sludge that you have to clean out later.

There are all sorts of issues when it comes to feed. Feed doesn't store very well, typically. So you want to try and find a nice, cool dry place to make your fish feed store for a nice long time before the oils in it get rancid, before the feed itself starts to spoil.

So building a good storage facility into your house or your garage is important. Making it rodent-proof, insect-proof, and moisture-proof is an important part of storing up feed for your system.

If something arises and you can't find feed, there are other options for feeding your fish. Most of the time, you'll always be relying on feed to some extent to supplement your fish's diet. If you don't have commercial feed, then your fish will probably just grow a lot more slowly. It just means you'll be able to harvest them not quite as often.

## SUPPLEMENTING YOUR FEED

There are a lot of ways that you can supplement your fish's diet inexpensively, without spending a whole lot of money on protein. I know a lot of folks that have used ***black soldier fly.*** This is a type of fly that lays eggs in compost and rotting material, and the little larvae from the black soldier fly are very high in protein and very high in fat, so high in fat and protein in fact, that it's recommended that you cut them with something that's low in protein so you don't make your fish sick.

Figure 35 Black soldier fly

There are people that will hang carrion or road kill in potato bags over their tanks, and the maggots from the flies will fall in and feed their fish. There are people that will put bug zappers over their tanks, although you have to be careful with this as well. We all know what would happen if you drop the bug zapper in the tank.

There are all sorts of options when it comes to supplementary feed sources. I've already discussed water hyacinth, water lettuce and duckweed to some extent, but all of these plant materials are also good supplementary protein sources.

If you're growing a fish like tilapia, you can add stuff like pelleted alfalfa and waste from breweries and other forms of agricultural wastes, and your fish will consume it and grow on it.

You just need to look at the resources available to you to figure out what you're going to employ in your particular system. In a lot of places, especially places that are highly seasonal, supplementing your feed with insect won't always be an option simply because the bugs will all disappear for the winter.Regardless of where you live,there's always something you can supplement to your fish's diet with. Look into black soldier fly and look into all the interesting alternatives that people are using to supplement the diets of their fish in their aquaponic systems.

## 19A. Nutrient Deficiency, Insects

Once your system is up and going and your plants have all been germinated or you're going to plant your seed, you want to start thinking about what your plants need, which we've already discussed to some extent. As you see things start to come up, you want to keep an eye on them and make sure they're not showing nutrient deficiencies.

## NUTRIENT DEFICIENCY

Nutrient deficiencies just basically mean that the plant doesn't have enough of one nutrient to grow and reproduce properly. And usually they're pretty easy to spot. The plants won't grow very well, oftentimes they'll be ***chlorotic***. That means that the leaves won't be bright green; they'll be kind of a yellowish to a white color. Sometimes leaves will cup and sometimes the fringes of the leaves will dry out and burn. All of these are symptoms of nutrient deficiency. And they can point to the fact that there just isn't enough of one particular nutrient in your system.

There will be a key attached to this book that will help you figure out what is deficient, but in most of these systems it will be potassium, magnesium or iron.

The trick with these systems is supplementing nutrients that are deficient without changing the overall function of the system. So that's why I mentioned earlier, when your pH is dropping, you're going to essentially treat your water to bring your pH up. To increase it, you're going to add a base that contains a plant nutrient.

One of the common bases that is used is caustic lye, or potassium hydroxide. You can find it just about anywhere. And it's very basic, so a very small amount goes a long way.

As the pH drops down to 1 or 1.2 and you add potassium hydroxide, the pH will rise up into a healthy range and at the same time, you're introducing potassium to the system, which is one of the primary plant nutrients.

Potassium ends up being deficient in these systems for a number of reasons. Oftentimes the water people are putting in these systems has a lot of calcium in it. The problem with calcium is that calcium and potassium are very similar in the way that they are dissolved in the water and in the way that plants take them up. But they compete in the solution so if there's a lot of calcium, sometimes your potassium will precipitate out or it becomes a solid and the plants can't use it. So much of the time, even if you have potassium in your system, but you've got too much calcium, you can start to see potassium deficiencies.

There's a lot of little tricks like this in aquaponic systems, and sometimes they go into so much detail that it would take an entire book just to figure them out. But you can go online and you can diagnose nutrient deficiencies very easily and find ways to supplement that nutrition.

Figure 36 Chelated iron

In all systems, you're going to have to be adding other nutrients like chelated iron. Chelated iron is just an iron that's available even at a high pH, so it's attached to a special molecule that allows the plants to take it up and prevents it from being oxidized no matter what the pH is. And it's a very handy stuff.

Figure 37 Epsom salt

So as time goes on, you're going to compile a list of these nutrients. Right off the bat, you're probably going to want lime, agricultural lime. This is ***calcium hydroxide***. You're going to want caustic lye (***potassium hydroxide***). You're going to want ***chelated iron*** and you're going to want ***Epsom salt***.

If your system pH stays high and it won't drop down, you don't want to be adding a base to it like potassium hydroxide. In instances like this, try ***potassium chloride***. Again, this is another very simple and easy-to-find compound. People will use it for melting ice and some people use it as a salt substitute in their meals. So these things, these chemicals are really easy to find and really easy to get your hands on. And they do a great job at supplementing deficiencies that you begin to see in your crop.

It's not super common in these systems to have really dramatic deficiencies unless things get way out of control. So careful monitoring is an important part of all of this. And once you get in the rhythm, you'll be able to supplement your nutrition and moderate your pH all at the same time, almost without thinking. It becomes really, really simple.

## INSECTS

Another issue is insect control, because fish are very sensitive to traditional insecticides. So if you're used to using a particular insecticide to get rid of aphids or white flies or thrips or whatever your problems are, you've probably need to go back to the drawing board and reconsider some alternatives.

I use a combination of several different insecticides that I found are not very toxic to fish. One is called ***Botanigard*** and it is a fungal spore that kills the insects. One is ***azadirachtin*** product. This is the active ingredient in neem oil. Two other great controls are ***Neem oil***, and then one is a ***Pyrethrin soap***, made by the *Safer*Corporation. They're all great products but you do have to be careful with them and limit your fish's exposure, especially with pyrethrins, or products that contain pyrethrins

Pyrethrins are very deadly to insects and they are good organic insect control chemical but they're very, very toxic. So I only recommend the use of pyrethrins if you're using vertical towers like ***ZipGrow Towers*** or if you're growing in ***NFT troughs*** or you have a way to prevent the pyrethrin from getting in your system's solution. If it gets in your system's solution, it can kill your fish so you need to be careful. But there are ways to control insects without using really toxic chemicals that will kill your fish.

Another thing to look into is beneficial insects. This allows you to use other insects to control insects. You can attract them with certain plants, and there's a lot of information on this out there. You can also introduce other insects to your garden intentionally. Buy them from an organic supply store or an agricultural supply store and release them in your garden. Insects like green lacewing, aphidius wasps and ladybugs are all great additions to most gardens or greenhouses.

You get more efficiency out of greenhouses because the bugs have a harder time flying away. A lot of the time, if you introduce these insects to your garden, your neighbors will come shake your hand and say, "Thank you for buying me ladybugs."

But if you're in a greenhouse, these bugs can't really escape and they'll typically stay in one spot and eat all of the offending bugs. So there are a lot of options as far as that goes. All bugs can generally be taken care of. But you want to have this in mind before you get started, and I would recommend buying a number of plant or insect control chemicals before you even get started.

## 20. CYCLING THE SYSTEM

***Cycling*** is a term that everyone has probably heard if they're familiar with aquaponics. It refers to getting your bacteria growing before you put your fish in your system.

If you don't have nitrifying bacteria in place before you put your fish in your system, your fish will die pretty quickly. And that's just because they're producing a lot of ammonia and there's nothing in the system to break it down. There are a lot of different ways that you can cycle and there are a lot of different techniques for it.

The traditional way to cycle has simply been to add ammonia to the system very slowly, usually up to just 1 or 2 parts per million. You can test it with a test kit for several weeks until the ammonia starts to disappear. And as you continue to add household ammonia in very low quantities to your system, you'll see it very quickly disappear and you'll see a nitrite spike after a week or two.

And after a couple of weeks of that nitrite spike, you'll see the nitrite drop and the nitrate begin to be produced in your system. What that means is that your system has been colonized and the nitrifying bacteria are happy and growing and doing what they're supposed to be doing.

After about 6 to 7 weeks of this, the ammonia will be consumed very quickly as soon as it's put in the system, and nitrates will be produced. You won't see a whole lot of ammonia and you won't see a whole lot of nitrites in the system. This is when you know it is okay to start thinking about putting some fish in.

## Alternative Cycling Methods

There are a lot of other ways you can do it if you don't have ammonia on hand. Some people will throw a dead fish in there. I don't particularly like that method simply because I think it introduces fish diseases.

Other people will use human urine. Again, if you are in circumstances where that's your only option, then it's not a bad option, and it will definitely work. But again, you run the risk of disease and of course, having some foul-smelling system water for a while. And down the road, it's just harder to be okay with drinking water that you know has had your urine in it.

There are a few other methods that people use.Some people will use inoculants to basically jumpstart their systems and get them going faster. I don't recommend it. I would recommend just waiting the full 6 or 7 weeks until nitrates start showing up and then just taking your time and doing it naturally. This method usually pays off in the long run.

Once those nitrates show up and your ammonia and nitrites dissapear, you're ready to introduce your fish. You want to consider the fish type that you're introducing, but you always want to introduce in small quantities.

A lot of people will test their systems with a couple of ***feeder goldfish*** from their local pet store before putting their more valuable fish in. So they'll throw some feeders in there and see if the goldfish survive. If the goldfish die, then you know that there's probably still a problem and you can go back to your water test and you can try and figure out what it is.

I had one instance where I was using a tank that had a machine oil coating that I didn't see, and when I threw my goldfish in there, they all immediately died because of the oil. Even though my ammonia and my nitrites were showing up, that thin, thin film of machine oil was enough to kill my fish.

So it's always important to try it out on some disposable fish like feeder goldfish before you throw in your bluegill or catfish or whatever the fishes that you plan on using in your system, whatever your valuable fish is.

After those nitrifying bacteria get established, they're pretty darn hard to kill unless you're exposing them to UV light or changing temperatures very quickly. They'll keep plugging along so long as you keep things fairly constant and they'll keep doing their job.

## Testing

Essentially, the biggest take home from the discussion about cycling is the importance of testing, and testing regularly. You can usually tell if something bad is going to happen from the results of your test.

And it's amazing how many people have systems die and wonder what was going on but they never performed a test to find out.

So test for ammonia, test for pH and test for nitrites and nitrates. It will almost always help you diagnose any problems in your system. And with fishless cycling, it's part of developing a good habit, of testing really regularly. Going out and testing each day to see what has happened to your ammonia is a good habit to carry on once you have fish in the system. It just helps make sure that your fish stay alive and everything stays really healthy.

So regardless of what cycling method you choose, whether it's cycling with urine, ammonia, a dead fish, or cycling with live fish like feeder goldfish, it's a good process to go through and it's an important part of establishing your system.

When you are cycling, don't get too impatient. Oftentimes impatience leads to the unnecessary death of valuable fish stock. So think carefully before you put fish into your system and make sure that everything is as it should be.

This process, like I said, is about a 6-week process and it's very hard to speed up. The only success I've ever had with speeding up the process is by taking established media from another system and introducing it to the system being cycled. And when this can be done, it can help decrease the cycle time.

I have had instant systems before where I've taken a live ZipGrow Tower and put it into a brand-new system, simply because all of the bacteria were already established and they were already ready to process that waste.

You can do it with aggregate mediums as well, and see a little bit of an uptick in how fast your system will cycle. Beyond that, it's very difficult to cheat nature. It will almost always take 6 or 7 weeks to get the cycling process done.

There are a lot of folks that say they can speed up the process but by and large, it's not a long-term solution. A lot of the time, it's introducing organisms that just aren’t going to be there in the long-term.

One other and final option you have is to use some water from another aquarium or from another system to help get your system started. I've already discussed this, it's essentially kind of a way to get those bacteria in there just a little bit faster. But you're still probably looking at a 5- to 6-week cycle time.

# 21. System Maintenance

System maintenance is an important thing to consider before you get into aquaponics. It does require fairly consistent maintenance. What you do on a daily, weekly and monthly basis will really just depend on your system, how old it is, how big it is, and how well-designed it is.

Systems like the one that we're going to build are fairly easy to take care of and they run themselves pretty well. However, if you have larger or higher stocking densities, you definitely want to check things like ammonia and pH on a regular basis.

As your system matures and gets older, it will become more productive, healthier and more resilient.. As you get to the one-year mark and the 18-month mark, you'll find that your maintenance requirements actually decrease simply because your system becomes a little bit more stable and it's less prone to change on you. It also develops the ability to deal with higher levels of waste.

So if you have a moderate stocking density and your system is fairly well-designed, the maintenance isn't super intensive but it is pretty consistent. Every day you want to check your temperature, you want to watch your fish and make sure that they're feeding well, and you want to just check on your vegetables to make sure there aren't too many insect infestations and there's no plants diseases showing up. If everything looks pretty good, you can test for pH and test for ammonia and call it good.

## Daily

Other things will arise but just being observant of your system on a daily basis will help you address problems as they occur. There are a lot of issues that can arise at these systems. They're fairly rare in well-developed systems and in well-designed systems. But they're things that should be at the forefront of your mind, things like leaks, overflows, issues with plants, fish jumping out of the tanks, fish diseases and fish dying. All of these things can happen, but generally, so long as you're paying attention, you can nip them in the bud and get ahead of the problem.

And as part of this, on your daily maintenance duties, you want to be adjusting your pH. If pH isn't changing very rapidly, then you can make it part of your weekly duties

## Weekly

On a weekly basis, I would be doing all of the above plus making sure you've got a good handle on where your nitrates are at, and perhaps doing an additional survey or two for insects and/or other plant disease issues that might be arising in your system that you haven't noticed before.

On a weekly basis, you want to check your pump and make sure it's clean and clear, and you want to make sure that your pipes aren't leaking, that things are just generally working the way they should be.

You should be looking for nutrient deficiencies, figuring out what you need to supplement in terms of plant nutrients, and adjusting your pH up if your pH is consistently dropping.

### MONTHLY

On a monthly basis, especially when you're first getting started, if you have a sludge buildup or if you have any solids building up in your system, it's worth going through and siphoning out those solids or rinsing out your grow bed. At the very beginning, it might not be important but down the road, on a yearly basis, you want to be cleaning out your media beds, at least once a year, giving them a good rinse and making sure that things are generally flowing well in there and that there's not too much solids build up.

## 22. HARVESTING

Harvesting is an important part of taking care of your system. Harvesting plants on schedule to make sure they don't get too old, too overgrown or too bug infested, is one of the best ways to stay ahead of pest issues and also make sure that all the plants in your system stay healthy.

### PLANTS

When you harvest vegetables, try to get as much of the root matter as possible out, when you take it out of the system, unless of course it’s a crop that you harvest a few leaves from regularly, like kale. This will help reduce solids accumulation in your bed.

Most crops like lettuce are ready to harvest after 6 to 7 weeks in the system from seed. And if you transplanted them in a peat pellet or something like that, it usually takes 4 to 5 weeks for them to mature.

So when the time comes to harvest, go out and simply pull the crop out. And you can cut the head off and then compost the root system. You want to try and get as much of the root system out as possible, however, the roots that you leave behindwill be consumed by the red worms and broken down over time. If there's a lot of them in there, they can essentially form kind of blockages and they can cause problems in your bed. So it's not something to be incredibly worried about but it's something to keep in mind when you're harvesting your crops.

Other crops you can  harvest bit by bit over time, these are crops like:

- Cucumbers
- Zucchini
- Kale
- Mustard greens

Now, if these crops start showing disease symptoms, if you start to see kind of light fuzzy patches on their leaves, something like a downy or a powdery mildew, then it's worth taking the whole plant out rather than letting it sit there and spread the disease to the other crops.

Also, large crops, when they get to the size that they're shading out their neighbors, oftentimes it's just better to take the crop out than to let it stay in and shade out the other plants. This will help you make the most use out of your grow bed and just help keep your grow bed productive.

If you want to have plants consistently, then you need to learn to be disciplined in harvesting on schedule in a way that won't overharvest and leave you for weeks at a time without anything to eat from your system.

## FISH

In the same way, harvesting fish on schedule is an important way to control your population and make sure that your fish are healthy as well, and not getting overstocked.

Similarly with fish, if you see fish that begin to behave funny, if they begin to bloat or if you see sores on them, then you want to harvest those fish and get them out of the system before the other fish catch the disease.

When your fish get too large, they either start eating the smaller fish or they just start hogging so much tank space and becoming aggressive that it's a good idea to get them out before they damage your other fish or consume them.

Over time, you'll get a feel for what the appropriate intervals are, but expect to harvest fish every several months in a small system like this. In larger systems, you can harvest fish much more frequently. Or if you don't want to do batch harvest, expect to take a fish out every other week or so depending on how many fish you have.

Fish reproduce kind of slowly in these systems often because there's not much control over water temperature and some of the other things that cause fish to breed. So if you have a breeding population, you can harvest as the population is replaced. However, this is kind of a slow process, especially in these smaller systems like we'll be building.

Now, if you have thousands of gallons, you've got a lot more options when it comes to harvesting. If you're in a survival situation, you want to make sure that you're not unsustainably harvesting fish. That means you're not harvesting more than the system can replenish.

So the rate that you harvest will really depend entirely on the types of fish you have and types of crops you grow and of course, where you're growing them. And these are all things that you can figure out on your own fairly easily. You'll have a very natural feel for what the system can bear and what you can take out of it without hurting it.

So just be thoughtful about what you do and be considerate of your system and of your crops and of your fish.

# 23. Getting Started Building Your IBC System

There are many options when it comes to IBC systems. IBCs are one of the staples of aquaponic systems throughout the world, primarily because they're cheap, they hold a significant amount of water (typically around 285 gallons), and they're usually pretty easy to get a hold of. They're also easy to work with because they are essentially a polyethylene liner within a metal frame, usually galvanized steel frame.

So we're going to show you how to make a very simple IBC system. It's one of the most common forms of aquaponic systems in the world, in fact. That's simply because it uses the top of the IBC to form the grow bed for the plants or a sump tank, and they are very easy to work with.

Now, with this particular system that we're going to build, you will be limited in the amount you can stock and the stocking density that you can use, primarily because it does have a relatively small grow bed. I'll talk a little bit about how you can expand grow beds and how you can alter this system to get a little bit more out of it or to change the design down the road if you want.

I will say upfront this is not a sump-based system. So this is not a system that has a sump or a low point in the system where the pump is located. In this particular embodiment, the IBC itself functions as the low-point. The pump is in the IBC with the fish and it pumps water up to the grow bed.

Down the road, if you choose to implement a sump-based system, you can essentially put the grow beds at ground level so long as your sump is in the ground. Your pump will always be located in the sump, or water collection point (low point) of your system. Water will flow from your grow beds and from your fish tanks to the sump tank. But for now, we're just going to concentrate on this particular type of system.

## PREPPING THE IBC

So to get started, you need to find an IBC. I would talk to your local freight carriers and talk to your local manufacturers. If there's any kind of industrial activity around you, go there and ask about IBCs and see if they have any for sale. If they do, go ahead and buy one. Again, we've already mentioned that it should have carried some kind of food product in it. If it was used for food transport, it should make it fairly easy to clean up. So after you buy it, you're going to take it home- you'll probably need a pickup truck for this.

Once you get it home, you're going to have to unscrew the little screws on the very top of the IBC that hold the bars over the top of the liner. Typically, you will see two bars there stretching across the top of the liner, holding it in place. You want to take out the screws that secure those bars to the frame.

Once you've taken those off, saved those screws, saved those bars, and you want to essentially tip the whole IBC over and pull that liner out of the frame.

Once it's lying on the ground, go ahead and take a tape measure and measure around approximately 9 inches deep from the top of the IBC and around the entirety of the IBC. So you might have to roll the liner over a couple of times to do this.But you want to just take either a permanent marker or a grease pencil or something like that and measure 9 inches from the top of the IBC in and just put a mark along the edge. Another option is to trace around the circumference of the IBC using the frame bar right below the very top bar as a guide.


Once you've marked along the entire outside of that IBC, go ahead and take a straight edge. This can be a level, this can be a 2x4, this can be any kind of straight thing that you have on hand, and use it to make a line in between all of those points, or to make sure that your line is clean and easy to follow.

Once you've marked off around the top, you should have a nice black line that travels around the entire circumference of the IBC, about 9 inches down from the top.

Now it’s time to cut the IBC.  You can use several different things for this. Some people prefer to use a circular saw. I typically just use a reciprocal saw because I typically have them on hand, or a sawzall. You can also use a jigsaw if that's what you have available.

Go ahead and start at the corner with your reciprocal saw or with your circular saw. Or if you have a jigsaw, you may have to drill a hole or just kind of get an angle on one of the corners. Go ahead and cut along the line that you traced, cutting off the entire top of the IBC.Be veryl careful as you cut, and watch for the burrs on the plastic because they can be coarse and they can cut you.


Once you’ve taken off the entire top of that container, that lid, the very top should just separate very cleanly from the bottom.

## CLEANING

At this point, you're going to clean your IBC. Get some good hot soapy water and, depending on what was inside that IBC, sometimes it helps to go over it initially with a base, like baking soda. If it was something basic, sometimes it helps to use something like vinegar, an acid, to get it clean.

Regardless, after you used your acid or your base to clean, go through with a bucket of hot soapy water and really scrub it out. You might have to do this several times until the liner is clean. You can do it visually and you can also often smell whether or not the liner is clean, depending on what it was used for previously.

Go ahead and clean up very thoroughly. Remember, you'd rather spend more time at this point cleaning than you would down the road dealing with problems that arise from having some kind of contamination in your system. So clean it really well.

## MAKING THE BEDS

Once you're finished cleaning, it's time to saw the bottom off of the frame. To lend some stability to the framework, you can take the two bars that we previously removed and secure them back to the frame if you wish, but it is not necessary.

At this point, we're going to take the sawzall with a metal blade, or an angle grinder with a cutoff disc, and we're going to cut the vertical frame bars right above the bottom bar that runs around the IBC above the bottom of the frame. This is the first bar above the pallet portion of the frame.

We're just going to go around and cut that framework right above that bar. We'll go around the entire circumference of the frame, cutting off each vertical frame bar.


Now this will leave a little bit of a jagged piece of metal there so it helps to have an angle grinder on hand that you can smooth things out with. You can also do this with an angle grinder with a cutoff disc. You can take your angle grinder and do the same job that your saw did, and then use it to round off the tops of those vertical bars so that they're not going to cut anyone down the road.

Once you've cut around the entire circumference of the frame, you should have two distinct parts. You should have an upper part of the liner and the bottom portion of the frame with the pallet attached, That upper portion of the liner should fit into that bottom part of the frame. You should also have the lower part of the liner and the upper part of the frame.


So these are the two fundamental parts of this system that we're going to be using for the fish tank and for the grow bed.

# 23A. IBC PLUMBING OUTFLOW

Once you have these two parts separated, we're going to do two different plumbing jobs. We need to plumb the system so water can flow into the upper portion, which will form the grow bed. And we also need to plumb the upper portion or the grow bed so that water can drain down into the fish tank below.

The way this is going to be set up is that the grow bed is going to be resting on top. The upper portion will be resting on top of the lower portion, forming kind of a grow bed. It's going to be rotated and staggered so it's going to hang off the sides and the back edge by about a foot, giving us access to the fish tank beneath it.

The plumbing will be comprised of two different parts. We're going to talk about the ***inflow*** and the ***outflow***. This is common to almost any aquaponic system. You always have to think about how you're going to deliver your water to your grow bed and you have to think about how you're going to drain the water out of that grow bed.

## GROW BED

I'll talk about the grow bed itself first because this is where we need to start in order to get going. The grow bed will be comprised of this upper portion of the IBC. You should have a liner and then you should have the frame where you cut it off. In the middle of that liner, there is a screw-on cap. This is common to all IBC containers. There's always a polyethylene screw-on lid.

Make sure that you've taken that lid off and you've cleaned it and then you've put it back on the upper portion of the IBC. And make sure it's secured fairly tightly.

In the middle of that, we're going to take our two ¼-inch hole saw and we're going to drill a hole. So go ahead and take it and center it right in the middle of that lid and drill a hole through it.


Once the hole is drilled with the hole saw, we're going to take our threaded fitting and we're going to screw the threaded fitting down through that hole. Now, if it doesn't want to give, you have to be careful because polyethylene will tear if it's stressed too much. So go ahead and start to screw that fitting through. If it's fairly snug, that's great. That's exactly what we want.

. It should fit very securely through the hole in the lid. If it doesn't want to go, go ahead and take out your hairdryer or your heat gun, which you should have on hand, and just kind of warm up the plastic around we're you're going to screw that on. Then thread it through the softened plastic.

You don't want to heat the plastic up so much that it threads in really easily. We just want to heat up the plastic to the point that fitting will screw through it a little bit easier and it's not going to tear the plastic as we put that fitting through it.


Now you want this fitting to be pointing up. So when we flip the grow bed over, this fitting should be pointed up into the air. Soit should be threaded through the bottom of the lid then because the lid will be upside down when the top of the liner is placed on top of the fish tank.

Thread that through, then wrap a bunch of Teflon tape around that fitting and carefully thread that female 2-inch fitting onto the male-threaded portion of the other 2-inch fitting that's already been threaded through that plastic.


You don't have to thread these two together really tight. There's not going to be a whole lot of structural stress on this fitting or on the PVC pipe that goes through it. It doesn't need to be on there really tight. You just want to screw it on so it has a good hold and it's not going to leak very much.

Then we're going to take a piece of 2-inch PVC and we're going to take about a 2-foot portion of it. (Now, this is something that you can change up depending on what you're trying to do. If we leave the PVC pipe off here, it means there will be more aeration to the water but it means it will splash more. If we add more PVC pipe on, it means there will be less aeration but it will splash less. So this part, however much PVC you actually put on this is totally up to you.)

We're going to essentially cut a portion of PVC somewhere between 8 inches and 2 feet to fit into the fitting that is now pointing down into the fish tank. This portion will be directed down into the fish tank.

We're not going to secure it at this point, it will be a “friction fit.”

## FISH TANK

On the upper portion, because we've got a 9-inch grow bed, we want to put a piece of PVC in that will allow the grow bed to drain down to the fish tank. I would recommend taking out a drill bit and drilling a few holes in an 8-inch piece of PVC. We want to cut this piece of PVC pipe to a length one inch less than the depth of the grow bed to make sure that our grow bed never overflows. So if something clogs up the holes in the side, you can always drain it down from the top of this pipe.

This is essentially a very crude drain that's made out of a piece of pipe. Take your drill bit and drill enough holes thatthat you know you can get good drainage down into the fish tank. Remember, drilling fewer holes at the beginning is better. This piece of PVC will just be friction fitted, so you’ll be able to pull it out and add more holes once your system is running.


Now, if you want to run your pump on a timer, it might be better for you to drill some smaller holes. So get out just a standard drill bit, maybe a quarter-inch and drill around ten holes in that PVC standpipe to start. What that's going to do is if you're running your pump on a timer at a little bit higher volume, it's going to fill your whole grow bed up and then when your pump turns off, it's going to drain slowly through those smaller holes.

This part is really up to you. If you want be conservative and play it safe with the pump you'll be working with, go ahead and you can always wait, drill fewer holes at the beginning, and then as time goes on, you can add holes to get the effect that you're looking for as far as speed of drainage.

After you drill a couple of holes in that standpipe, you can go ahead and fit it by hand. You don't want to glue it into the upper fitting. Just make sure you can fit it into that female slip fitting, and make sure that it's about an inch less than the height of the grow bed. That's just essentially a form of insurance.

At this point, you're going to actually have to take an 8 foot or a 10 foot 2x4 and cut it in halfto form kind of a rack to place the grow bed on because it's not going to want to sit on top of that frame and be very stable.

After you cut those 2x4's into pieces, lay them across the support bar that runs the top circumference of the IBC frame. Place them on top of that support bar and then you can place your grow bed on top of those 2x4's. This forms a bench on top of your fish tank.


You want to space it so that the 2x4s aren't blocking that 2-inch fitting because we need to be able to get to that before we plumb the system up.

At this point, go ahead and partially fill that grow bed up with whatever media you've chosen. Just put a little bit in the growbed and then take the 4-inch or 6-inch piece of PVC and drill a bunch of holes in it, just to make it very porous. Ideally, you want to drillholes that are slightly smaller than the media you choose. So if you're using 3/4-inch crushed granite, go ahead and use your half-inch spade bit to drill half-inch holes all around the circumference of that piece of PVC. Be careful when you do this, as PVC can be brittle and shatter. You want to drill these holes slowly and carefully.

Once these holes are drilled, we're going to place the section of drilled PVC pipe around our standpipe and let it rest on the bottom of the growbed. This is going to form a screen that prevents the media

from falling into that central area and draining down into the fish tank or clogging our drain pipe. Once that's in place, you can use the gravel to secure it and fill it about half of the rest of the way up.

If you're using gravel, it's very heavy. So before we fill up our fish tank, we don't want to get a whole lot further. So go ahead and hold off at this point. This is the point where we move to plumbing in our inflow plumbing. This part is a very simple task, and we'll address that right now.

## 23B. INFLOW 1

Now it's time to plumb the inflow. The inflow is is the plumbing that delivers water from the fish tank to the grow bed.

To do that, we're going to take our pump and stick it in the fish tank near the edge, on either the back or one of the sides – preferably one of the sides.

Your pump will come with a barbed fitting for a ¾-inch piece of *poly* pipe. Take that *poly* pipe, heat up the end of it with the heat gun and push it over the barbed fitting on the pump. Then measure it up to the top or the rim of that IBC. Cut it off there to put in a barbed ell fitting.

Next, take that barbed ell fitting, heat up the end of the tubing coming up from the pump, and then push that L fitting down into it. Take another piece of tubing and fit it over the other side of that L fitting.


We've now formed a big “L” out of our *poly* pipe. And this “L” should stick out of the side of the IBC. Right as it sticks out, cutoff the tubing, heat up the end of it and force another ell into the cut tubing.


At this point we've got a big L, with a little L-shaped barbed fitting pointing up on the side of the grow bed. Next, take a piece of tubing,heat it up, and push it over that L fitting so it's going straight up in the air.Once it’s fixed to the ell, cut it off level with the top of the grow bed.

At this point we're going to put another barbed L fitting in the top of our tubing so that it's pointing in towards the interior of the grow bed.

Take a small piece of poly pipe, only a couple of inches long, and using the heat gun fit it over the ell, pointing in towars the center of the growbed. Once it's fixed, we're going to cut if off right inside the grow bed.


At this point, we're going to take our ¾-inch-barbed-to-1-inch threaded fitting and heat up the end of that *poly* tube to force that barbed fitting in. Next we're going to take the threaded portion of that barbed fitting and wrap it in Teflon tape. Then thread it into the female portion of the other fitting. Once you're done, the poly pipe should lead into the growbed area and end in the PVC tee. More on this below.

# 23C. INFLOW 2

Once we have the barbed fitting wrapped with Teflon tape, we're going to take our PVC T. It should be 1-inch PVC T with a ¾-1-inch threaded fitting. We're going to screw that T onto the threaded portion of our ¾-inch-to-1-inch fitting.

When you screw the barbed fitting into the PVC tee, it doesn't need to be super tight. We just want it tight enough so that it will be fairly water-tight, and water is not going to leak out around those threads. If you've used Teflon tape, then it should be no problem.

At this point, we've got our inflow leading up, forming an L, and it kind of shoots into our grow bed or over the edge of our grow bed, and then we've got our PVC T.


At this point, if you're using a lightweight media like hydroton, you can go ahead and fill the grow bed the rest of the way up. It's not going to stress the structure of the IBC too much.

However, if you're using gravelit may be helpful to take a couple of 2x4's and brace up the bottom of the grow bed or to build a little framework to help support the weight of the media.  This isn't necessary

though, just recommended for heavy media types. Then, fill up the grow bed up to within about an inch off the top, (so about 8 inches of media).

At this point, you should have your standpipe in, your screen made out of 4-inch or 6-inch PVC around the standpipe, and then your grow bed should be filled with media.

At this point we want to completely fill the growbed with media so that we can place an irrigation pipe around the perimeter of the grow bed. To do this, we will use 1-inch pipe, and the nice thing about this is we're not going to do any gluing. We're just going to do hand-fitting. It doesn't matter if it leaks because it is already inside of the grow bed.

Take 1-inch pipe, and cut it so you can fit two pieces in on either side of that T. They should extend almost to the corner of your grow bed on either side.

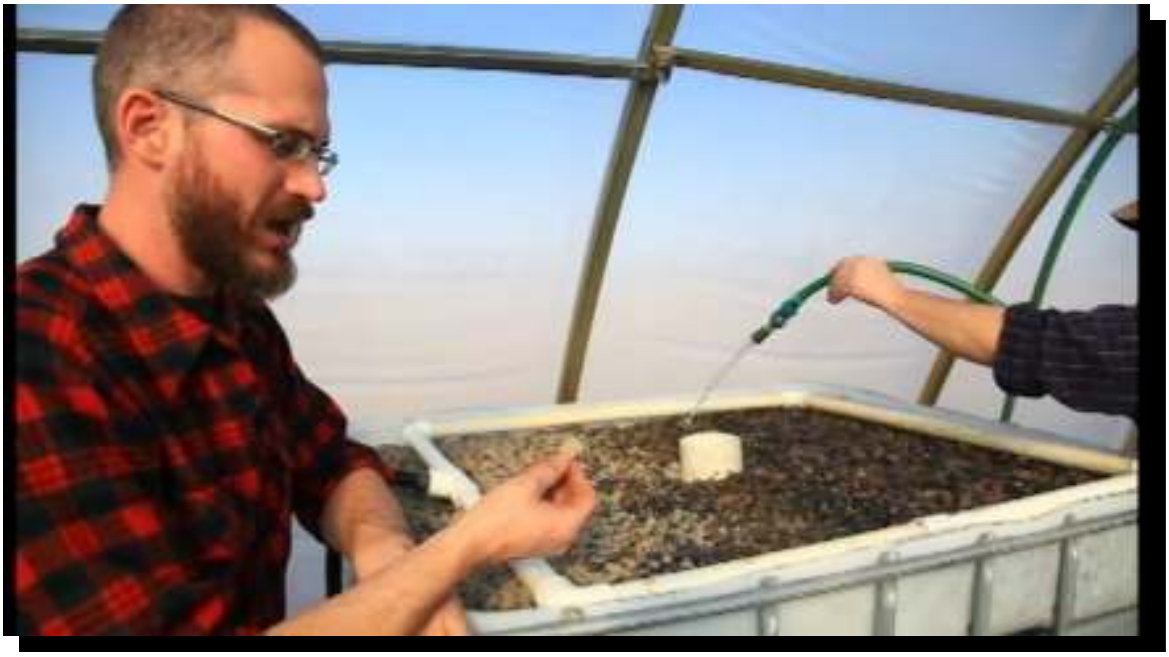
Take a pair of 1-inch L's and fit one L to each end of those 1-inch pipes. Then cut another piece of 1-inch pipe so that it runs the length of your grow bed. Do this on either side.

Then take another L and stick it on the end of each of those lengths of pipe and another piece that will fit between the two of them on the far end. Now you should have a perfectly enclosed square "loop" of pipe that runs around the entire perimeter of your grow bed.

At this point we're going to take this loop of pipe and disassemble it. Go ahead and take out a drill with a ¼ -inch-3/8 inch bit (a ¼-inch bit is usually adequate) and just drill holes on the bottom of those pipes. You do not have to drill very many at first. Drill more holes on the far end of the "loop" than on the near end to make sure that water is distributed fairly evenly.

You can disassemble it to do this, but you just want to drill three or four holes on each piece of that pipe along the perimeter of that grow bed. And then you're going to twist them so they face down. The goal is to make it so that when the water is being pumped up from the pump, it runs into that pipe and is forced down into the media. Ideally, you will get fairly even coverage because if you don't have holes drilled very evenly, or you have corners that aren't getting circulation, you can end up with anaerobic conditions.

Once you've drilled those holes it is time to rinse the grow bed out. There's a few different ways to do this. If you haven't used rinsed gravel to start with, you can just take some water and go ahead and spray it into the top of your grow bed.



You'll have to do this regardless of the media you choose. You might have to do it for quite a while to get most of the dirt and the sediment out of it. It's all just going to drain down into the fish tank at this point, so go ahead and go down and turn the valve at the bottom of the IBC. There's a big butterfly valve at the bottom of your IBC. You're going to go ahead and turn the handle on that and just let that water drain out as it pours down from the growbed. The goal here is just to wash all that sediment out so that you have nice clean pretty water and not murky, disgusting muddy water.

Rinsing might take a while. After you've rinsed all that out, we can take our portion of 2-inch pipe and we're going to stick it into the female slip portion of that 2-inch fitting that's sticking out down towards the fish tank.

At this point, you can choose how long you want that to be, or you can wait a while and just kind of see how things work out. Remember, the shorter it is, the more oxygenation you'll have; the longer it is the less oxygenation you'll have from the pouring action, but there will be less spashing and noise. If you want maximum oxygenation, don't bother putting any 2-inch PVC on it at all. But I warn you it will splash a little bit so you might have higher water loss.

At this point, you're ready to go. You can go ahead and fill up the bottom portion of your IBC with water, after of course, making sure that you've closed that butterfly valve at the bottom. They do sell caps for those valves. It might be worth going out and buying a cap that you can screw on just to make sure that someone doesn't come along and turn that valve open and drain your tank at any point. Sometimes they come with caps. Just make sure that cap is on there so that you don't have an incident where all of the contents of your fish tank drain.

Once you have filled up your aquaculture tank and rinsed out the media in your grow bed, you can turn the system on. Once you plug in your pump, it should be pumping water out of your aquaculture tank into your grow bed. It should be squirting down through the holes you've drilled in this tubing that it goes around the perimeter of your grow bed and dropping back into your aquaculture tank. It should be running fluidly without leaking and function fairly well at this point.

# CONCLUSION

You should now have the ability to completely setup your very own survival aquaponics system. Utilize all of the tips found in this book to make sure you're able to survive in any type of crisis situation. You possess knowledge and skills that many others do not have, which will put you at an advantage when issues with the food supply occur.

Even the average aquaponics farmer will not have some of the knowledge you've gained in this book such as the ability to adjust your system in the event that certain resources are unavailable. Remember, many of the people who practice aquaponics do it solely for the purpose of saving money and being environmentally conscious. You not only have the ability to do that, but you know the full capabilities of aquaponics for survival situations.

As mentioned, you can apply what you've learned right now but gathering up the necessary tools and parts to put together your very first aquaponics setup. The sooner you get your setup ready and get some experience, the more efficient you will be able to tune your system when you need it the most.The time to start thinking about surviving a crisis situation is not after it begins, it's before.

# PHOTO SOURCES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# WHERE TO BUY…

You can buy all that you need mostly from Amazon.com and Ebay.com, for more check out the list bellow.

1. IBC - Ebay.com

http://www.ebay.com/sch/i.html?_trksid=p5197.m570.l1313&_nkw=ibc&_sacat=0&_from=R40

2. Ecoplus submersible pump – Ebay.com

http://www.ebay.com/itm/Ecoplus-396-GPH-Submersible-Water-Pump-eco396-eco-plus-/130601679809?pt=LH_DefaultDomain_0&hash=item1e68777bc1

3. Barrels – Amazon.com

http://www.amazon.com/Open-Head-Plastic-Drum--labeled-picture/dp/B002SVZ4XM/ref=sr_1_7?ie=UTF8&qid=1359724077&sr=8-7&keywords=barrel

4. OSB and plywood – Home Depot

http://www.homedepot.com/h_d1/N-5yc1vZbqpq/h_d2/Navigation?catalogId=10053&langId=-1&storeId=10051

5. Crushed granite or other rocks for media - Soil buildings systems

http://www.soilbuildingsystems.com/index.php

6. Tilapia

http://www.aquaponicsusa.com/Aquaponics_USA_Tilapia_For_Sale.html

7. Lighting systems - 4Hydroponics, E-bay.com, Amazon.com

http://www.4hydroponics.com/

8. Seaweed extract – Ebay.com, Amazon.com

http://www.ebay.com/itm/8-OUNCES-ORGANIC-KELP-EXTRACT-POWDER-WATER-SOLUBLE-SEAWEED-FERTILIZER-HYDROPONIC-/160962857706?pt=Fertilizer_Soil_Amendments&hash=item257a224aea

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http://www.ebay.com/itm/50-Jiffy-7-Peat-Pellet-30mm-50-per-lot-/170446081730?pt=LH_DefaultDomain_0&hash=item27af60cec2

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http://www.ebay.com/itm/ORGANIC-EDIBLE-AZOLLA-DUCKWEED-MIX-BOTH-TYPES-FREE-DELIVERY-POND-FISH-AQUARIUM-/200887135615?pt=AU_Plants_Seeds_Bulbs&hash=item2ec5ce6d7f

14. 3/4 inch black polyethylene tubing

http://www.sprinklerwarehouse.com/Drip-Irrigation-Tubing-p/14-002.htm

15. Fittings

http://www.plumbingsupply.com

16. PVC pipes - Ebay.com

http://www.ebay.com/itm/PVC-PIPE-All-Sizes-available-/140718146239?pt=LH_DefaultDomain_0&hash=item20c37482bf

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http://www.amazon.com/Mr-Gasket-2842G-Teflon-Tape/dp/B000BWCFT6/ref=sr_1_1?ie=UTF8&qid=1359727262&sr=8-1&keywords=teflon+tape

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