Aquaponics 101 – Concepts

Understanding the hows and whys of Aquaponics Operations.

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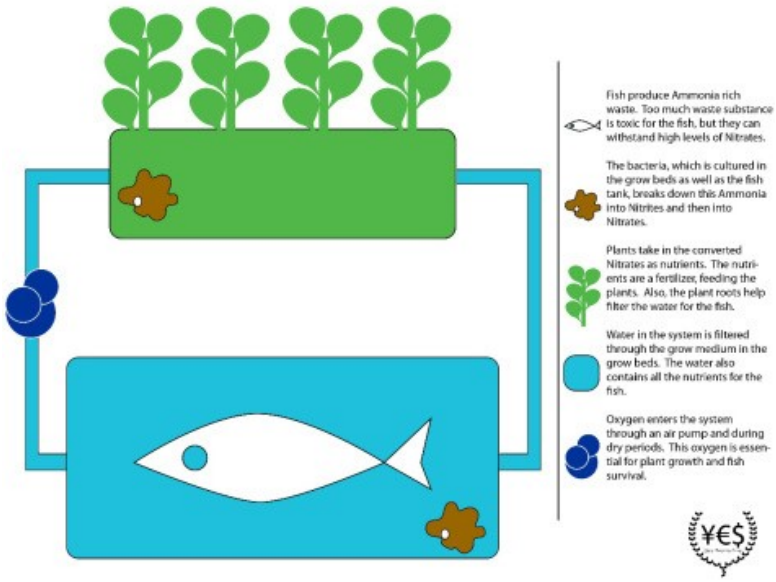
Concepts

Before we get into the practical applications of aquaponics systems design and operation, it is important that we understand the fundamental theories that underpin the concepts of aquaponics. Learning these new concepts, new terms, and a bit of science will prepare you for the next series of articles. Without this understanding, the building and operation of a successful aquaponics system, no matter the size or complexity is almost impossible.

An Overview of the Basic System

The most basic of aquaponics systems consist of only two parts, a grow bed and a fish tank. The illustration shows in the simplest terms the circular design of the basic aquaponics system. While an aquaponics system is not a true closed system since it depends on a few basic outside inputs to operate successfully, it is as close as can be practical.



Basic Parts

In this graphic, the lower figure is the fish tank. In the fish tank, as can be expected, live the fish. The small brown item in the tank represents the bacteria colonies that grow within the system. These bacteria cultures are the heart of the system, and without these bacteria cultures, aquaponics is impossible.

The flow of water through the system is clockwise. Water flows from the fish tank into the upper green box, which represents the grow beds. It doesn't matter whether you are using a media such as gravel or rock, or are running a sophisticated nutrient film technology (NFT) system, the concept is the same. The water then drains or flows from the grow bed back to the fish tank. This simple circular design is at the core of every aquaponics system, no matter how large or how sophisticated.

Beyond the Simplicity

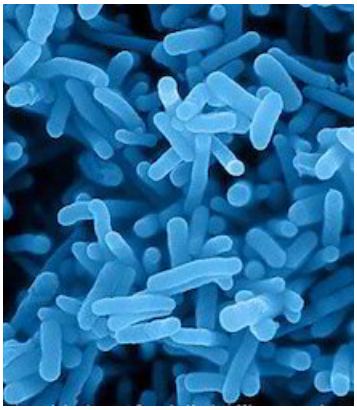
As simple as this system appears, beneath it is a complex biological and chemical set of interactions. An understanding of these processes is necessary for the design and management of a successful aquaponics system. The system must be designed to support these interactions. The operation of the system must be carried out with these interactions always in mind so as not to disturb or interfere with the processes.

These processes all depend on the active and ongoing work of several bacteria colonies that flourish in the water and the grow media of the aquaponics system. It is these bacteria that convert the waste compounds produced by the fish through several steps until the waste material is converted to forms that are readily available to the plants for nutritional uptake.

System Health

Systems must be designed and maintained to ensure that the bacteria colonies in the system remain healthy. Without these bacteria, the system fails, plants and fish die. We will look at these bacteria colonies in more depth in later articles.

Nitrification



This process is called nitrification and involves two bacteria colonies working in conjunction. Ammonia (NH_3) in the form of fish waste is toxic to fish and most other marine organisms at high levels. The ammonia is first converted to nitrite (NO_2) by the nitrosomonas bacteria. Nitrite is also toxic to fish and marine animals at higher concentrations. The Nitrobacter bacteria steps in and converts that toxic Nitrite to nitrates, a less toxic form of the nitrogen compounds and a form that plants can uptake directly for nutritional use. Not surprisingly, this is the same process that happens in healthy soil, and it is the same bacteria doing the work.

On a much smaller scale, the same processes happen to deal with the other waste products from the fish as well as the small amounts of organic material that enter the system through the decomposition of plants and uneaten food.

There are, of course, other chemical and biological factors and all of these will be covered in detail in later articles.

The Green Side of the Equation

That leads us to the second side of this equation. Just as the systems depends on the nitrification process to deal with the fish waste, without the growing plants to remove the nitrates from the water,

these toxic compounds would eventually build up to levels that would mean the death of the fish. The relationship is symbiotic. Neither can exists successfully in the system without the other doing their part.

System Types

There are three basic types of media grow systems. The most prevalent in home hobby systems is the flood and drain system filled with a neutral media to support the plants. This media can be anything from some form of rock to material such as perlite or vermiculite. These flood and drain systems utilize several methods to fill and drain the grow beds. The concept is that the plants grow in a media that fills and drains on a timed cycle. This flood and drain process accomplishes several things.

Flood and Drain Systems

First, as the water in the grow media bed rises, it covers the plant roots and allows them to begin to uptake the required nutrients. When the water begins to drain, the dropping water level pulls fresh oxygen into the spaces between the grow media, allowing the plant's roots to oxygenate. It also allows those organisms that live in and on the grow media the opportunity to respirate. The media also acts as a filtration system, trapping large particles and keeping them where bacteria and other organisms can work on breaking them down so that they can again become part of the food chain in the aquaponics system.

In a properly designed and operating system, the grow media is just as alive as healthy soil. It is teaming with life from the microscopic to those big enough to be seen with the naked eye. These organisms work in conjunction with the rest of the system to maintain a healthy and biologically balanced system.

We will look more closely at these organisms and mechanical systems in later chapters. Understanding how these organisms and mechanical system co-exist is fundamental to managing a healthy and productive system.

The Mechanics of Aquaponics.

Mechanically, a basic aquaponics system like the one illustrated above, is relatively simple. It doesn't take much to keep a simple system operating. Most home hobby systems operate quite efficiently with a single small pump and a minimum of plumbing. Designing a system that utilizes gravity to move water is one of the challenges and should always be a priority. Simplicity in operation offers returns in minimal maintenance, reduced operating expense, and fewer mechanical problems.

While almost any submersible pond pump will work, there are considerations when choosing the size of the pump. Pump Selection will be covered in depth in a later article.

Bell Siphons

In terms of complexity, the most complex part of a home hobby aquaponics system is the bell siphon that enables the flood and drain system to work without electricity, pumps or valves. Care must be taken to proportion the bell siphon assembly properly for the size of grow bed, the desired flow rate, and the cycle time for the flood and drain. When properly designed and built, these bell siphon assemblies will perform reliably with minimal maintenance. An entire article will be devoted to the design, installation, and maintenance of bell siphons.

Bell siphons come in a wide variety of designs. Some reside inside the grow bed, and some work from the outside of the grow bed. Whatever the design choice, the bell siphon is an integral part of a well-designed system.

Bell siphons are available commercially as pre-built units or can be built easily from off the shelf parts available at any home supply store. We will discuss building and installing a bell siphon as part of your system.

The Living Parts

There are two more very important pieces to this puzzle. Those are the living parts of the system. We have already talked a bit about the micro-organisms that play such an important role. Now we must consider the other two, the fish and the plants.

You can grow almost any plant or aquatic animal in your aquaponics system. Some work better than others, some are simpler, and some seem to thrive in an aquaponics environment. There are many variables to consider when choosing a species of fish and varieties of plants. Such questions as; "Do I want to eat the fish or am I growing just to support the plants?", "Do I want to do exotic species to resell or those that require minimal care?" and "How much do I want to raise?" Decisions about fish species will be discussed in depth in a later chapter.

Decisions, decisions

Plants are another decision point for consideration before designing and building your system. If you are primarily interested in growing green vegetables, then perhaps a raft system or an NFT system would be better. Do you want to grow vegetables that vine and climb? A low trough system with trellising above may be a better option. Also, considering which particular variety is important as well. Are you looking for a shorter growing time? Do you need to consider disease and pest resistant varieties? Is there a known cultivar that does especially well in aquaponics? We will spend several articles later on plant selection and care.

Operations and Maintenance

When designing and building your system, think about the daily operation and maintenance. These are systems that require constant observation and care. Routine checks, service, and recorded observation prevent major problems. This ongoing data collection is important to diagnosing problems, spotting trends, and in learning how the system reacts to various changes in inputs.

A small problem observed early and corrected never gets to be a big problem. A single sick fish removed and quarantined early can prevent the loss of the majority of a tank of fish. A simple leak remedied quickly can prevent a wholesale flood in the greenhouse.

Planning can help mitigate the drudgery of many chores. Properly designed systems operate cleaner and are easier to maintain than hastily designed systems. A well-designed system is easier to repair. The choice of components and equipment can make the day to day management of the system much more enjoyable and rewarding.

Several later articles will go into each of these areas in greater detail.

Coming Next

Next time we will take an in-depth look at the different types and styles of aquaponic systems, the pros and cons associated with each and the factors that you should use in deciding which type of system best suits your situation.