Aquaponics 101

An Introduction to Aquaponics Systems of Food Production

Dennis K Howard, Certified Master Gardener, Natural Organic Certification – Texas Organic Research Center
http://www.westtexasorganicgardening.com

Aquaponics is unique. It is a food production system which offers advantages to both small and large growers that other forms of aquaculture or hydroponics fail to deliver. Aquaponics combines conventional aquaculture techniques (raising aquatic animals in tanks) with hydroponics (cultivating plants in a water/nutrient solution) in a symbiotic environment. Aquaculture production systems have been in use around the world for centuries, especially in Southeast Asia and the Pacific Rim. Studies estimate that 70% of the fish consumed in western nations grow in commercial fish farms. Hydroponics is a relatively new technique of growing vegetables. Hydroponics is an industrialized process allowing vegetables to grow in huge numbers in very dense planting processes. The plants are grown without soil, depending on the delivery of nutrients to the plants through liquid solutions. Each of these systems, while economically viable and in wide use, have some downsides especially for those who are concerned about environmental issues.

Commercial fish farms are dependent on large amounts of fresh water. In some instances, as much as 20% of the total water volume in the grow ponds must be replaced every day to maintain a healthy environment for the fish. These systems also are subject to high disease rates due to the extremely high fish population densities that are required to make the operation profitable.

Hydroponics is itself, a completely artificial growing environment. These systems usually exist in huge industrial operations within greenhouses under tightly controlled environmental conditions. The plants grow in systems delivering nutrients as water-soluble chemical

solutions. These systems are extremely profitable in most instances because of the capability of the operator to control almost all the variables that go into producing a food crop. The downside to this type of production is the artificial nature of the production. Since it depends on the use of chemical solutions for nutrient delivery, it is almost impossible to gain organic certification for vegetables produced in hydroponics systems. Most producers use man-made synthetic chemical fertilizers to blend their nutrient solutions. Also, since nutrients must be added to the system constantly, there are some environmental concerns with the chemical residues that are the end products of the growth cycle.

Aquaponics is a fusion of these two systems of production. This fusion makes use of a more natural system of production that eliminates almost all of the negative factors associated with either aquaculture or hydroponics. Aquaponics is a form of permaculture and seeks to create balanced, sustainable systems to provide wholesome and healthy sources of both protein and vegetables.

One of the most attractive aspects of aquaponics to the average home gardener is the simplicity and the ease with which a beginning system can be built and put into operation. Systems can be built from scrap materials and parts or with supplies available at any of the big box home improvement stores. The build does not require any special or unique tools or expertise. Aquaponics systems tend to be very scalable. A hobby gardener can start with a small back porch system and easily scale a system up as interest grows and there is a need to increase production. (Integrated Agriculture-aquaculture: A Primer, Issue 407, 2001).

History

Aquaponics is not a new concept. In Asia, it has long been a practice to introduce beneficial fish species to flooded rice paddies to help with insect control as well as to provide fertilizer for the plants in the form of fish waste. When the paddies are drained to allow harvesting, the fish are harvested as well and used as a protein source. As early as 1000bc, the Aztecs in central Mexico were practicing a form of aquaponics to support the population in their capital city.

The Aztecs built artificial floating islands in the lake surrounding the city and anchored them to the lake bottom. By piling mud from the lake bottom onto platforms built of reeds and bamboo, the Aztecs created fertile growing areas called chinampas. Food crops planted on these platforms grew their roots through the artificial island and into the lake below where they drew water and nutrients from the lake. Fish in the lake fed on the roots of the plants thus drawing large fish populations close to the chinampas making the fish easier to harvest. As part of the natural processes, the fish added more nutrients to the water in the form of waste products. This technique allowed the Aztecs to support a population much larger than would have otherwise been possible based on the amount of tillable land available for conventional farming techniques (Boutwelluc, 2007)

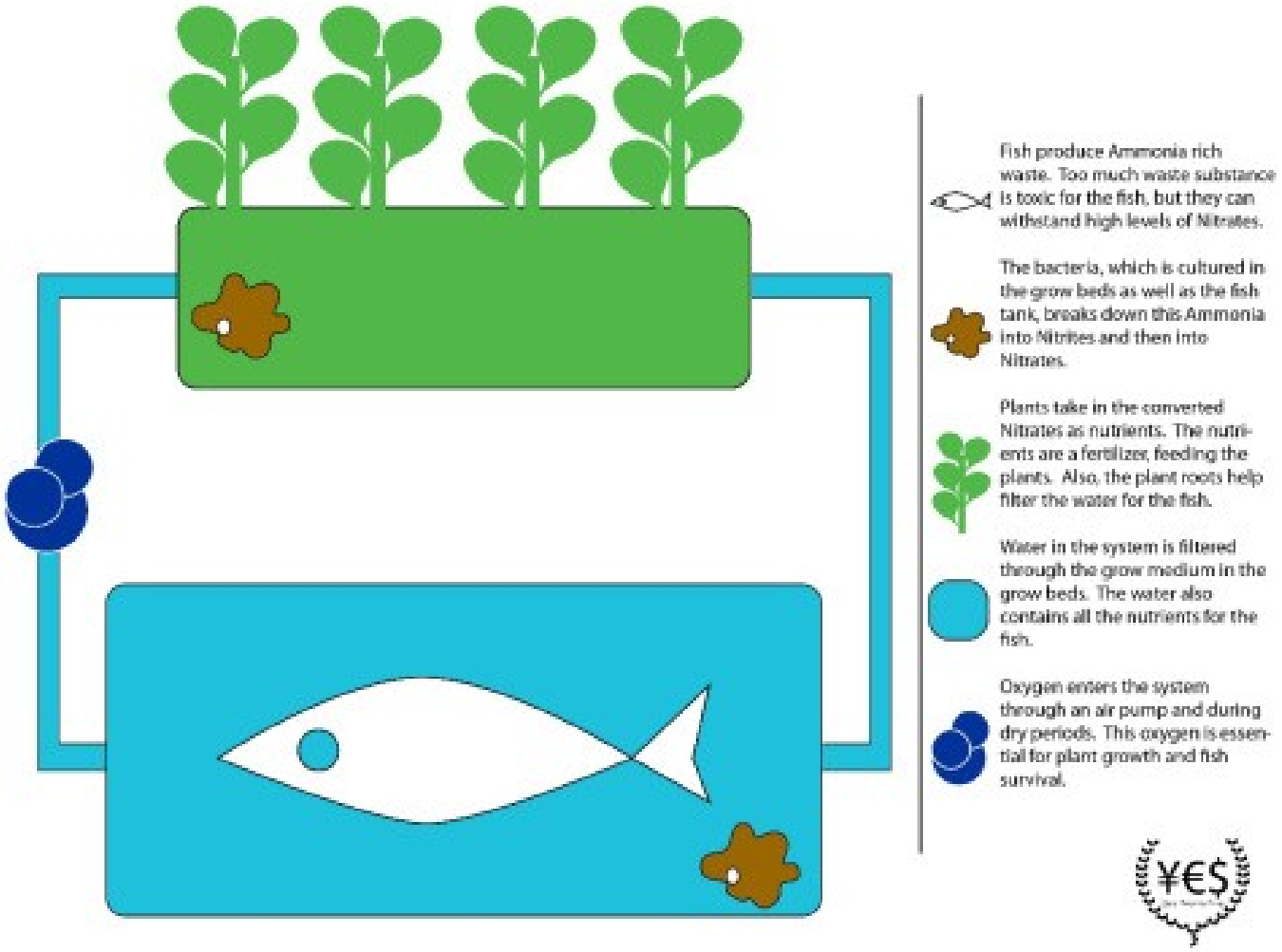
Aquaponics systems have been in use on a small scale worldwide for many years. However, with the growing interest in aquaponics as a means of producing both vegetable and protein sources in areas where tillable land is scarce or non-existent, serious academic study of the processes and methods has been growing. In such diverse places as Bangladesh, the Virgin Islands, Canada, and Barbados, governments and universities are investigating the best means to use aquaponics to boost food production without increasing the demands on the eco-systems. (Rakocy) (Innovation of a BAU researcher: “Aquaponics technology” three times production without any cost, 2011)

There is growing interest in aquaponics system for third world countries where arable or tillable land is at a premium or where water is scarce. Since aquaponics systems do not depend on tillable land and because they are closed systems which tend to be very water-wise, many non-profit organizations, dedicated to bringing relief to these areas of the world, are working diligently to develop aquaponics systems that can be delivered intact to remote areas.

Aquaponics holds the promise of producing high-quality vegetable and protein in a sustainable, economical and efficient manner.

Systems – Design and Operation

The most basic aquaponics system consists of a grow tank for raising fish or other aquatic animals and a grow bed for raising vegetables. The diagram below graphically illustrates this basic aquaponics system.



The fish in the grow tank produce waste products. Most of the waste produced by fish is in liquid form excreted through the gills in the form of ammonia and can be as much as 90% of the waste produced by fish. The remaining 10% is in solid form.

This ammonia, if left in the water will soon reach levels that become toxic to the fish and constitutes one of the biggest problems in large commercial fish farms. Ammonia accumulation

is mitigated by constantly introducing huge volumes of fresh water and the removal of an equal amount of contaminated water from the ponds.

In an aquaponics system, a bacterial colony grows naturally and then converts this waste ammonia into nitrates. This bacteria exists naturally all around us. It occurs in the soil and the air and is a completely organic process.

The nitrates produced by the bacterial action are in a form that can be directly utilized by the plants that as they grow in the system. This uptake of the nutrients by the plants acts as a natural filtration system that keeps the water a healthy environment for the fish. Thus we have a system in which all the parts work together to create a mutually supportive environment. This symbiotic process is the real beauty of aquaponics and mimics natural processes.

Because the same water recirculates in the system, aquaponics systems tend to be very water wise. In most instances, if comparing the total production of vegetables in an aquaponics system to that produced in a regular soil environment, the amount of water used in the aquaponics system can be as much as one fifth the amount of water used in a soil garden. That is a tremendous water saving and is a much more environmentally sound operation.

The simplest setup for a hobbyist can be accomplished using an aquarium tank for the fish and a plastic bin as the grow bed. As hobbyist begin to scale their systems up, they may use food grade plastic 55-gallon barrels or 275-gallon IBC totes as the basis on which they build their systems. There is a wealth of information on the internet about building these small to the medium-sized system using recycled materials. The first image in this article shows a system utilizing an IBC tote which has been cut down and the bottom 2/3rds used as the fish tank and the top third used as the grow bed.

Commercial systems can be expanded to incorporate fish tanks in the thousands of gallons and grow beds of hundreds of square feet. Some commercial operations can produce millions of pounds of vegetables and tens of thousands of pounds of fish on as little as 3 acres. To produce these same levels of vegetables and fish in a conventional production system would require hundreds of acres. However, the basic concept of operation remains the same from the smallest system to the largest commercial system in operation

Aquaponics, as a science, is in its infancy. Although it is a technique rooted in history, the technical and biological processes are still being researched and improved. Because of its relatively low entry cost for a good sized system, it is not surprising that much of the innovation is still coming from the small backyard greenhouse projects where dedicated hobbyist tinker and experiment. The community of aquaponists is a varied and motivated group. They share readily, and the amount of information on the internet can be staggering.

As a hobby or as a possible answer to food shortages and the lack of tillable land in some parts of the world, aquaponics can be rewarding and promises answers to many of the world's problems. For the hobbyist or home grower, it offers the means to produce both vegetable and protein for the family in an organic, sustainable and environmentally responsible way.

Resources

Dumbauld, B. R., Booth, S., Cheney, D., Suhrbier, A., & Beltran, H. (2006). An integrated pest management program for burrowing shrimp control in oyster aquaculture. *Aquaculture*, *261*(3), 976-992.

Boutwelluc, Juanita (December 15, 2007). "Aztecs' aquaponics revamped". *Napa Valley Register*. RetrievedApril 24, 2013.

Rakocy, James E, Innovation of a BAU researcher: "Aquaponics technology" three times production without any cost. In Bengali.The Daily Kalerkantho, January 25, 2011