Evolution of Aquaponics

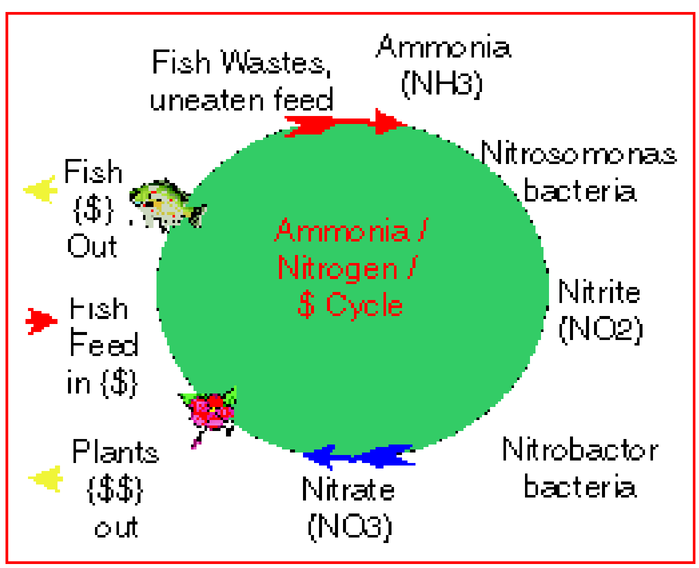
By Scott Jones

Aquaponics is an intricate circular chemical sequence often described, in a simple manner, as, “you feed the fish, the fish feed the plants and the plants clean the water for the fish.” On a grand scale Mother Nature uses aquaponics to make the world grow. Without natural aquaponics (in our ponds, streams and fields) we simply could not exist here on earth.

History of Aquaponics:

Other than Mother Nature’s natural aquatic eco systems, aquaponics first appeared at least 1,500 years ago in China. One entrepreneur got tired of dragging feed out to the ducks, the finfish and the catfish. He stacked the ducks in cages above the finfish and moved the catfish downstream from the finfish. Now when he fed the ducks their droppings and uneaten food fell into the water with the finfish. The finfish ate and “processed it.” The wastes from the finfish flowed downstream and sank to the bottom, giving food to the catfish which are natural bottom feeders and scavengers. The processed feed and anything that the catfish missed was channeled out to the fields to feed the rice crop. He fed once and harvested four times. The only drawback was that it was outdoors, so it got cold. Everything froze up for 5 months of the year. The theory was good but the execution left a little to be desired.

The Inca’s of Peru practiced a different style of aquaponics before the Conquistadors arrived. They dug oval ponds near their mountain dwellings, leaving an island in the center. After the ponds filled, they added fish. Geese flew in, harvested their meals from the water and relaxed on the island. Their droppings and fish scraps quickly turned the island into a super rich, high quality garden. Now not only did the Inca’s have the geese doing the fertilizer work, they also had fresh fish readily at hand and a moat around each garden to keep out hungry prowlers. Plus the mini pond/island system created a local micro-climate that stayed a little warmer than the surrounding mountains, giving extra days of harvest every year. The production from the Inca aquaponic systems fed more people per square mile than any type of farming to this day, in that same type of high arid land.



Aquaponics today:

Aquaponics is back in the news today, not because it's the "newest rage," but because it solves many of the vexing problems that strike traditional soil-based growers worldwide.

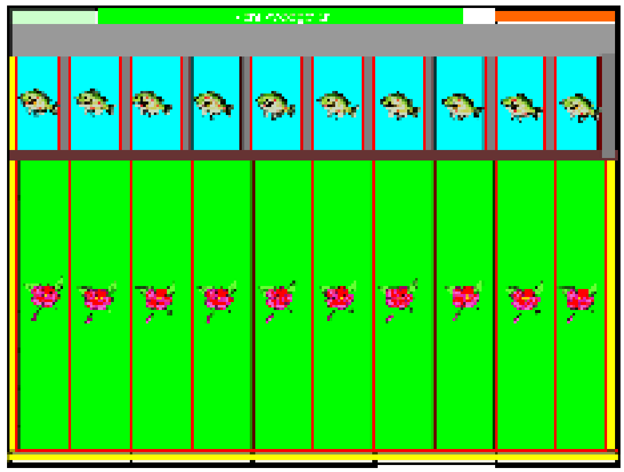
Water is a scarce commodity. Without clean drinking water humans don't thrive. And yet, up to ¾ of our fresh water is used to water crops and then it rapidly drains away. Not only is the farmer's hard-earned money draining away into the ground but, also, as the water drains away, it collects fertilizers and farm chemicals, leaching them into the ground water (our drinking water). The excess fertilizers and chemicals flow into our rivers and bays causing algae-blooms and killing the aquatic life. Roughly 10% of the chemicals that a soil farmer spreads on his fields are actually taken up by his plants, the rest goes on to wreak havoc on the natural life downstream. Modern aquaponics recycles water, reusing this valuable resource. The air is also recycled. The fish give off carbon dioxide (CO_2) as they "breathe". The plants take in the CO_2, strip off the carbon (C) to build their leaves and release the remaining oxygen (O_2) molecules. That oxygen-rich air is filtered and then blown into the water for the fish to recycle. In every aquaponic system wastes in one part of the system are utilized as a resource in another part.

Pollution is drastically reduced because the water and the wastes contained therein are recycled instead of being dumped into the ground water. The fish and plants are grown in intensive, aboveground systems. As a result, food is produced without the loss of valuable flatlands. Most aquaponic growers are inside a greenhouse, so by simply adding light and heat, the grower has the ideal growing season every day of the year.

With the aquaponic operation inside a greenhouse, the need for pesticides and herbicides is minimized. Cultured beneficial insects will eat the occasional bug that manages to get past the walls of the greenhouse. The tightly controlled hydroponic section of the operation is naturally weed-free.

Size of the commercial aquaponic industry:

The controlled environment (greenhouse) commercial aquaponic industry is in its infancy, both in the U.S. and around the world. Currently there are less than five large-scale (+1 acre) facilities around the world and only two in the U.S. While several smaller operations are scattered around the country, most are on the "family farm" scale, rarely exceeding ¼ acre.



10 separate aquaponic systems in the Phoenix Foods LLC Greenhouse complex

Methods of operation:

All large-scale aquaponic operations are using either Nutrient Film Technique (NFT) or floating bed hydroponic systems combined with either rectangular or round fish culturing tanks. Most small-scale aquaponic operations are using the simpler Ebb & Flow hydroponic systems with small round fish culturing tanks.

Crops Grown...Fish:

Several species of fish have been cultivated successfully in aquaponic systems. Current technology limits the choices to fresh-water species, though recent research has shown promise on medium salt-water (brackish water) species such as Hybrid Striped Bass and shrimp. By far the largest share of the aquaponic fish market, in both pounds harvested and number of commercial operations, goes to Tilapia. Tilapia has several attractions for commercial operation: they have a short cycle from birth to harvest (6-9 months), tolerate drastic swings in water quality and are tolerant of low oxygen levels for extended times. Unfortunately, the farm-gate price, direct to wholesalers or haulers, is barely above the break-even costs. Tilapia is a great species with which to *start* a system, but a poor choice for the long-term operation of a viable commercial facility.

For long-term economic viability and to lessen the threat of catastrophic disease loss, a mixture of species is advisable. Prices for fish fluctuates by species. While one species is high, another is low. Sudden inflow of fish from overseas markets can drop a profitable species of domestically grown fish down to, at best, a break-even point in less than a year. Disease is often species-or-cultural-condition-specific. What will devastate one species will often totally pass over a different species in the next tank.

Above: Pearl tilapia
Below: basil

Presently all commercial aquaponic facilities and nearly all aquaculture facilities produce food fish. Potential new markets are likely in ornamental pond fish and in aquarium fish markets, both of which are forecast to grow dramatically as more people stay home and invest in their private space since the events of 9-11-01.

Crops Grown...Plants:

Nearly all plants can grow in an aquaponic system but only a few have been tested and proven to be economically viable. For the most efficient operation of a commercial aquaponic facility, a steady condition must exist between the pounds of fish (including the relation to fish feed) in the system and the poundage of plants in order to prevent toxicities and deficiencies of various elements from developing over time for both the fish and the plants.

The plants used in large-scale operations must have the same nutrient needs the entire way through its life cycle (i.e. lettuce needs high Nitrogen (N) levels at all life stages). Fruiting plants such as tomatoes and peppers need high nitrogen for good initial vine growth, then low N and a high Phosphorous (P) and Potassium (K) levels for good fruit development. Customized commercial fish feed blends are not available with variable NPK ratios. Therefore, since it is the fish feed that ultimately determines the fertilizers fed to the plants, only plants that thrive on high N levels are suitable for commercial production with today's technology. The near future looks to change this one-step approach. Custom mini-mills and extruders, along with advanced adjustable formulas of feed, *may* soon produce cost-effective feed for maximized growth of fish and plant, no matter what the stage of growth of the fish and the plants.

Suitable commercial crops for aquaponics that require high N are greens such as lettuces, mints, and culinary herbs. Other potential crops for commercial production are medicinal herbs and plants and, also, plants grown for their essential oils used in manufacturing and pharmacology. Holopathic medicine has seen a 30 year up-swing into wide-spread acceptance limited, in part, by the unavailability of fresh (as opposed to dried) plants on a year-round basis, which could be solved by greenhouse production. New plants are discovered almost daily that have pharmacological properties but are normally available only in small quantities and often in far-off lands. Aquaponic greenhouse production guarantees a consistent, high quality source of the plants that the pharmacological market craves.

Integration of technology:

Successful commercial aquaponic operations in the future will rely in part on three major modern technologies: co-generation of power and heat, tissue culture for plant propagation and advanced year-round breeding (most species of fish -other than Tilapia- are normally seasonal in their spawning).

Controlled environment or greenhouse cultivation of high-value plants and fish requires a large amount of electricity available year-round without interruption for production lighting, ventilation and mechanization. Heat requirements can rise to as much as 40% of wintertime operating costs. Recent development of small, private, distributed grid electrical generators that sell excess electricity back to the main power grid, offer both constant and cheap electrical power that is readily available on-site. Other means of heating and power generation, such as solar or geo-thermal, can serve as back-up or supplemental reserve. The grower normally has to pay for both heat and power. With co-generation he pays for the electricity and gets the heat for free, or vice-versa.

Electric generator

Tissue culture is the science of cultivating and replicating thousands of plants from one individual plant segment. Also referred to as cloning, tissue culture gives the ability to chose an ideal plant with the exact characteristics desired and to create in a short amount of time countless replicates of that plant. Using various techniques, small plantlets can be stored for many months and then brought to full luxuriant growth when the market is ripe. When combined with modern gene splicing techniques, custom-designed plants can be quickly mass-produced for specific pharmacological characteristics or for adaptation to different cultural requirements of the end user (i.e. plants modified for higher growth rates or more resistance to a rapidly changing environment).

Most commercial species of fish, both food fish and ornamental fish, are only available as fry at specific times of the year. Without easy availability to fry year-round, producers are forced to adhere to a yearly cyclical production schedule upsetting the balance between fish and plants and forcing the dumping of the fish onto the market at the same time that other producers are . . . resulting in price drops. New propagation techniques are now available which give the commercial grower the ability to breed most species of fry at any time of the year to meet projected demands. Breeding in-house also helps assure bio-security since the disease and parasite status of the fish is known from day one, greatly lowering the chance of a loss of the crop.

Aquaponics is leaping onto the radar screen of the general population. It conserves our priceless groundwater. It eliminates our exposure to harmful farm chemicals on and in our food. It produces safe, full-flavored food year-round, often in close proximity to highly populated areas. It adapts very readily to the latest advances in plant and fish propagation . . . and it hooks the customer's interest (and pocketbook) like no other form of food production. It sells itself because it is unique and natural. Aquaponics will be one of the major methods of food production in the coming centuries!

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