Week 14. Integrated Systems- Example of Aquaponics II

Feed source[edit]

As in most aquaculture based systems, stock feed often consists of fish meal derived from lower-value species. Ongoing depletion of wild fish stocks makes this practice unsustainable. Organic fish feeds may prove to be a viable alternative that relieves this concern. Other alternatives include growing duckweed with an aquaponics system that feeds the same fish grown on the system,[27] excess worms grown from vermiculture composting, using prepared kitchen scraps,[28] as well as growing black soldier fly larvae to feed to the fish using composting grub growers.[29]

Plant nutrients[edit]

Like hydroponics, a few minerals and micronutrients can be added to improve plant growth. Iron is the most deficient nutrient in aquaponics, it can be added through mixing Iron Chelate powder with water. Potassium can be added as potassium sulfate through foliar spray. Less vital nutrients include epsom salt, calcium chloride and boron.[30] Biological filtration of aquaculture wastes yield high nitrate concentrations, which is great for leafy greens. For flowering plants with high nutrient demands, it is recommended to introduce supplemental nutrients such as magnesium, calcium, potassium, and phosphorus. Common sources are sulfate of potash, potassium bicarbonate, monoammonium phosphate, etc. Nutrient deficiency in wastewater from fish component (RAS) can be completely masked using raw or mineralized sludge, usually containing 3–17 times higher nutrient concentrations. RAS effluents (wastewater and sludge combined) contain adequate N, P, Mg, Ca, S, Fe, Zn, Cu, Ni to meet most aquaponic crop needs. Potassium is generally deficient requiring full-fledged fertilization. Micronutrients B, Mo are partly sufficient and can be easily ameliorated by

increasing sludge release. The presumption surrounding 'definite' phyto-toxic sodium levels in RAS effluents should be reconsidered – practical solutions available too. No threat of heavy metal accumulation exists within the aquaponics loop.[31]

Water usage[edit]

Aquaponic systems do not typically discharge or exchange water under normal operation, but instead, recirculate and reuse water very effectively. The system relies on the relationship between the animals and the plants to maintain a stable aquatic environment that experience a minimum of fluctuation in ambient nutrient and oxygen levels. Plants are able to recover dissolved nutrients from the circulating water, meaning that less water is discharged and the water exchange rate can be minimized.[32] Water is added only to replace water loss from absorption and transpiration by plants, evaporation into the air from surface water, overflow from the system from rainfall, and removal of biomass such as settled solid wastes from the system. As a result, aquaponics uses approximately 2% of the water that a conventionally irrigated farm requires for the same vegetable production.[33] This allows for aquaponic production of both crops and fish in areas where water or fertile land is scarce. Aquaponic systems can also be used to replicate controlled wetland conditions. Constructed wetlands can be useful for biofiltration and treatment of typical household sewage.[34] The nutrient-filled overflow water can be accumulated in catchment tanks, and reused to accelerate growth of crops planted in soil, or it may be pumped back into the aquaponic system to top up the water level.[*citation needed*]

Energy usage

An aquaponics system that uses downwards movement of water and greenhouse light to reduce energy consumption.

Aquaponic installations rely in varying degrees on man-made energy, technological solutions, and environmental control to achieve recirculation and water/ambient temperatures. However, if a system is designed with energy conservation in mind, using alternative energy and a reduced number of pumps by letting the water flow downwards as much as possible, it can be highly energy efficient. While careful design can minimize the risk, aquaponics systems can have multiple 'single points of failure' where problems such as an electrical failure or a pipe blockage can lead to a complete loss of fish stock

Fish stocking

In order for aquaponic systems to be financially successful and make a profit whilst also covering its operating expenses, the hydroponic plant components and fish rearing components need to almost constantly be at maximum production capacity.[16] To keep the bio-mass of fish in the system at its maximum (without limiting fish growth), there are 3 main stocking method that can help maintain this maximum.

- *Sequential rearing:* Multiple age groups of fish share a rearing tank, and when an age group reaches market size they are selectively harvested and replaced with the same amount of fingerlings.[16] Downsides to this method include stressing out the entire pool of fish during each harvest, missing fish resulting in a waste of food/space, and the difficulty of keeping accurate records with frequent harvests.[16]
- *Stock splitting:* Large quantities of fingerlings are stocked at once and then split into two groups once the tank hits maximum capacity, which is easier to record and eliminates fish being "forgotten". A stress-free way of doing this operation is via "swimways" that connect various rearing tanks and a series of hatches/moving screens/pumps that move the fish around.[16]
- *Multiple rearing units:* Entire groups of fish are moved to larger rearing tanks once their current tank hits maximum capacity. Such systems usually have 2–4 tanks that share a filtration system, and when the largest tank is harvested, the other fish groups are each moved up into a bigger tank whilst the smallest tank is restocked with fingerlings.[16] It is also common for there to be several rearing tanks yet no ways to move fish between them, which eliminates the labor of moving fish and allows each tank to be undisturbed during harvesting, even if the space usage is inefficient when the fish are fingerlings.[16]

reduce stress from crowding, efficiently feed the fish, and promote healthy growth.[16]

Disease and pest management[

Although pesticides can normally be used to take care of insects on crops, in an aquaponic system the use of pesticides would threaten the fish ecosystem. On the other hand, if the fish acquire parasites or diseases, therapeutants cannot be used as the plants would absorb them.[16] In order to maintain the symbiotic relationship between the plants and the fish, non-chemical methods such as traps, physical barriers and biological control (such as parasitic wasps/ladybugs to control white flies/aphids) should be used to control pests.[16] The most effective organic pesticide is Neem oil, but only in small quantity to minimize spill over fish's water.[*citation needed*]

Automation, monitoring, and control

Many have tried to create automatic control and monitoring systems and some of these demonstrated a level of success. For instance, researchers were able to introduce automation in a small scale aquaponic system to achieve a cost-effective and sustainable farming system.[35][36] Commercial development of automation technologies has also emerged. For instance, a company has developed a system capable of automating the repetitive tasks of farming and features a machine learning algorithm that can automatically detect and eliminate diseased or underdeveloped plants.[37] A 3.75-acre aquaponics facility that claims to be the first indoor salmon farm in the United States also includes an automated technology.[38] The aquaponic machine has made notable strides in the documenting and gathering of information regarding aquaponics.[*citation needed*]

Economic viability

Aquaponics offers a diverse and stable polyculture system that allows farmers to grow vegetables and raise fish at the same time. By having two sources of profit, farmers can continue to earn money even if the market for either fish or plants goes through a low cycle.[21] The flexibility of an aquaponic system allows it to grow a large variety of crops including ordinary vegetables, herbs, flowers and aquatic plants to cater to a broad spectrum of consumers.[21] Herbs, lettuce and speciality greens such as basil or spinach are especially well suited for aquaponic systems due to their low nutritional needs.[21] For the growing

Ideally the bio-mass of fish in the rearing tanks doesn't exceed 0.5 lbs/gallon, in order to number of environmentally conscious consumers, products from aquaponic systems are organic and pesticide free, whilst also leaving a small environmental footprint.[21] Aquaponic systems additionally are economically efficient due to low water usage, effective nutrient cycling and needing little land to operate.[21] Because soil isn't needed and only a little bit of water is required, aquaponic systems can be set up in areas that have traditionally poor soil quality or contaminated water.[21] More importantly, aquaponic systems are usually free of weeds, pests and diseases that would affect soil, which allows them to consistently and quickly produce high quality crops to sell.[21]

Current examples[edit]

- Europe
  - The Urban Farming Company,[39] an organization based out of Switzerland, has been created to offer a method of rooftop based aquaponic growing systems to businesses. Its purpose is to offer fresh, sustainable produce to local urban areas.
  - In March 2018 the European Aquaponics Association[40] was established among European countries. This opened up an organization for European countries to continue aquaponic research and the implementation of aquaponic practices.
  - EcoPonics[41] is an aquaponics company based out of Iceland that is joining similar companies from Iceland, Denmark, and Spain to advocate for the implementation of commercial and competitive Aquaponics systems in European countries.
  - The Caribbean island of Barbados created an initiative to start aquaponics systems at home, called the aquaponic machine, with revenue generated by selling produce to tourists in an effort to reduce growing dependence on imported food.[*citation needed*]
- Asia
  - In Bangladesh, the world's most densely populated country, most farmers use agrochemicals to enhance food production and storage life, though the country lacks oversight on safe levels of chemicals in foods for human consumption.[42] To combat this issue, a team led by M.A. Salam at the Department of Aquaculture of Bangladesh Agricultural University has created plans for a low-cost aquaponics system to provide organic produce and fish for people living in adverse climatic conditions such as the salinity-prone southern area and the flood-prone haor area in

micro-production goals at the community and personal levels whereas design work by Chowdhury and Graff was aimed exclusively at the commercial level, the latter of the two approaches take advantage of economies of scale.

Vegetable production part of the low-cost Backyard Aquaponics System developed at Bangladesh Agricultural University

- With more than a third of Palestinian agricultural lands in the Gaza Strip turned into a buffer zone by Israel, an aquaponic gardening system is developed appropriate for use on rooftops in Gaza City.[45]
- In Malaysia Alor Gajah, Melaka, Organization 'Persatuan Akuakutur Malaysia' takes innovative approach in aquaponics by growing Lobster in aquaponics.[*citation needed*]
- Aquaponics in India aims to provide aspiring farmers with aquaponics solutions for commercial and backyard operation.[46]

- North America
  - Dakota College at Bottineau in Bottineau, North Dakota has an aquaponics program that gives students the ability to obtain a certificate or an AAS degree in aquaponics.[*citation needed*]
  - The Smith Road facility in Denver started pilot program of aquaponics to feed 800 to 1,000 inmates at the Denver Jail, and a neighboring downtown facility which consists of 1,500 inmates and 700 officers.[47]
  - VertiFarms in New Orleans targets corporate rooftops for vertical farming, accruing up to 90 corporate clients for rooftop vertical farming in 2013.[48]

the eastern region.[43][44] Salam's work innovates a form of subsistence farming for

- Windy Drumlins Farm in Wisconsin redesigns aquaponic-solar greenhouse for extreme weather conditions which can endure extremely cold climate.[49]
- Volunteer operation in Nicaragua "Amigos for Christ" manages its plantation for feeding 900+ poverty-stricken school children by using nutrients from aquaponics method.[49]
- Verticulture in Bedstuy utilizes old Pfizer manufacturing plant for producing basil in commercial scale through aquaponics, yielding 30-40 pounds of basil a week.[50]
- Aquaponics startup Edenworks in New York expands to full-scale commercial facility, which will generate 130,000 pounds of greens and 50,000 pounds of fish a year.[51]
- There has been a shift towards community integration of aquaponics, such as the nonprofit foundation Growing Power that offers Milwaukee youth job opportunities and training while growing food for their community. The model has spawned several satellite projects in other cities, such as New Orleans where the Vietnamese fisherman community has suffered from the Deepwater Horizon oil spill, and in the South Bronx in New York City.[52]
- Whispering Roots is a non-profit organization in Omaha, Nebraska that provides fresh, locally grown, healthy food for socially and economically disadvantaged communities by using aquaponics, hydroponics and urban farming.[53][54]
- Recently, aquaponics has been moving towards indoor production systems. In cities like Chicago, entrepreneurs are utilizing vertical designs to grow food year round. These systems can be used to grow food year round with minimal to no waste.[55]

- Miscellaneous
  - In addition, aquaponic gardeners from all around the world are gathering in online community sites and forums to share their experiences and promote the development of this form of gardening[56] as well as creating extensive resources on how to build home systems.
  - There are various modular systems made for the public that utilize aquaponic systems to produce organic vegetables and herbs, and provide indoor decor at the same time.[57] These systems can serve as a source of herbs and vegetables indoors. Universities are promoting research on these modular systems as they get more popular among city dwellers.