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AQUAPONICS- A STEP TOWARDS URBAN AGRICULTURE

Popular Article

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ABSTRACT

Currently aquaculture is becoming intensified in India to meet the demand of fish protein for increasing population. Agricultural land is shrinking day by day due to its conversion for other uses which is creating pressure on natural resources. Aquaponics, as a combined system of recirculating aquaculture and hydroponics, is an innovative technology in India which could contribute to addressing these problems. Although many studies have addressed some scientific aspects, there has been limited focus on commercial implementation. Aquaponic system renders the minimal use of water, while producing more fish and vegetable per unit area than the conventional aquaculture and agricultural systems. There is expanding interest in aquaponics as a form of aquaculture that can be used to produce food closer to urban centers.

Introduction

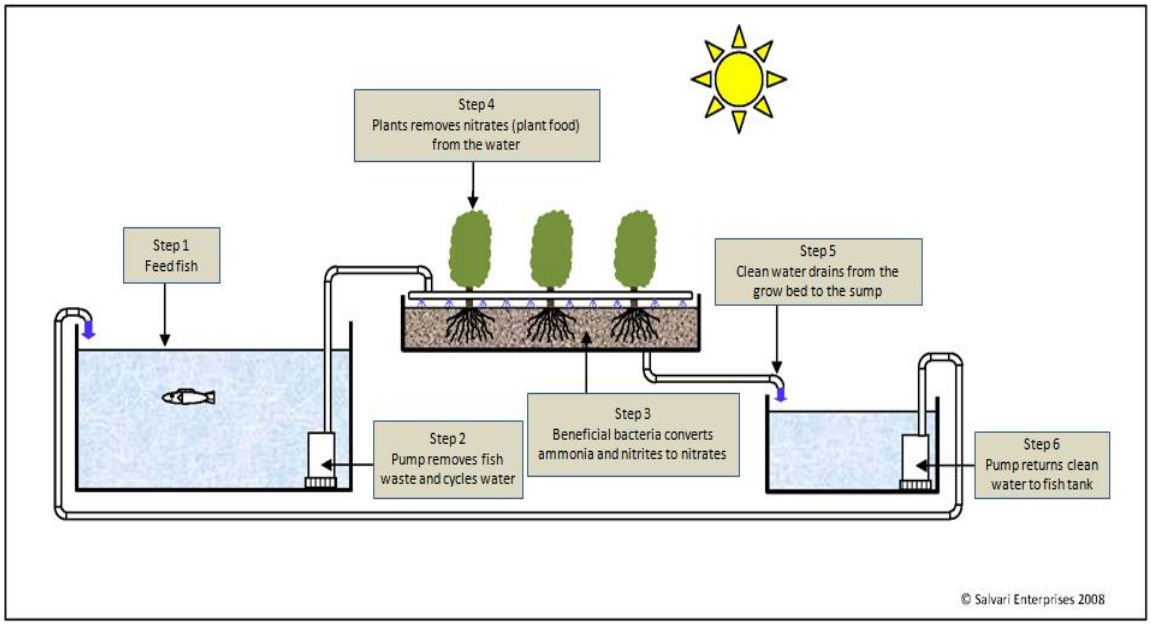
Aquaculture is a powerful livelihood tool for large section of population, and expanding as an industry which has increased the land use competition between agricultural crop production and fish farming. Moreover, land gets shrinking, reckless population growth, manmade environmental pollution and impact of climate change creates new challenges to the country's agriculture sector that has emphasized on integrate crop and fish farming like aquaponics (Salam et al., 2014). Aquaponics is a system of cultivating plants and aquatic animals symbiotically in a balanced recirculatory environment. The symbiotic relationship is that the fish provides nitrogenous waste, which serves as a nutrient or fertiliser for the plants, and the plants remove the nitrogenous compounds from the water thereby returning the clean water for the fish. On the other words it is a food production system that combines intensive aquaculture (Raising of aquatic animals mainly fishes in a tank) with hydroponics (Raising of plants without soil beds). The fish farming aspect of aquaponics is based on the eco-friendly, indoor recirculatory aquaculture system that allows for careful control of the culture environment year round (FAO, 2012). Now-a-days, Aquaponics is gaining increased attention as a bio-integrated food production system which follows the concept of "grow your own organic food." Recent advances by researchers and growers have turned aquaponics into a working model of sustainable food production.

Advantages of aquaponics system

- Significant reduction in the uses of water
- No need to use artificial fertilizer
- Provide an artificial filtration system of fish culture environment
- Does not require farmland with fertile soil
- Naturally organic
- Tourist attractors in rural communities
- Reduced damage from pests and disease
- No weeding
- Plants grow faster
- Sustainable
- Cleaner form of gardening
- Easy to setup

Principles of aquaponics

In aquaponics, nutrient-rich water from fish tanks is used as liquid fertilizer to fertilise hydroponic production beds. These nutrients in the water produced from fish manure, algae, and decomposing fish feed which otherwise increases the toxic levels in the fish tanks affecting the fish growth. The hydroponic beds function as a biofilter stripping off ammonia, nitrates, nitrites, and phosphorus so the freshly cleansed water can then be recirculated back into the fish tanks. The nitrifying bacteria living in the gravel and in association with the plant roots play a critical role in nutrient cycling, without these microorganisms the whole system would stop functioning. These nitrifying bacteria convert ammonia to nitrate, a form of nitrogen utilised by the plants. Thus when the water returns to the fish tanks, nitrogen level are tolerable for the fish. Unlike that of traditional farming, in aquaponics system there is a constant flow of water and constant supply of nutrients to the plants occurs.



Design and type of aquaponics

There are three main types of aquaponics:

- Media bed method (particulate bed)
- Nutrient film technique (NFT) method
- Deep water culture method (DWC) or raft method or floating system.

Media bed method

It is the most common type of aquaponics system in which plants are grown in the media where water (Nutrient riched) from the fish tank is supplied to the planted media bed and the plants absorbs the water and take nutrients as it flows through plant roots. Then the clean water returns to the fish tank.

Media beds can be made from plastic, fibreglass or a wooden frame with water-tight rubber or polyethylene sheeting on the base. The standard shape of media bed is rectangular or circular and commonly used medium in the media bed includes volcanic gravel (tuff), limestone ($CaCO_3$), clay aggregate, river-bed gravel etc. The medium used in the media bed must be inert, not dusty, and non-toxic and it most have a neutral pH so as not to affect the water quality. In media bed units,

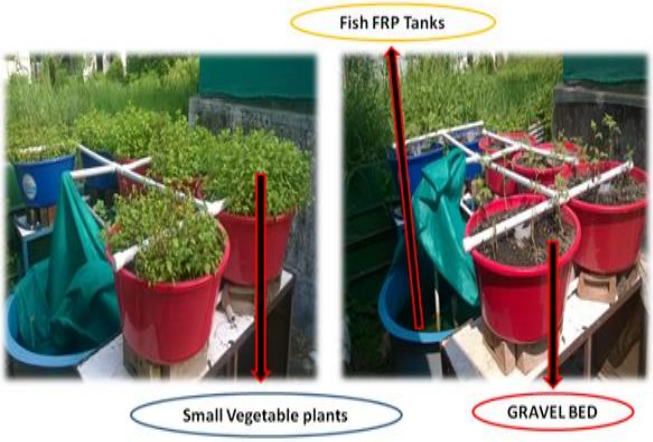


Fig 1. Media bed Technique using Gravels as a medium

the medium is used to support the roots of the plants and functions as a efficient filters (both mechanical and biological) and help in the mineralisation *i.e.* solid and suspended fish waste and all other debris are slowly broken down by biological and physical processes into simple nutrients in the form of simple molecules and ions that the plants can easily absorbs (Fig 1). Media-filled bed units are the most popular design for small-scale aquaponics system.

Nutrient film technique (NFT) method

It is an aquaponics system using horizontal pipes or long narrow channels each with a shallow stream of nutrient-rich aquaponic water flowing through it. Here small holes are made in the top of the pipes where plastic glass/ cups are placed and plants are grown in glasses allowing their roots to access the water and absorb the nutrients. In this way a thin film of water continuously flows to the channel which provides nutrients and oxygen to the plants and clean water returns to the tank.

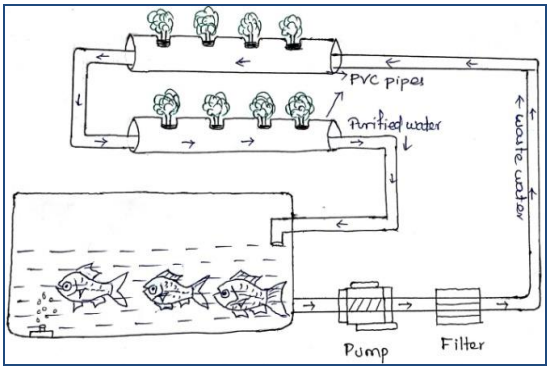


Fig 2. Nutrient film technique

It is a popular method for commercial operations as is financially more viable than media bed units. In this technique, the bio-filter becomes crucial as there is no large surface area where bacteria communities can develop so it requires additional mechanical filters as described. Generally NFT is suitable for green leafy vegetables.

Deep water culture method (DWC)

In this system the plants are grown on Polystyrene boards (rafts) that float on top of water. Holes are made into boards and net pots are fitted. Plants are either grown directly into the bed, or transplanted from other growing area. The plant roots are always immersed into the water under the boards where they get nutrients and clean the water of the fish tank (Fig: 3).

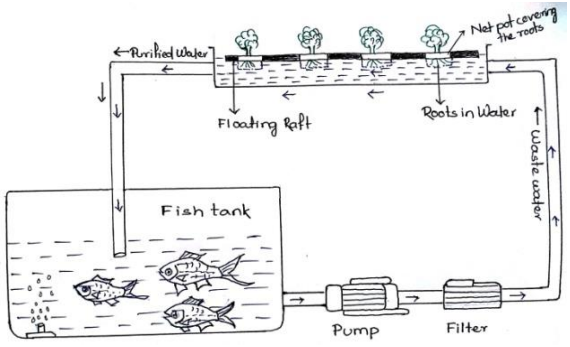


Fig 3. Deep water aquaponics

Besides the above some other forms of aquaponics systems are as follows:

Vertical aquaponics system

In this type of system, vegetable grows without soil in columns above fish tank. A small pump draws nutrient rich water from fish tank to the top of the vertical columns. The water trickles down through the roots of the plants, gathering oxygen from the air as it backs into the tank. It is a water efficient and space saving way to garden and raise fish (Fig 4.).

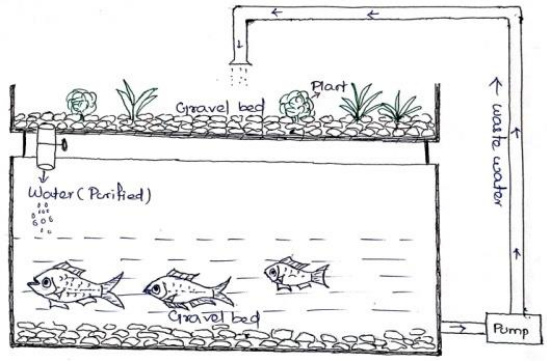


Fig 4. Vertical aquaponics system

Wicking bed system aquaponics

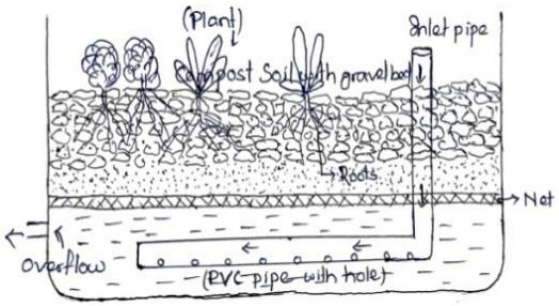


Fig 5. Wicking bed system

In this system, the water from the fish tank is fed once a week in summer through slotted pipe that allows the water to flow down and slowly wick its way up by capillary action and feed the plant roots from the bottom up (Fig 5.).

Site selection for setting aquaponics system

- Selected sites should be on a stable and levelled surface should be protected from severe weather but exposed to substantial sunlight.
- It is recommended that the system may be protected from extreme environmental conditions like strong winds, heavy rainfall etc. Strong prevailing winds can damage the stems and reproductive parts of plants. In addition, large amounts of rain can dilute the nutrient-rich water, and can flood a system if no overflow mechanism is integrated into the unit.
- As sun light is essential for the growth of the plants, the systems should be designed in such a way that plants get sunlight throughout the day. Generally, the grow beds should be spatially arranged so that the longest side is on a north–south axis. This makes the most efficient use of the sun during the day.

Components of an Aquaponics unit

Plants

Selection of plant species suitable to hydroponic culture in aquaponics system depends on the stocking density of fish tanks and the nutrient concentration of aquacultural effluents. However some plants such as lettuce, herbs, and specialty greens (spinach, chives, basil, and watercress) have low to medium nutritional demands and are well adapted to aquaponics systems. Fruit plants such as tomatoes, bell peppers, and cucumber etc have higher nutritional requirements and perform better in a heavily stocked, well established aquaponic system.

Fish Species

Fishes those are hardy and can tolerate wide range of water quality parameters are suitable for aquaponics culture. Several warm-water and cold-water fish species are adapted to recirculating aquaculture systems, including tilapia, trout, perch, Arctic char, and bass. Now-a-days, aquaponics with ornamental fishes have been gaining importance in developing countries of the world. In India, Aquaponics with Tilapia and ornamental species such as koi carp, fancy gold fish, Pacu, Angel fish, Guppies, Tetras, and Swordtails etc have been carried out.

Fish tank

Fish tanks are a crucial component in every unit. Fish require certain conditions in order to survive and therefore the fish tank should be chosen wisely. There are several important aspects to consider, including the shape, material and colour. Although any shape of fish tank will work, round tanks with flat bottoms are recommended. The round shape allows water to circulate uniformly and transports solid wastes towards the centre of the tank by centripetal force. Either strong inert plastic or fibreglass tank is recommended because of their durability and long life span. Metal is not possible because of rust. Plastic and fibreglass are convenient to install (also for plumbing) and are fairly light and manoeuvrable. In general, low-density polyethylene (LDPE) tanks are preferable because of their high resistance and food-grade characteristics. White or other light colour tanks are strongly advised as they allow easier viewing of the fish in order to easily check behaviour and the amount of waste settled at the bottom of the tank. White tanks will also reflect sunlight and keep the water cool. All fish tanks should be covered. The shade covers prevent algal growth. In addition, the covers prevent fish from jumping out of waters, prevent leaves and debris from entering, and prevent predators such as cats and birds from attacking the fish.

Filtration

In aquaponics, mostly biological filters called biofilter is used, but somehow in large scale aquaponics system

mechanical filters are also used. Mechanical filter separates solid and suspended waste from fish tanks (mainly used in NFT and DWC system). It is essential to remove these wastes for the health of the system, because harmful gases are released by anaerobic bacteria if solid waste is left to decompose inside the fish tanks. Moreover, the wastes can clog systems and disrupt water flow, causing anoxic conditions to the plant roots. In bio-filters, the nitrification bacteria grow and convert ammonia into nitrates, which are usable by the plants.

Aerators

Air pumps inject air into the water through air pipes and air stones that lie inside the water tanks, thereby increasing the DO levels in the water. Additional DO is a vital component of NFT and DWC units. Consequently, quality air pumps are an irreplaceable component of aquaponic systems,

Hydroponics subsystem

It is the portion of the system where plants are grown by absorbing excess nutrients from the water. It is consist of either FRP or plastics.

Sump tank

It is the lowest point in the system where water flows to and from which it is pumped back to the rearing tanks.

Plumbing materials

Every system requires a selection of PVC pipe, PVC connections and fittings, hoses and tubes. These provide the channels for water to flow into each component. Bulkhead valves, silicone sealant and Teflon tape are also needed. The PVC components are connected together in a permanent way using PVC cement or by using silicon sealant. In addition, some general tools are needed such as hammers, drills, hand saws, electric saws, measuring tapes, pliers, channel-locking pliers, screwdrivers, levels, etc.

Scope and Potential of Aquaponics

There is a serious concern that how future generation will produce more food sustainably. Increasing use of pesticides as well as chemical fertilisers affects the agricultural lands adversely leading to decrease of soil fertility as well as its water holding capacity. Moreover, water and soil are two important natural resources, the scarcity of which is going to acute in the coming years.

In this context, aquaponics can provide a suitable complementary high culture method both for fish and vegetables. Aquaponics, as an innovative technology, has been appeared in India. Not only, enough vegetables per unit of area can be produced through this technology, but also growth of fish is satisfactory. But its acquaintance and popularity has not been spread all over the country yet as much as it is required in developing country like India. This technology can be applied in both of rural and urban area, even in arid regions to produce available chemical-free and organic products, which can ensure food safety and food security all over the country.

References

Azad, K.N., M.A. Salam and K.N. Azad. 2016. Aquaponics in Bangladesh: current status and future prospects *Journal of Bioscience and Agriculture Research,* **7**(2): 669-677.

Salam, M.A., N. Jahan, S. Hashem, K.M.S. Rana. 2014. Feasibility of tomato production in aquaponic system using different substrates. *Progressive Agriculture*, **25**: 54-62.

Diver, S. 2006. Agriculture aquaponics-integration of hydroponics with aquaculture. Retrieved from https://attra.ncat.org/attra, pub/viewhtml.php?id=56

SOFIA, 2012. The State of World Fisheries and Aquaculture. 2012 (SOFIA), FAO.

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