E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(6): 170-173

www.fisheriesjournal.com
Received: 22-09-2018
Accepted: 23-10-2018

Pawan Kumar Sharma
PhD Research Scholar, Department of Aquaculture, FC & RI, Ponneri, TNJFU, India

Dr. J Stephan Sampath Kumar
Director, Directorate of for Sustainable Aquaculture, TNJFU, Tamil Nadu, India

Dr. S Anand
Assistant Professor & Head i/C, EBCeSA, TNJFU, Tamil Nadu, India

Correspondence
Pawan Kumar Sharma
PhD Research Scholar, Department of Aquaculture, FC & RI, Ponneri, TNJFU, India

Aquaponics: A boon for income generation in water deficient areas of India like Rajasthan

Pawan Kumar Sharma, Dr. J Stephan Sampath Kumar and Dr. S Anand

Abstract
Rajasthan is the largest state of India where both water quality and quantity are variable and the soil quality is also not very favorable in some areas for the fish culture. India being a tropical country with the second largest population in the world, it needs to ensure the nutritious diet for people. As a support for people, the country has started many programs and NMPS (National Mission for Protein Supplements) is one of these. This mission combines Hydroponics and Re-circulatory aquaculture system and in such a way that nutrient requirements for both the system is fulfilled, viz., the nutrient-rich fish waste from aquaculture unit acts as a nutrient media for the plant, at the same time the plants clear the water of obnoxious elements that may be toxic to fishes. Vegetable yield in hydroponic and aquaponic systems can be twice the yield from the conventional horticulture systems. Economics of hydroponic systems has been assessed by several authors and presently is estimated to be a mere 960 Rs/m^2 for a grow bed of 34 m^2 system in Asia. Wherever the production site is far away from the business site the aquaponics is a suitable solution to produce the vegetables and fish simultaneously on site.

Keywords: Aquaponics, hydroponics, re-circulatory aquaculture system, fish, vegetables

1. Introduction
The Indian government under National Mission for Protein Supplements (NMPS) scheme is enhancing the supply of protein rich diet to the people. However, increasing human population has crept into agriculture land for want of residential area, creating large scale problems for agriculture produce, not only in India but also in the entire world. It is thought that over a billion people in the world are currently undernourished (World Food Programme, 2010). In this situation, it is the need of the hour to focus on alternate techniques of farming which can ensure better production in lesser area and lesser time. In this context, aquaponics is one of the best techniques. This technique has been successfully implemented where the water availability is limited and soil quality is not up to mark for agriculture. Further, this techniques is useful for both rural as well as urban areas because in this technique there is no need of the soil and extra land. It is convenient to implement this system in indoor as well as outdoor terraces.

Moreover, the management of aquaponics is simple and easy, as both the systems, hydroponics and re-circulatory aquaculture balance each other. Thus, the water quality is maintained by the hydroponic system and nutritional requirements are fulfilled by the excretory material released by the fishes. It is a revolutionary technique for growing plants, where the aquaculture effluent is deliberately diverted through plant beds in a sustainable closed system. It is illustrated in a survey report led by Love *et al.*, [1] that aquaponics has been getting growing concern since 2010, which reinforces its increasing impact for society as an innovative response for food security.

Rajasthan is the largest state of India where water quality and quantity both are variable and the soil quality is also not much favorable in some areas for the fish culture. The soil is sandy in the western part of state hence cannot be used for fish farming. Therefore, in such areas aquaponics can be adopted as an innovative practice for fish farming and enhancing productivity of the region in the form of fish protein.

2. Aquaponic systems
An aquaponic system combines the two different systems
1. Re-circulating aquaculture system
2. Hydroponics system

2.1 Recirculating aquaculture system

It is very important component of aquaponics as it ensures continuous water supply in the culture system and also maintains the quality of water by mechanical and bio-filtration processes. This Recirculating Aquaculture System (RAS) minimizes the use of water and it is approximately 10% compared to intensive pond aquaculture system.

2.1.1 Important steps in water treatment in RAS system-

- Removal of solid waste like uneaten fish feed, fish residues or other large size materials through mechanical filtration.
- Nitrification – in this step toxic ammonia is converted into nontoxic nitrate with the help of aerobic bacteria. Two different types of bacteria are involved in this process.
- Nitrosomonas – it converts ammonia into nitrite.
- Nitrobactor - it converts nitrite into nitrate; which is non-toxic and essential for planktonic growth.
- De-nitrification: excess amount of nitrate is converted into nitrogen by the anaerobic bacteria and released in to the atmosphere.

2.2 Hydroponic system

There are three main types of hydroponic plant growing systems that are suitable as the plant growing component in aquaponic systems (Resh, 2013) [2]. These three main techniques used for hydroponics system are briefly explained below:

2.2.1 Nutrient film technique (NFT)

In this system we use a pipe in which the holes are drilled on the upper side and a continuous water flow is provided with good amounts of nutrients. Simultaneously, we ensure the proper aeration in the flowing water so that the nutrients will be absorbed in good amount by the plants.

2.2.2 Floating raft method

In this system we use a grow tank of polystyrene rafts with a 20 to 30 cm depth. This tank is filled by the nutrient rich water and aeration is ensured by the aerators for better nutrient uptake by the plants.

2.2.3 Media based systems

In this system for growing the plants some media are used like gravel, clay balls, small stones, vermiculite etc. These beds may be "trickle fed" nutrient solution, or subject to periodic flooding and draining ("ebb and flow") to maximize exposure to both air and nutrients. This media acts as mechanical filter or biofilter or both.

Nutrients are typically supplied from three stock tanks using an automated dosing system to maintain nutrients at optimal concentrations for the plants. Nutrients can be managed within closed or open (flow-through) systems. Flow-through systems make the management of nutrients easier but raise concerns over water use and pollution. (Tesi R., 2002) [3].

3. Working of Aquaponics system

It combines hydroponics and re-circulatory aquaculture system both and this is suitable for both as the nutrients requirements is fulfilled by the disposing of nutrient-rich fish waste from aquaculture unit thus there is no need for nutrient media. This fish waste provides an all-natural nutrient solution for plant growth and this nutrient-rich effluent is used to irrigate a connected hydroponic bed while fertilizing its plant crops at the same time. The filtration of water is done by the hydroponic unit as the plants absorb the nutrients and filter the water through the sand filter so this media based hydroponic system serves as an aerobic biofilter that is generally used in RAS, converting ammonia to nitrate. The ammonia is converted by denitrifying bacteria in the hydroponic grow bed into forms readily up taken by plants for energy and growth. Essentially, the hydroponic bed and its crops serve as a bio-filter for the fish waste water before it is cleaned and returned back into the fish tank. Thus, the anaerobic (de-nitrification) filter used in RAS is largely replaced with a hydroponic plant production system. Out of total nitrogen input used into the system as feed, up to 30% may be captured as fish flesh, and 40% or more may captured as plant biomass. The balance is lost as nitrogen gas or as solids, which may be used as fertilizer in a garden (Fox, *et al*., 2013) [4]. Higher levels of nutrient capture may be possible with additional separate biofiltration. Furthermore, the complex mix of nitrifying bacteria, rhizobacteria, fungi, and micro plankton in the recirculated water appears to benefit the plants due to both positive interactions at root level, and the higher resilience of the system against some plant pathogens (Savidov, 2005) [5].

To utilize the nutrients more in amount from the waste water effluent of aquaculture unit, the aquaponic unit should be dominated by the hydroponics system. To improve the water flow and minimize the dead areas it is better to have circular tanks for fish rearing. In such a system Nile Tilapia (*Oreochromis niloticus*) can be stocked at up to 60-70 kg/m^3 stocked at up to 60-70 kg/m^3.

4. Components of aquaponics

- Fish tank
- Settling tank or clarifier
- Physical filter (which may also serve as an anaerobic, denitrifying filter)
- Aerobic bio-filter
- Degassing unit
- Grow-beds or tanks
- Blower/aerator/diffuser Pump

5. Suitable fish and plant speciesForAquaponics System

5.1 Plant species

Generally, leafy vegetables and herb like lettuce are preferable for culture in an aquaponic system. Fruits, due to their long production cycle the fruits are not suitable for this culture technique. The recommended plants species are –

- Lettuce
- Basil
- Coriander
- Spring onion
- Fruit vegetables such as tomato, cucumber
- Beets
- Okra
- Blueberries, etc.

5.2 Fish species

- ***Oreochromis niloticus*** **(Nile Tilapia)**

It is the most preferable fish for tropical and sub tropical areas because this fish can survive in high stocking densities, lower oxygen level (0.2 ppm), high ammonia or nitrogen concentration (>90 ppm @ pH 6.0), it can tolerate low pH level (< 5.0) and it can easily breed in tanks.

***Clarias gariepinus* (Cat fish)**
It can also tolerate the low oxygen, high density and high nutrient concentration.

***Cyprinus carpio* (common carp)**
It can tolerate the low temperature and high stocking density.

- Other common desirable fishes are
- Asian Barramundi (*Lates calcarifer)*
- Mullet (Mugil cephalus)
- Perch (Perca flavescens)
- Largemouth bass (Micropterus salmoides)
- Bester sturgeon (Thunnus alalunga)
- Grass carp (Ctenopharyngodon idella)
- Ornamental fishes.

6. Potential of Aquaponics *Production* System*(Fish and Vegetable)*

The vegetables are produced around double in hydroponic and aquaponic systems as compared to more conventional horticulture system. The stocking densities for Tilapia are suggested typically in the range of 20-40 kg/m^3 (Aid-approach-aquaponics-Pacific-report-2013). Yields of cucumber may be 7kg/m^2/crop. In an efficiently run tropical or sub-tropical system we might therefore anticipate 20-40 kg of leafy vegetable production per m^2 per year. (McMurty *et al*.) [8]. Based on substantial experience Resh (2004) [6]suggests typical production rates of lettuce at 2.3kg/m^2 per crop, which might translate to 23kg/m^2/year for locations where year round production is possible. The annual production may reach double the levels, if fish is harvested and restocked on a quarterly basis. For tropical/sub-tropical systems, the yield range may be 30-70kg/m^3/yr. The total production from fish and vegetable has been reported to vary between 3 to 160 kg/m^2/yr, but with the majority of values between 30 and 80 kg/m^2/yr. Aquaponics is an innovative, sustainable food production system integrating aquaculture with hydroponic vegetal crops (Graber & Junge-Berberovic, 2009) [9].

7. Investment requirements

It depends upon the size of culture unit, but the researchers developed a "model" commercial system, with grow bed area of 1,142m^2, with a cost of roughly 11400 Rs/m^2. Economics of hydroponic systems has been assessed by several authors and presently is estimated to be a mere 960 Rs/m2 for a grow bed of 34 m2 system in Asia. This illustrates possibility for a small scale enterprise.

8. Opportunities for development

There is a great opportunity to develop aquaponics for areas with less availability of water and poor quality soil like Rajasthan. This technique will be useful for the low level farmers and entrepreneur's also as it uses a small space and provide two crops in one time. Due to cooperative management by hydroponics and recirculatory aquaculture systems it minimize the maintenance cost as well as input costs, viz., fertilizer and pesticides. Further, we can use this technique in these respects.

8.1 Small or medium scale Retailors

The small scale entrepreneurs can prepare a unit at their shop site it will be beneficial for their business.

- Can increase the price for their organic and fresh products
- Can provide fresh vegetables and fresh fish to the costumers as they can see live their product growing in culture units.
- It can be implanted in urban and rural areas so can be used by the restaurant and resort owners.
- Basically in the water deficit areas it will be great opportunity for the small scale producers and entrepreneurs.
- It will be attractive for the buyers so it will also work as a business promotional activity.

8.2 Household production

It may be useful for the households for daily use purpose and sometimes for the hobbyist. They may start a small aquaponics unit in their garden or in backyard of the house in water deficit areas. The main constraint may be here energy cost but it may be substituted by using a solar panels. If properly managed an aquaponic system can generate a good income for small households.

8.3 Education and social development in small institutions.

The government of Rajasthan can make it the part of education. They can make a unit of aquaponics in the school and colleges and can make this mandatory for the students. This project will also contribute to the NMPS mission as it will provide a nutritious protein diet. The technology should be disseminated through KVKs and all training centers under skill development programmes. If the students, farmers and entrepreneurs learn from these units and utilize this technology at their level than the food security problem of the nation will be minimized. This technique is also useful for the prison wardens to motivate and educate the prisoners. Similarly, it is also useful for the military and police training schools.

9. Promotional activities

As this system combines two different systems viz., hydroponics and re-circulatory aquaculture system, for the proper set up and proper education of framers, government should recommend the horticulturist and aquaculturist both at every KVKs to organize training and demonstration of these units. The farmers' entrepreneurs and students may be trained there and during training, practical part should be given more emphasis than theory.

10. Conclusion

Aquaponics is a very much useful technology wherever, water is deficit and soil quality is poor with the strong demand for leafy vegetables and modest quantities of fish at a relatively high price. When the production site is far away from the business site then aquaponics is a suitable solution to produce the vegetables and fish simultaneously on site. If the vegetables and fish supply is seasonal in any market aquaponics could sustain continuous supply. Solar power can be used to reduce the power costs. As it is a skilled venture so before starting this unit proper knowledge of the unit operation is essential.

11. Acknowledgment

I acknowledge all the publications, journals and researchers which I have used their valuable research findings for the preparation of this paper. I am highly grateful for the Maharaj Kumar Shri Lakshay Raj Singh Mevad (LRSM, Udaipur, Rajasthan) to encouraging me for my research work and

publications. I am also thankful for Professor J Stephan Sampath Kumar (Director of DCeSA, Thanjavur, TNJFU, Tamil Nadu), Dr. L. L. Sharma (Retired Dean COF, MPUAT Udaipur, Rajasthan) and Dr. B. Ahilan (Dean i/c FC & RI Ponneri TNJFU, Tamil Nadu) for their guidance. This paper is a contribution of knowledge in aquaponics and it will be helpful to generate new dimensions for the entrepreneurs and unemployed.

12. References

1. Love DC, Fry JP, Genello L, Hill ES, Adam Frederick KSJ, Ximin Li. An International Survey of Aquaponics Practitioners, PLoS One. 2014; 9:e102662.
2. Fox B *et al*. Toward Lower-Cost, More Reliable, Pacific-Friendly Aquaponics Systems. Presentation to the Expert Consultation: Aquaponics for the Pacific Islands Region: Review of Opportunities and Constraints Secretariat of the Pacific Community Aquaculture. September 23rd-27th, 2013, Rarotonga, Cook Islands, 2013.
3. Tesi R. Colture Fuori Suolo in Orticoltura e Frutticultura. 112 p. Edagricole, Bologna, Italy, 2002.
4. Resh HM. Hydroponic Food Production. A definitive guidebook for the advanced home gardener and commercial hydroponic grower. Seventh Edition. CRC Press, 2013.
5. Savidov N. Evaluation and development of aquaponics production and product market capabilities in Alberta. Phase II. Final Report - Project #2004-67905621, 2005.
6. Pantanella E, Cardarelli M, Colla G, Rea E, Marcucci A. Aquaponicsvs Hydroponics: Production and Quality of Lettuce Crop. Acta Hort. 2012; 927:887-893.
7. Resh HM. Hydroponic Food Production. A Definitive Guidebook for the Advanced Home Gardener and the Commercial Hydroponic Grower. Sixth Edition. Newconcept press, Mahwah, NJ, USA, 2004, 567.
8. Graber, Junge-Berberovic. Aquaponic Systems-Nutrient recycling from fish wastewater by vegetable production, elesvier. 2009; 246:147-156.
9. McMurty MR, Sanders DC, Cure JD. Efficiency of Water Use of an Integrated Fish vegetable Co-Culture System Journal of the World Aquaculture Society. 1997; 28:420-428.
10. Aid-approach-aquaponics-Pacific-report-2013. Pdf.