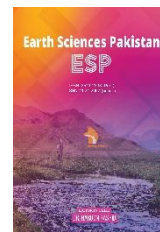


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RESEARCH ARTICLE

SUSTAINABILITY AND DEVELOPMENT OF AQUAPONICS SYSTEM: A REVIEW

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ABSTRACT

The world is facing soil, air and water pollution problems which may arise the soil degraded, global warming, food shortage and droughts. For our future generations we have to develop sustainable environment technologies. Many studies have addressed some scientific aspects and have been limited focus on the commercial implementation based on urban food production industrial-scale production in rural areas small scale farming is developed in different countries for education and decoration inside buildings. We must encourage the sustainable small farming as indoor fish farming which is the farming of the new millennium aquaponic is a structure of closed-loop combine the elements of hydroponics and aquaculture which could contribute the addressing these problems. This system emphasis on improvement through management and integration of the living components and the bio filter system. From trickling bio filters and plant uptake of aquaculture wastewater results in improved water and nutrients use efficiency and conservation. The challenge to sustainability centers on balancing the aquaculture system environment for the optimum growth of these organism's maximum production outputs and minimize effluent discharges to the environment emission and might develop the future application of aquaponic for food security.

KEYWORDS

aquaponics, hydroponics, recirculating aquaculture system (RAS), water scarcity, climate change.

1. INTRODUCTION

The continual development within the world human population natural resources has been decreased and intensification of our current food production system is necessary (Munguia-Fragozo, 2015). Traditional agriculture methods for growing plants require huge land space, time and manpower. Consequently, there's an increasing concern for safe and sustainable food resources which finally ends up within the necessity for the spanking new method. Additionally, order to mitigate the negative environmental impacts, it's also desirable to style new productive models with the capabilities to save lots of energy cost, reduce gas emission, reduce waste disposals and recycle nutrients inside the system (Beddington, 2011).

2. AQUAPONICS

Aquaponics is an integrated multi-tropic system that combines elements of recirculating aquaculture and hydroponics (Goddek, 2015). It's a soil-free activity which will be found in lakes, ponds, and rivers. During this process, we are able to use soil-free plant and water from the tank as fertilizer for the crops in practice. Its role for food security is particularly relevant due to the rapid growth of the world population of over 7.3 billion. It's expected to succeed 9.6 billion near 2050 which includes people living in an urban area (Alexandratos and Bruinsma 2012). Aquaponics will be considered a sustainable agricultural production system regarding the definition, who defines sustainable agriculture as a process that doesn't deplete any non-renewable resources that are

essential to agriculture so as to sustain the agricultural practices (Francis, 2003).

3. PRINCIPAL OF AQUAPONICS

It is the combination of hydroponics and recirculating aquaculture system, traditional hydroponics require minerals and fertilizer in liquid form for their plant growth but in aquaponics, nutrients supplied from the waste of the fish bypassing the biofilter for the growth of plants, other advantages of this system are that excess nutrient does not need to remove through the pipe but utilize in this combined system. The system in between fishes, micro-organism, and plant, encourage sustainable use of water and nutrients including through cycle.

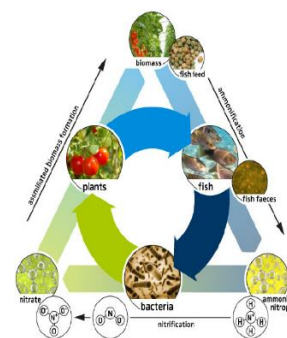


Figure 1: Symbiotic aquaponic cycle

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Within this synergistic contact, the respective ecological weaknesses of aquaculture and hydroponics are converted into strengths. This combination substantially minimizes the need for input of nutrients and output of waste, unlike when running as separate systems (Resh, 2012). Plants need macro and micronutrients, which are essential for their growth. Hydroponics solution well-defined proportion of macro and microelements but in aquaponics plant nutrients input from the fish waste that is solubilized in liquid form in the water and integrated by the plants some nutrients may add to adjust their concentration (Rakocy, 2003). Aquaponics need different micro-organism that is involved in fish processing and solubilization, Ammonia (NH₄⁺) from fish urine and gill extraction can build toxic level if we cannot remove from the system and done by stepwise microbial conversion to nitrate. Ammonia within the system converted to nitrate by nitroso-bacteria, special kind of biofilters require where intensive nitrification occurs is required (Tyson, 2008). The optimal ratio between fish and plants to get the right balance of nutrients and uptake by plants system. Average value range 60 and 100 g day⁻¹ has been recommended for leafy-greens growing for the aquaponics system, additionally, fish micro-organisms and plants are in the same water loop, environmental parameters such as temperature, ph. and mineral concentration needs to be set at a compromise point as well as possible to their respective optimal growth conditions.

4. METHODOLOGY

4.1 System description

As described above, the system can be a connection between a conventional recirculating aquaculture system (RAS) and hydroponics. Water recirculates in a loop as it flows from the fish tank to the filtration unit and pumps into the plant's bed may use as water reprocessing units, which are composed of mechanical filters for removal of solid particles and biofilter for nitrification process.



Figure 2: Basic aquaponics system layout

In the RAS environment, an aquaponic structure is a very important microbial community in the same order of scale as fish because they are directly involved in fish actions and their effect on water quality. The system provides different microfiches for the microbial populations according to a differential gradient of oxygen and nutrients. Every microfiche supports the development of specific microbial populations (Leonard, 2000).

4.2 Technical challenges

The system projects and application be considered as the highly multidisciplinary approach from environmental, machinal, and civil concepts about water and plant ecology, biochemistry, and biotechnology. Arrangement quantity and control expertise require information for computer science and programmed control system. The biggest challenge in profitable aquaponics is its multi-disciplinarily, needing further skill in finances, economics, and advertising. Thus, a high degree of field-specific vision in terms of both applied and in-depth theoretical knowledge is required. This leads to a growing level of difficulty, which directly affects the efficiency issues of the running system. In the interest of the highest effectiveness and efficiency, some numerical trade-offs are recommended and are outlined below. They include pH stabilization, nutrient balance, phosphorus, and pest management.

4.3 pH stabilization

The central in an aquaponics system is the pH stabilization, also for all living organisms within a cycling system that includes fish, plants, and bacteria. Most plants need a pH value between 6 and 6.5 in order to enhance the uptake for nutrients, fish species tilapia is known disease resistant and tolerant to large fluctuation in pH valve with a range between 3.7 and 11. there are three major bacteria for which optimal pH condition areas

- Nitrobacter: 7.5
- Nitrosomonas: 7.0-7.5
- Nitrospira: 8.0-8.3

The degree to which the pH is raised is dependent on the adjustable flow rate (Beveridge and McAndrew 2012). However, this concept needs initial practical measurements with respect to the system's steady pH-drop in order to determine the size of the lime-bed apparatus taking the specific flow-rate into consideration.

4.4 Nutrients Balance

Innovative sustainable food production system, the challenges in aquaponics to use the nutrient efficiency minimizing its discard and tending to a zero-discharge recirculating system, fish feed and nutrients be divided into soluble solid fish excreta (Gelfand, 2003). there is a need to establish the proportion of the macro-micro nutrients that fish can release in the water for the feed in a system, which may depend upon fish species, fish density, temperature, and type of plants (Montanhini and Ostrensky 2015). This estimate of the successive organic addition needed to match optimum plant growth requirements, inorganic mineral input adds extra cost and issues for sustainable management.

Table 1: Comparison of pH & nutrients concentration in aquaponics for different plants species

Plant Species	pH	Ca	Mg	Na	K	Cl	Fe	Ma	Cu	Zn	B	Mo
Lettuce	8	180	44	17	106							
Basil	7.4	12	7		45		2.5	0.8	0.05	0.44	0.19	0.01
Water spinach	5.6-7.3											
Tomato	7.7	34			27		0.2		0.04	0.37		
Okra	7.1	24	6	14	64	12	1.3	0.06	0.03	0.34	0.09	0.01

4.5 Pest and Disease Management

The challenge of pest and disease management another aspect for further improvement, aquaponics has characterized a range of microflora than the hydroponics system because fish and biofiltration occur in the same water loop (Vermeulen and Kamstra 2012). Pesticides that used in hydroponic can't use in aquaponics because of toxicity risk to the fish and desired biofilm, to maintain the biofilm and other nutrients solubilizing micro-organisms also prevent the use of antibiotics and fungicides for fish pathogen control and removal in the aquatic environments (Nichols and Savidov 2011).

Rearing and yield apply that decrease the existence of diseases could be applied such as protective clean actions, low density of fish and/or plants, and/or control of environmental conditions, which decrease relative humidity around the plants (Haissam 2011). In addition to these observes, a few advanced methods of biocontrol previously be for plants cultured under field or greenhouse conditions. These methods are based on the use of microorganisms with biocontrol action or extracts of such microorganisms or extracts of plants (including essential oils) that show high antimicrobial efficiency and short residence time. Its determinations to remain a trial to first-rate and adjust these devices to aquaponics structures, seeing their similarity with the other living creatures of the system.

4.6 Water scarcity

As various countries facing economical and physical water scarcity which may lead to the growth in capability in facing their people. The average world water use for agriculture is about 70% even up to 90%. Associating with conservative farming like aquaponics uses less than 10% of water-dependent on the climate condition. Aquaponics can reduce freshwater depletion with irrigation whilst encourage sustainable farming and food production practices, System-related water losses that occur in evaporation, plant transpiration and the water content of the agricultural products can be compensated for by capturing water from air humidity or by reverse osmosis desalination plant in coastal areas (Greenlee, 2009).

4.7 Mineral Recycling

In the relation of sustainability, both phosphorus and potassium are main mechanisms of farming composts, and like oil, they are non-renewable resources. Therefore, growing the use and exhaustion of these reserves without recycling or recall has a negative impact on and is of implication to their future supply (Sverdrup and Ragnarsdottir 2011). Nutrient recovering strategies, particularly for phosphorus, are vital in order to dodge worldwide food shortages.

4.8 Energy

The requirements of energy for aquaponics are based on the system configuration and geographic location, which based on the different measures are needed in order to ensure each system has sustainable energy resources that provide a stable condition for fish and plants (Zhu and Chen 2002). The requirements constitute a factor in the region with a seasonal change climate control system with additional technology.

5. DISCUSSIONS

All the issues declared overhead require extra care because some making limits still need to be strong-minded and enhanced to prepare aquaponics for commercial use as some components and their interactions are not technically mature yet. This cannot be adequately attained without a superior focus on joining existing information of the different involved fields within a technical and international framework. These features are important, as the commercially associated technology should not be limited by certain external conditions. Instead, the systems to be developed should be totally applicable, which indicates resource-economic (i.e., resource-saving) production systems that can be run in arid, hot, cold, and urban areas or any combination.

6. CONCLUSION

The fact is that aquaponics follows nutrients and water reusing principles, it looks to be a capable solution for sustaining aquaculture and hydroponic practices. However, further research and developments are needed as established by the challenges described. These challenges need to be resolved with the intention to establish fully controlled and standardized aquaponic systems that will be easy to handle and economically viable. The attractiveness of the production method depends on technological developments, local markets, and climatic and geographic conditions that need to be assessed and cannot be generalized. Only addressing those factors methodically will eventually validate aquaponics as a sustainable food production alternative.

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