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Small Scale Aquaponic System

Rashmi Menon, Sahana G.V., Shruthi V and Suganya R

Department of Electrical and Electronics, Amrita Vishwa Vidyapeetham, Coimbatore, INDIA.

Abstract

The most prevailing issues of the modern world are food and water crises. It is neither possible to consume the pesticide affected food nor grow once own plants, due to scarcity of water and land. Under such conditions, there arises a need for portable agricultural system which uses less water, space and is purely organic. One such solution is a small scale aquaponic system. This system is made by introducing an automation and data acquisition system; thereby there is no need for setting aside extra time for system care. This paper has used the data acquired from an existing aquaponic system to design and implement an effective small scale sustainable aquaponic system. This can lead to cost effective, sustainable ways of organic farming independent of the need for comparable land space requirement.

Keywords: Portable agricultural system, aquaponics, automation and data acquisition.

1. Introduction

The following paper contains the methodology to build a small scale aquaponic system suitable for different economic strata of the society especially focusing on the urban population where there is evident space and time constraints. This method contributes to one aspect of sustainable household development. In a small scale Aquaponic system, organic vegetables are cultivated in a limited space by recirculating water from a fish tank, rich in nutrients which are essential for the plant growth. Out of all the available water resources on planet Earth, 2.5% is freshwater resource. In this 2.5%, only 0.3% is the readily available freshwater resource accessible to humans. 70% of this limited amount of freshwater available is used for agriculture. Water scarcity already affects almost every continent and more than 40 percent of the people on our planet. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity and two-thirds of the world’s population would be living under water stressed conditions. In 2030, 47% of world population will be living in areas of high water stress. Most population growth will occur in developing countries, mainly in regions that are already experiencing water stress and in areas with limited access to safe drinking water and adequate sanitation facilities. Most of our food requires 100s of liters of water for production and adequate of per crop area for cultivation. The daily drinking water requirement per person is 2-4 liters, but it takes 2000 to 5000 liters of water to produce one person's daily food. In such a situation, a method like aquaponics which is the combination of hydroponics and aquaculture, can contribute effectively to the problem by lowering the amount of water usage for cultivation by 80% and also 75% of the area requirement.

2. Traditional Methodology of Aquaponics

Aquaponics is one method of sustainable food production system in which aquaculture and hydroponics complement each other to make growing of different crops viable. With the two-in-one process, the effluents that fish leaves in the water filter make the latter grow. Aquatic effluents refer to the remains or natural waste matters of the fish raise in a fish tank. These effluents make the tank water develop toxicity which could be harmful to the fish therein, but these are nutrients vital to the growth of the plants in the aquaponic system. Hence, the system calls for a component that would remove the effluents and pump out the water into the grow bed for plants. Thus one of the major advantage of aquaponics is use of less water and spaces; producing less water waste and pollutants when compared to conventional method and using semi-skilled and local labour (if necessary) thus contributing to a sustainable livelihood. The fish waste provides 10 essential nutrients needed for plant growth out of the 13 nutrients. The fish waste decomposes to ammonia which is oxidized by nitrifying bacteria to give Nitrites which is further oxidized by nitrogen fixing bacteria to give Nitrates which can be absorbed by plants.

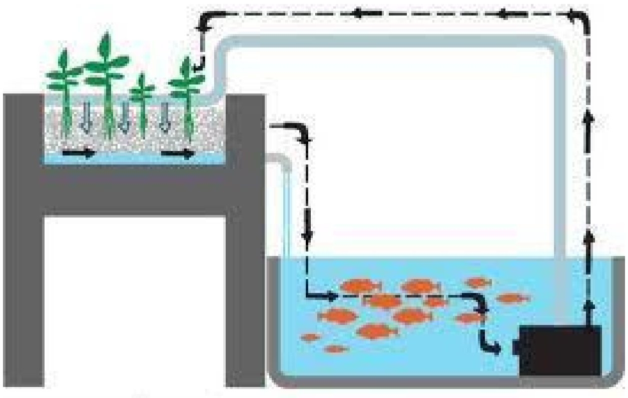

Figure 1: A traditional aquaponic system.

3. Proposed Design of the System

A basic system was designed with the materials locally availed. This system which is very simple can be economically affordable by a middle class family.

3.1 Components Used

Table 1.Components required and their specifications.

S. No	Components Required	
	Component	**Specification**
1	Aquarium	55l capacity
2	Grow bed	110l capacity
3	Motor	Boyo 2500(any locally available motor)
4	PVC Tube	0.5 inches, 3 inches
5	Pipes	0.5 inches(length as per requirement)
6	Air pump, sponge filter	For 55l capacity

3.2 Design of Grow Bed

A 110 liters plastic box was used as the grow bed. Two PVC tubes of size 2-3 inches radius was used. One tube was used as a repair tube for the siphon, thus cut at equal height of the grow bed. A hole was made at the corner of the grow bed so as to fit a half- inch pipe which goes to the fish tank. The siphon is mounted on top of this tube so as to regulate the water level within the grow bed. The repair tube is placed on this siphon. The other tube is used as a nutrition tube.

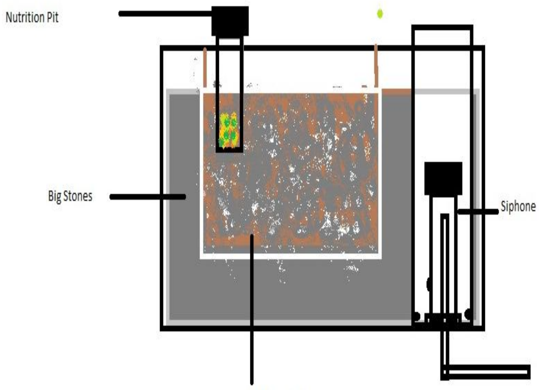

Figure 3: Design of Grow Bed.

The basic steps of implementation of the grow bed is as follows:

1. The first step is to fix the siphon on to the grow bed. For this as mentioned before, a half inch hole was drilled on to the corner of the grow bed and a half inch pipe was fixed on to it. The Siphon was designed according to specifications given below:
    a) Size of the outer repair tube: Radius=5cm and Height=35cm (5 cm more than the bed size)
    b) Size of siphon with cap: Radius=2cm and Height=15cm
    c) Siphon tube(inner): Radius=1cm and Height=12.5cm

2. The next step is to make sure the water reaches adequate level in the grow bed and also to mark the minimum water level in the grow bed which is very important in the fixing the nutrition tube level. For this water was poured into the grow bed fixed with siphon and the levels are noted. A reservoir is kept beneath the grow bed so as to ensure no water wastage during the test.
3. After the water test, the repair tube was placed above the siphon and the grow bed base was filled with large sized stones until the minimum water level noted was reached.
4. The nutrition tube was fixed on to the corner at the minimum water level and the rest of the tank was filled with medium sized pebbles.
5. A 55 liter fish tank was placed beneath the grow bed.
6. An air pump for the aeration of the tank and a sponge filter for filtering the water from the grow bed was provided. This sponge filter also helps with the fixation of nitrogen fixing bacteria. The materials were procured from the local market so as to find the cheapest and the most economic sources.
7. The fish should be according to the ratio of 1 fish to 10 liters of water. Thus 5 Tilapia fishes for the tank of 55 liters of capacity were added.

3.3 The species of plants and fishes introduced into the system:

Aloe vera (Aloe *vera*), Cluster Beans (Cyamopsis *tetragonoloba)*, Chilly(Capsicum *frutescens*),Ginger(Zingiber *officinale)*, Onion(Allium *cepa*) in an area of 0.27meter square.

Fish used: Tilapia (Oreochromis *niloticus*)

Neem oil and tobacco mixed with water are the organic pesticides used in the system.

The above mentioned system is the basic model of an aquaponics system which requires frequent pumping of water. This system is most suitable for common household where there is a person to supervise all day.

The system can be further modified with a help of Arduino microcontroller board for switching ON and OFF the motor using time delay mode. This system can also be made more self-sustaining using solar power to harness the power required.

Arduino is suggested for this purpose of automation because it provides a user-friendly interface and program can be learnt by any lay man. Moreover,solar power panels can be easily fixed by the farmers above the system as required.

4. Observations

Table 2: Observations made.

Parameters	**Comparison Through Observation**	
	Small Scale Aquaponic system	**Normal Cultivation**
Space	13 plants (5 different species) were grown in an area of 0.27 sq. meter	13 plants need at least 4meter square plot for complete growth.
Water	55 liters	100 liters/day

The following inferences were made from the observation table:

1. In an aquaponic system, the space requirement is less.Also,since the ground resistance of the media filled bed is less, allowing the roots to grow straight easily, there is no requirement for the plant to develop a wide root system.
2. The recirculation of water makes the water requirement for cultivation less and water compensations weekly have to be made for evaporation losses only.

5. Conclusion

Small scale aquaponic system is certainly the best solution for growing organic vegetables at homes in crowded cities as the space and water requirement for this system is less. It is an eco-friendly technology which can be improvised and made energy efficient at an individual’s convenience and pattern of usage.

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