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Study of Automated and Controlled Aquaponics System: An Innovative & Integrated Way of Farming

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ABSTRACT

At the moment, an attempt has been made to adapt, adapt and automate the Aquaponics System technology for the benefit of farmers and to tackle key issues such as food safety and water scarcity. Aquaponics is a combination of aquaculture, which is growing fish and other aquatic animals, and hydroponics which is growing plants without soil. Aquaponics uses these two in a symbiotic combination in which plants are fed the aquatic animal's discharge or waste. In return, the vegetables clean the water that goes back to the fish. Along with the fish and their waste, microbes play an important role to the nutrition of the plants. These beneficial bacteria gather in the spaces between the roots of the plant and converts the fish waste and the solids into substances the plants can use to grow. Aquaponics considered a sustainable production system. It presents a series of beneficial features for the environment such as land conservation, efficient use of water and nutrients, organic fertilization, produce the highest yield on a field, no floor is required, environmental benefits etc. This study describes the overall design and working, list of the component required, cost involved in the setup, maintenance, and operation, advantages and disadvantages of the system. A automatic prototype has also proposed to created a to test the system sustainability.

KEYWORDS: *Aquaponics, organic fertilization, environment, Automatic etc*

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I. INRODUCTION

It wasn't long ago that we either grew our own food or knew the farmer who grew it. However, in recent decades, small local farms have been virtually wiped out by an industrial and corporate controlled food system which has destroyed our natural resources, depleted our soils, sprayed toxic chemicals and has genetically modified our food in an effort to "feed the masses". A tremendous amount of packaging, processing, energy and carbon emissions goes into distributing food to consumers. Conventional food distribution systems emit 5 to 17 times more CO2 than local and regional food production. If that wasn't enough, commercial agriculture is the largest consumer of water worldwide.

AQUAPONICS CAN BE THE SOLUTION

An aquaporin farm creates and generate

1. Significantly less water consumption than soil-based agriculture.
2. **No harmful pesticides and fertilizers**. This is a natural eco-system.
3. Compost for soil replenishment.
4. Fodder for animals and livestock.
5. Sustainable farm raised fish.
6. A green business contributing to the well-being of people and planet.
7. Local jobs, education, volunteer and therapeutic opportunities.

II. TYPES OF AQUAPONICS SYSTEM

Essentially, there are 3 main types of aquaponics system design

1. Media-filled bed
2. Deep water culture (or raft)
3. Nutrient film technique.

Media-filled bed can be considered to be the most common and simplest aquaponics design. This is typically the design adopted by most backyard aquaponics gardeners. In this design, plants are grown directly in a media-filled grow bed. The growth media used can be expanded clay or gravel. Water rich in nutrients (ammonia-rich waste and nitrates) are pumped from the fish tank to the media-filled grow bed.

Figure 1: Media-filled bed

The media-filled bed aquaponics setup can be further subdivided into 2 configurations – continuous flow system and the flood and drain system (also known as ebb and flow system), based on the way the water is being re-circulated.

Deep water culture or raft is predominately used for commercial system as it is relatively inexpensive to set up and a wide variety of leafy vegetables and herbs can be grown. Holes are drilled on floating boards or foam rafts for the pots. The plants are then grown in these pots with their roots immersed in the water.

Figure 2: Deep water culture

The raft can be simply floated directly on top of the fish tank. The more common approach, however, is to rear the fish in a separate tank, pump the nutrient-rich water through a filter and into long channels where rafts filled with plants are floated on the water surface to absorb the nutrients. Unfiltered water contains fish solids that may adhere to the plants roots, hence affecting their ability to absorb water and oxygen.

Nutrient film technique *(also known as NFT aquaponics)* is the least commonly practiced aquaponics system design. However, it is widely practiced for hydroponics.

Nutrient-rich water from the fish tank is pumped down small enclosed channels.

Figure 3: Nutrient film technique

In most NFT aquaponics setup, holes are being drilled along the length of medium-sized PVC pipes. Alternatively, second-hand gutters can be used. The amount of water trickling through the base of the channels is so small that it only forms a very thin film.

ADVANTAGES
- Reduced labour
- Aquaponics uses 90% less water than traditional farming
- DO NOT require farm land and soil
- Fish feed is the only nutrient inputs
- Aquaculture waste products are used
- Aquaponics protects our rivers & lakes
- Health & Nutrition value high
- Higher production rate
- Provides income from two separate products

DISADVANTAGES
- High initial cost
- To fill up water tanks
- To build the system (Greenhouse, pumps)
- Difficult to grow root crops
- Requires skill and experience
- Constant monitoring of water parameters
- Pests and diseases can be devastating
- Limitations concerned with fish species reared

III. DESCRIPTION OF HARDWARE

Aquaponics uses the best of all the growing techniques, namely Hydroponics, Aquaculture, and traditional agriculture; utilizing the waste of one element to benefit another mimicking a natural ecosystem. In Aquaponics, the fish waste along with a significant volume of water it resides in, does not need to be removed daily as it does in an Aquaculture system. Costly plant food does not need to be added as it would with a hydroponic system. Also, there is no need to flush out the grow beds periodically to replace it with water that is fresh and clean. Aquaponics thus becomes a system of growing fish, produce, and other plants types in a sustainable closed-loop system.

The Aquaponics System Cycle:
1. First the fish in the aquaponics tank are fed with fish food supplied by the grower.
2. Fish secrete waste and ammonia that can be detrimental to the fish in sufficient quantities.
3. The fish breathe in oxygen but exhale carbon. The water is contaminated with fish waste and carbon. The fish tank water is cycled into the plant grow bed media.
4. The grow bed media is a perfect environment to billions of bacterial microbes that convert the ammonia initially to Nitrite, and then to Nitrate.
5. *The plant roots absorb the nutrient-rich Nitrate and the carbon helping to clean the water while elevating the health of the plant.*
6. The purified water is poured back into the fish tank while oxygenating it at the same time.

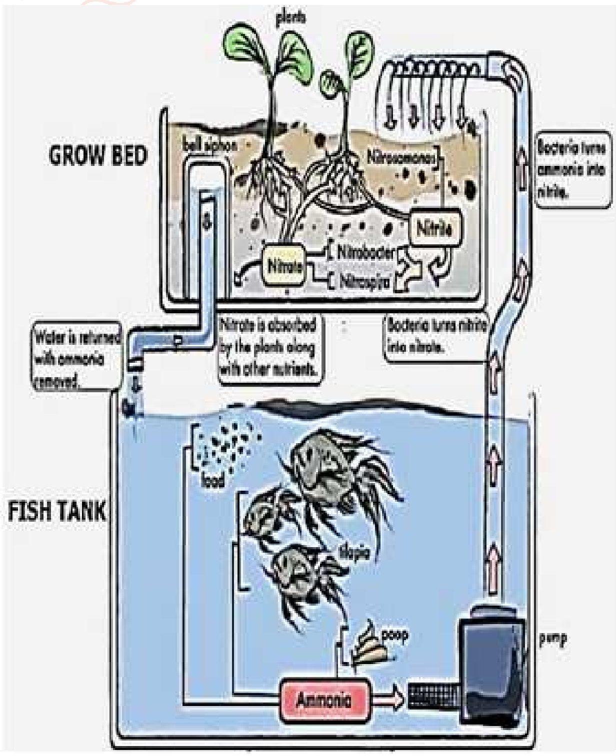

Figure 4: Cycle of Aquaponics System

IV. LAYOUTS OF PROPOSED MODEL

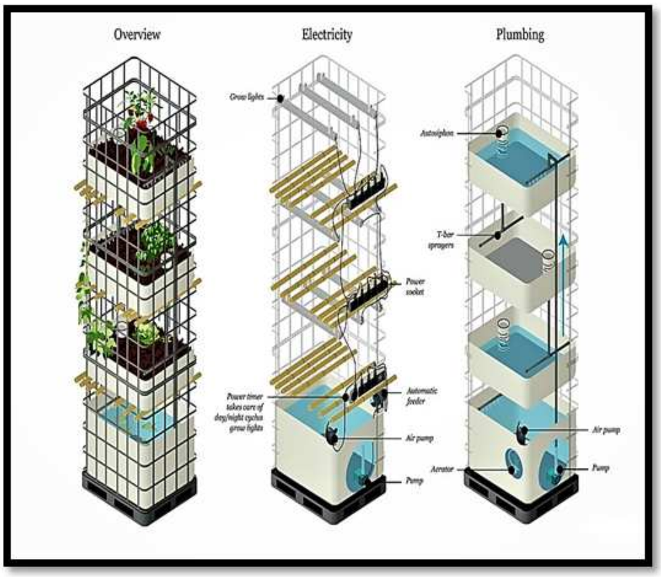

Figure 5: Design & Construction layouts of the proposed System.

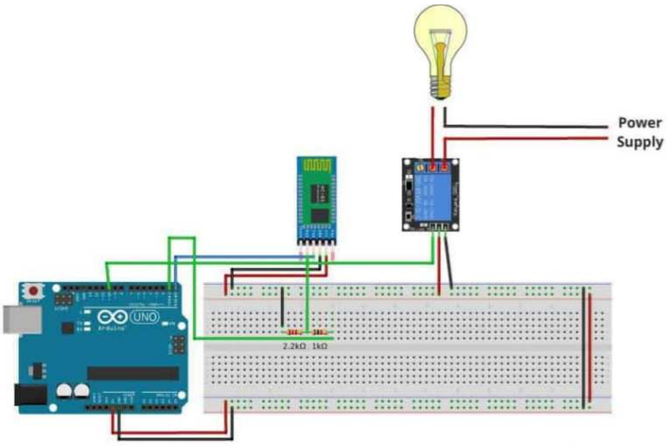

Figure 6: Hard ware circuit connection diagram of the proposed System

Figure 7: Hardware implementations of the proposed System.

Cost of operation and maintenance:

Subject	Remarks	Estimated costs
Fish fingerlings	Once every new batch of fish is to be reared.5 to 8 months.	500/-
Plant seeds	Once for every new harvest for 2 to 4 months for leafy vegetables.	300/-
Fish feed	As per the daily requirement. 10 kg will last for a batch of ten fish over the full growing period.	500/- for 10 kgs
Water quality check	Once every week such as pH and turbidity.	Negligible
Electricity	According to the amount of time grow light is used and wattage of water pump	1000/- per month
Miscellaneous maintenances and depreciation.	Unforeseen repair and aging of components	5% per annum

V. COMPONENT REQUREMENT FOR AUTOMATIC AND CONTROLLED SYSTEM

The components of the aquaporin system may vary in size or style but each system requires a fish tank, a grow bed or beds, plumbing, plants, and fish. To illustrate this, a prototype model prepared that is controlled and automated by a Bluetooth controlled switch.

Component	Quantity
Grow beds	3
Fish tanks	2
Sump tank	1
P.V.C pipes (different diameter)	10 meters
Elbows, tees, & valves	10,10,&3
Aerator pump	1
Water pump	1
Grow lights	9
Bio filter media	3 kgs
Mechanical filter	1
Arduino Uno board	1
HC-06 bluetooth module	1
Wires	10 meters
8 port relay switch	1
Miscellaneous (nails, bolts, etc)	*As per req.*

SPECIFICATIONS OF COMPONENTS OF PROPOSED MODEL:

Foot space acquired by the System: 48 sq. feet (8"x6")

Height of the system: 10 feet

Number of grow beds: 3

Number of fish tanks: 2

Amount of grow space: 144 sq. feet (triple the foot space acquired)

Grow bed: 60x40x32.5cms

Fish tank: 60x40x32.5cms

P.V.C. PIPES & FITTINGS diameter/s: 1'' and 1.5''

Stand: 8x6x10 feet (5 racks)

Water Pump: .5 HP

Grow lights: 4.9 watts (x9)

Control Switches: Arduino based Bluetooth switch

VI. CONCLUSION

By combining aquaculture and hydroponic systems aquaponics built whereby nutrient rich waste water from the aquaculture system is utilized into the hydroponic system.

Aquaponics system has many untapped potentials, this way of farming can really help the community in a big way. It can be the solution for the serious problems like water scarcity, food security, and its purity. It uses minimal resources and gives a better yield, both in terms of quality and quantity. It has no ill effects on environments and if used on a larger scale could help in tackling the problems of water pollution and soil degradation due to the conventional use of chemical fertilizers and pesticides. In this era in which land is a rare commodity it could be a valuable step towards getting higher yields from land in terms of nutrition.

In aquaponics, wastewater from aquaculture is filtered and is recirculated into the system. An aquaponics shows an opportunity to rethink the conventional fish farming, to bring in more money farm

VII. FUTURE SCOPE

Simplicity in design and management with essentially no ene rgy and low cost of equipment makes these systems an inter esting solution wherever land availability, flooding, producti vity but also ecological footprint are a major issue. In addition the employ of water weeds as a resource can certainly increase livelihoods opportunities in all those areas affected worldwide. Further research needs to address the nutrient dynamics of different growing media and to optimize system design and nutritional requirement of vegetables in those water bodies with limited dissolved nutrients. The possibilities of this integrated system are quite strong and can give both smallholders and big aquaculture companies' responsive benefits. Moreover, the potential of these frameworks is not fully understood and interdisciplinary interconnections and study will definitely resolve many of the still unidentified issues.

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