D.Y. PATIL COLLEGE OF ENGINEERING & TECHNOLOGY,

KASABA BAWADA, KOLHAPUR

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(2020-21)

A

Report on

Domain Specific Mini Project

"Fully Automated Aquaponic System"

Submitted by:

Roll No.	Name
51	Mr. Aradhya Shailesh Powar
52	Miss. Pallavi Padmakar Patil
53	Mr. Shailesh Sanjay Dhumma
54	Mr. Atharva Sachin Deshpande
55	Miss. Preeti Avinash Jadhav

Under the guidance of

Ms. P.S.Ramtekkar

Class: TY(CSE) **Div: C** **Batch: T3**

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING,

KOLHAPUR

D Y PATIL
COLLEGE OF
ENGINEERING & TECHNOLOGY
(AN AUTONOMOUS INSTITUTE)
KASABA BAWADA, KOLHAPUR

CERTIFICATE

This is to certify that the following members have satisfactorily completed the Domain Specific Mini project work entitled **"Fully Automated Aquaponic System"** at TE (CSE) semester-VI as prescribed in the syllabus of Shivaji University for the academic year 2020-21.

Name	**Exam seat no.**
1. Mr. Aradhya Shailesh Powar	
2. Miss. Pallavi Padmakar Patil	
3. Mr. Shailesh Sanjay Dhumma	
4. Mr. Atharva Sachin Deshpande	
5. Miss. Preeti Avinash Jadhav	

Date:

Place: Kolhapur

Ms. P.S.Ramtekkar
(Project Guide)

Prof. Dr. G. A. Patil
(HOD)

Mrs. Aashna Rukhsaar
(Project coordinator)

Prof. Dr. S. D. Chede
(Principal)

External Examiner

ACKNOWLEDGEMENT

This Mini project work entitled “Fully Automated Aquaponic System” was a formidable task, but the collective effort of our group and active guidance made it possible for us to complete.

First of all, we would like to thank **Prof. Dr. G. A. Patil** (H.O.D., Department of computer science and engineering) for delineating us with this Mini project work.

We would also like to thank Mini project coordinator **Mrs. Aashna Rukhsaar** for the support and interest that he has shown in bringing out this project and for their guidance and cooperation, We would also like to express our most humble and deepest gratitude to our Mini Project Guide **Ms.P.S.Ramtekkar**, for providing us with the right guidance at the time of need it was for his presence and active guidance that we were able to complete the project work.

We would like to thank all our friends for their help, ideas, criticisms, and also their encouragement in the preparation of this project work. Any further ideas and constructive criticisms of our work shall be highly welcomed.

Date:

Place: Kolhapur

Name of Student	Sign
1. Mr. Aradhya Shailesh Powar	
2. Miss. Pallavi Padmakar Patil	
3. Mr. Shailesh Sanjay Dhumma	
4. Mr. Atharva Sachin Deshpande	
5. Miss. Preeti Avinash Jadhav	

INDEX

Abstract

Traditional agriculture has come under scrutiny due to its adverse effects on the environment – depletion of natural resources, like water and soil, and various health hazards due to the use of synthetic chemical inputs. So we have come up with this topic.

Aquaponics is a method of growing plants without soil, which combines hydroponics with aquaculture. In Addition to growing plants in water, it also introduces fish into the system

Aquaponics is the incorporation of two well-established food production techniques, aquaculture, and hydroponics, into one system. As a result of the continuous cycle of water throughout the system, a nitrification process exists wherein the bacteria from the fish waste present in the recirculating water convert ammonia into nitrate, therefore turning it into an essential element needed for the plants' growth.

The aquaponics set-up hence allows a healthy symbiotic relationship among the three living groups present, the fish, plants, and bacteria. All in all, the nutrient effluent water from the fish waste is pumped out of the fish tank into a series of filtration beds, leaving the nutrient-rich water to flow, by gravity, through a series of containers and grow beds where the plants are being cultivated and are then circulated back through the sump tank into the fish tank. Fish, plants, and bacteria are the three primary populations to be considered in aquaponics pH management. Since the water is recirculating, its pH has a major impact on all aspects of the system.

For plants, the pH is the factor responsible for their access to micro-and macronutrients. It means that at a pH range of 6.0–6.5, these nutrients are freely obtainable, but outside of this range, the nutrients become almost impossible for the plants to access. A pH level of 7.5 can lead to iron, phosphorus, and manganese deficiencies, which greatly affect the growth of plants.

To maintain the factors which are essential for aquaponics, we are designing a system that will be automated in such a way that there is minimum interference and attention from humans.

1. INTRODUCTION

Aquaponics combines two of the most productive systems in their respective fields. Recirculating aquaculture systems and hydroponics have experienced a widespread expansion in the world not only for their higher yields but also for their better use of land and water, simpler methods of pollution control, improved management of productive factors, their higher quality of products, and greater food safety

1.1 Description

Aquaponics is the integration of recirculating aquaculture and hydroponics in one production system. In an aquaponic unit, water from the fish tank cycles through filters, plant grow beds, and then back to the fish (Figure 1). In the filters, the fish wastes are removed from the water, first using a mechanical filter that removes the solid waste and then through a biofilter that processes the dissolved wastes. The biofilter provides a location for bacteria to convert ammonia, which is toxic for fish, into nitrate, a more accessible nutrient for plants. This process is called nitrification.

As the water (containing nitrate and other nutrients) travels through plant grow beds the plants uptake these nutrients, and finally, the water returns to the fish tank purified. This process allows the fish, plants, and bacteria to thrive symbiotically and to work together to create a healthy growing environment for each other, provided that the system is properly balanced.

In aquaponics, the aquaculture effluent is diverted through plant beds and not released into the environment, while at the same time the nutrients for the plants are supplied from a sustainable, cost-effective, and non-chemical source. This integration removes some of the unsustainable factors of running aquaculture and hydroponic systems independently. Beyond the benefits derived from this integration, aquaponics has shown that its plant and fish productions are comparable with hydroponics and recirculating aquaculture systems. Aquaponics can be more productive and economically feasible in certain situations, especially where land and water are limited.

However, aquaponics is complicated and requires substantial start-up costs. The increased production must compensate for the higher investment costs needed to integrate the two systems. Before committing to a large or expensive system, a full business plan considering economic, environmental, social, and logistical aspects should be conducted.

Although the production of fish and vegetables is the most visible output of aquaponic units, it is essential to understand that aquaponics is the management of a complete ecosystem that includes three major groups of organisms: fish, plants, and bacteria.

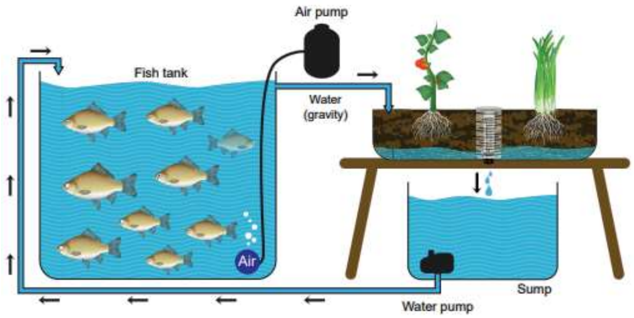


Fig. 1 Simple aquaponics unit.

1.2 Methodology:

The traditional farming technique requires the use of fertilizers and pesticides as it is done on open land. By using the aquaponics method we will be able to give time to the soil to replenish its nutrients, make farming more economical, and most importantly make agriculture automatic. This system which we are building is a small-scale system that will be sufficient for household applications. The system will have a website from which it could be monitored. The system consists of multiple types of sensors that help to detect the factors affecting aquaponics. The system will be smart enough to detect overflow and automatically stop the pumps to avoid further loss of water and continue when the overflow is under control.

As this system consists of aquaculture as well, the feeding process will be also automated.

2. LITERATURE REVIEW

1. **Y. Wei, W. Li, D. An, D. Li, Y. Jiao and Q. Wei, "Equipment and Intelligent Control System in Aquaponics: A Review," in IEEE Access, vol. 7, pp. 169306-169326, 2019, DOI: 10.1109/ACCESS.2019.2953491.**

   Abstract: Traditional planting and aquaculture have the problem of large consumption of water resources and land resources, and water environmental pollution is also a difficult problem facing human beings. Population growth and food safety issues have promoted the concept of aquaponics--a recycling ecological planting and breeding mode. It combines hydroponics and recirculating aquaculture technology to realize water resources and nutrient recycling, low pollution, and high productivity and efficiency. In this paper, hydroponics as the main vegetable cultivation method in aquaponics and the main equipment of water treatment in recirculating aquaculture are introduced, and the traditional equipment and its development prospects are analyzed. The greenhouse environments, water quality, and nutrient circulation involved in intelligent monitoring and control of aquaponic systems are systematically analyzed and summarized. This paper summarizes the current development of technology and methods in aquaponics and provides prospects for future development trends. With the development of technology, in the future, the aquaponics system will become more intelligent, intensive, accurate, and efficient.

   URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8901112&isnumber=8600701

2. **Rakocy, James E., Michael P. Masser and Thomas M. Losordo. "Recirculating Aquaculture Tank Production Systems: Aquaponics — Integrating Fish and Plant Culture." (2006).**

   Abstract: Aquaponic systems are recirculating aquaculture systems that incorporate the production of plants without soil. Recirculating systems are designed to raise large quantities of fish in relatively small volumes of water by treating the water to remove toxic waste products and then reusing it. In the process of reusing the water many times, non-toxic nutrients and organic matter accumulate. These metabolic by-products need not be wasted if they are channeled into secondary crops that have economic value or in some way benefit the primary fish production system. Systems that grow additional crops by utilizing by-products from the production of the primary species are referred to as integrated systems. If the secondary crops are aquatic or terrestrial plants grown in conjunction with fish, this integrated system is referred to as an aquaponic system Plants grow rapidly with dissolved nutrients that are excreted directly by fish or generated from the microbial breakdown of fish wastes. In closed recirculating systems with very little daily water exchange (less than 2 percent), dissolved nutrients accumulate in concentrations similar to those in hydroponic nutrient solutions. Dissolved nitrogen, in particular, can occur at very high levels in recirculating systems. Fish excrete waste nitrogen, in the form of ammonia, directly into the water through their gills. Bacteria convert ammonia to nitrite and then to nitrate.

3. **Somerville, C., Cohen, M., Pantanella, E., Stankus, A. & Lovatelli, A. 2014. Small-scale aquaponic food production. Integrated fish and plant farming. FAO Fisheries and Aquaculture Technical Paper No. 589. Rome, FAO. 262 pp.**

Abstract: This technical paper begins by introducing the concept of aquaponics, including a brief history of its development and its place within the larger category of soil-less culture and modern agriculture. It discusses the main theoretical concepts of aquaponics, including the nitrogen cycle and the nitrification process, the role of bacteria, and the concept of balancing an aquaponic unit. It then moves on to cover important considerations of water quality parameters, water testing, and water sourcing for aquaponics, as well as methods and theories of unit design, including the three main methods of aquaponic systems: media beds, nutrient film technique, and deep water culture. The publication discusses in detail the three groups of living organisms (bacteria, plants, and fish) that make up the aquaponic ecosystem. It also presents management strategies and troubleshooting practices, as well as related topics, specifically highlighting local and sustainable sources of aquaponic inputs. The publication also includes nine appendixes that present other key topics: ideal conditions for common plants grown in aquaponics; chemical and biological controls of common pests and diseases including a compatible planting guide; common fish diseases and related symptoms, causes, and remedies; tools to calculate the ammonia produced and biofiltration media required for a certain fish stocking density and amount of fish feed added; production of homemade fish feed; guidelines and considerations for establishing aquaponic units; a cost-benefit analysis of a small-scale, media bed aquaponic unit; a comprehensive guide to building small-scale versions of each of the three aquaponic methods; and a summary of this publication designed as a supplemental handout for outreach, extension, and education.

URL: https://www.fao.org/3/i4021e/i4021e.pdf

3. PROBLEM STATEMENT

Most of us are familiar with words and concepts such as Climate Change, Carbon Emissions, Air Pollution and Water Scarcity, but very few have focused attention on Soil. For millennia, life on earth has been sustained by a thin layer of fertile soil on the earth's crust. Soil is a non-renewable natural resource. For the formation of 1 cm soil, it takes up to 1000 years. It is a natural process that takes time. But in the last few years, we are abusing soil in such a way that we won’t take much time to ruin the soil.

Rich soil is an important element in nature that helps to hold water, even if the rainy season lasts for 3 months the soil holds the rainwater for the rest of the year and also helps keep the river flowing. The soil plays an important role in the ecosystem. The soil contains n number of micro-organisms that help in completing the food chains.

Scientists have predicted that we have only 60 to 80 good harvests left before we run out of nutritious topsoil. That means we have 40 to 50 years of food left in the world. 52% of agricultural soil is already degraded. In 20 years, 40% less food is expected to be produced for 9.3 billion people. Poor soil leads to poor nutritional value. Today's fruits and vegetables already contain 90% fewer nutrients. 2 billion people suffer from nutritional deficiencies leading to a multitude of diseases. Once food shortages come our entire civilization will collapse. But if act on this right now, in the next 10-15 years we can turn this around significantly.

Population growth, and food and water scarcity could cause over 1 billion to migrate to other regions and countries by 2050. Land issues have played a significant role in over 90% of major wars and conflicts in Africa since 1990. From the French Revolution to the Arab Spring, high food prices have been cited as a factor behind mass protest movements.

Thousands of farmers are committing suicide due to depletion in soil. 74% of the poor are directly affected by land degradation globally. It is estimated that soil extinction is costing the world up to US$ 10.6 trillion every year.

Scientists say that around 27000 species of life forms are becoming extinct every year due to loss of habitat. The crisis has reached a point where 80% of the insect biomass has gone. Loss of biodiversity further disrupts the soil habitat and prevents soil regeneration.

4. OBJECTIVES

We know that we cannot solve the problem entirely but we are sure that this is a small and important step toward solving the problem. We will be building a small model for aquaponics for household use and can be scaled for large-scale farming. The system will be automated in such a way that it does not require much human attention.

In the system our main objectives would be:

- Building a small-scale model for Aquaponics.
- Grow some leafy vegetables and fish.
- Automated feeding.
- Monitor the growth of plants/vegetables.
- Monitor the temperature and humidity.
- Maintaining water temperature levels.
- Monitor PH level of water.
- Water Parameter Correction.
- Design a server for keeping track of everything.
- Develop a web application to monitor and track the system.
- Alert user if some kind of attention is required.

4.1 Objectives Completed in semester 6

- Purchased the required hardware components required to build the system.
- Assembled the hardware for growing beds.
- Build a green shade for the system.
- Pipes attached to the grow beds.
- Leaks fixed.
- Biofilter setup completed.
- Attached motor for solid waste removal and water flow.
- Water cooling block assembled.
- Added bacteria to start the nitrogen cycle.
- Seeds planted in cocopeat.
- Found the right amount of ph level and iron level in the water
- Found adequate temperature for water.
- Added air pump to maintain oxygen level.
- Reduce the flow of the water pump to reduce the chances of an overflow.

- Study of fish suitable in the region.
- Attaching motor to the cooling block.
- Attaching sensors.
- Wiring for sensors.

4.2 Objective to be completed in the next semesters

- Adding fish and plants to the system
- Setting up the server using a low spec. machine.
- Setup the Django Rest API
- Software module for reading data from sensors using Arduino.
- Setup raspberry pi to accept data from Arduino using serial communication.
- Software module to capture images from raspberry pi.
- Setup raspberry pi to send images and data to the server using Rest API.
- Store data to the server using Rest API.
- Displaying data fetched from sensors.
- Create a ReactJS Application for displaying data.
- Fetching data from the server using Rest API.
- GUI for displaying data.

5. PROPOSED WORK

5.1 System Requirements

- Linux/Windows
- Minimum 2GB of RAM
- Processor: Core2duo or further
- Raspberry Pi 3b+
- Raspberry Pi Camera
- Router
- Jumper Cables
- PH Sensor
- Air Pump
- SMPS
- Arduino for controlling and monitoring
- Network with a public IP accessible
- Water Pump 40w
- Solenoid valve
- Cooling block
- Relays
- Thermoelectric Peltier
- Temperature sensors
- Waterlevel detection sensors
- DHT11 Sensor

5.2 System architecture diagram

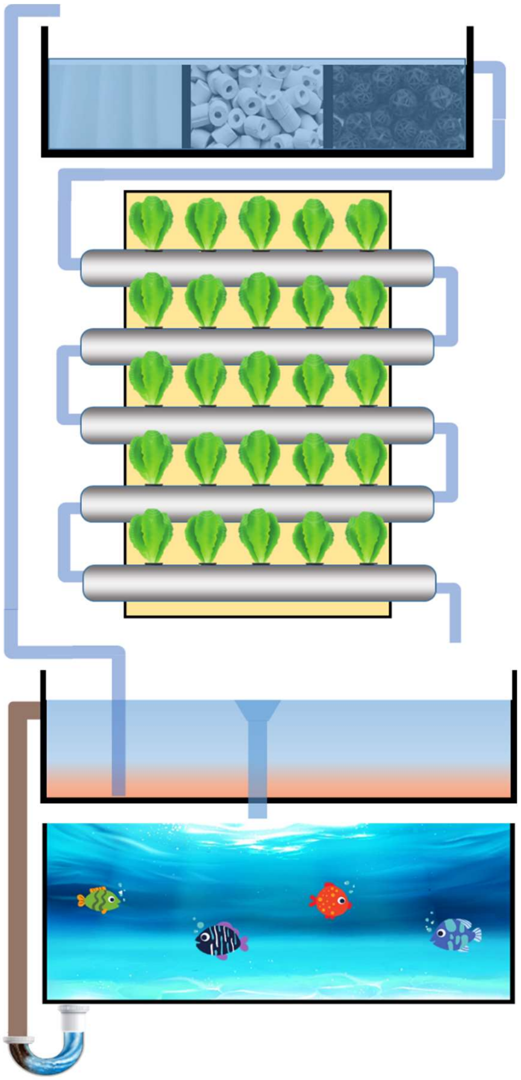


Fig. Proposed Design for System **Fig. Proposed System**

5.3 MODULE DETAILS

Requirement gathering: Collect all required information about the aquaponics and local weather conditions.

Estimation of Project: Estimate the cost and time required for the project.

Building a small-scale model for Aquaponics: Purchase all the required hardware to build the system. Build the system and optimize the system.

Grow some leafy vegetables and fish: Adding yields to the system.

Automated feeding: Build a feeder for feeding fishes.

Monitoring the water parameters: Monitor the temperature, humidity, and growth of plants/vegetables.

Water Parameter Correction: Maintain water level, ph level, temperature, etc.

Design a server for keeping track of everything.

Develop a web application to monitor and track the system.

Alert the user if some kind of attention is required.

6. Results & Conclusion

6.1 Results

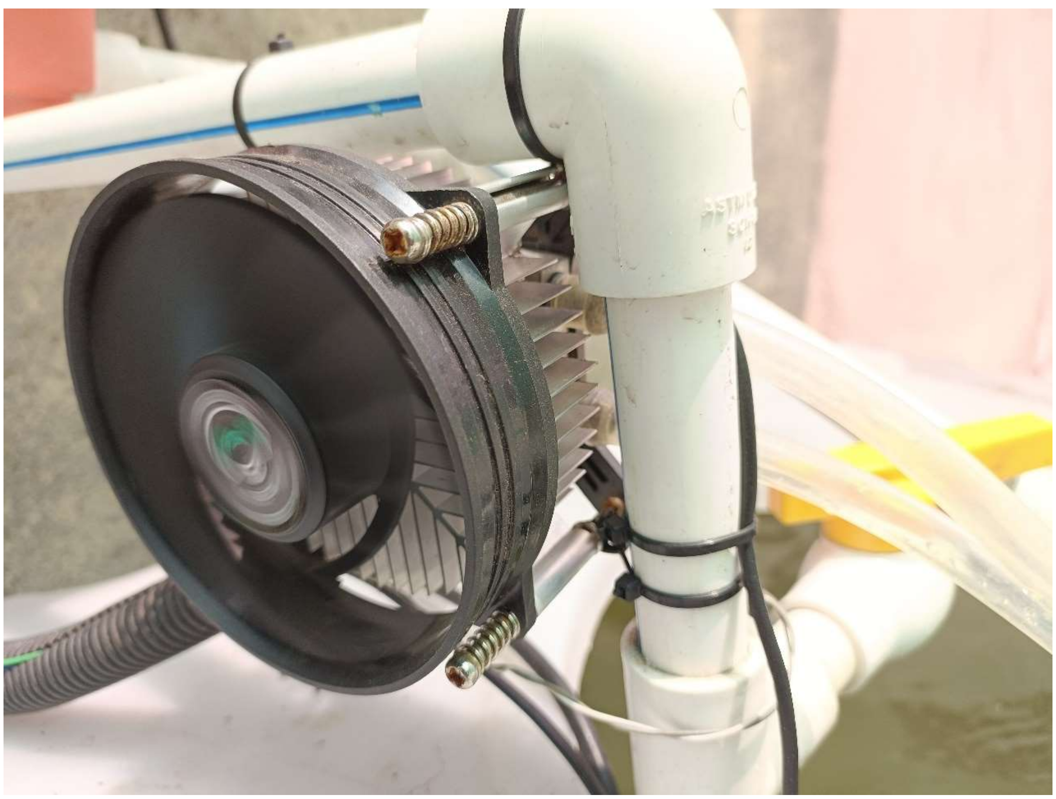
Till date, we have completed about 50-60% of the work which is most of the hardware part and cost around Rs. 18000. According to our cost estimate, it was estimated about Rs.20000.

And according to our time estimate, the project should be completed in December 2022.

Here are a few images of work completed to the date:

Pic.: Photo of actual implementation of the system

Pic.: Flow control mechanism, Cooling block, and pH sensor



Pic.: Cooling System for water

6.2 Future Scope

The project can be scaled into larger sizes for industrial-level agriculture. By December 2022 the project is expected to be complete.

6.3 Conclusion

The project aims to develop an IoT web application and server for an Arduino and Raspberry pi controlled aquaponics system to answer the demand for developing innovative, resource-effective, and urban-suitable solutions for aquaculture and farming.

Building a small-scale model for Aquaponics, Growing some leafy vegetables and fish, monitoring the growth of plants/vegetables, monitoring the temperature and humidity, maintaining water temperature levels, Monitor PH level of water, designing a server for keeping track of everything, developing a web application to monitor and track the system, alerting the user if some kind of attention is required could be done to automate the system.

The system will be able to produce more yield and will be more economically beneficial as well. And as the system requires no soil it would help to replenish the soil.

7. REFERENCES

7.1 Research Papers:

- Y. Wei, W. Li, D. An, D. Li, Y. Jiao and Q. Wei, "Equipment and Intelligent Control System in Aquaponics: A Review," in IEEE Access, vol. 7, pp. 169306-169326, 2019, DOI: 10.1109/ACCESS.2019.2953491.
- Rakocy, James E., Michael P. Masser and Thomas M. Losordo. “Recirculating Aquaculture Tank Production Systems: Aquaponics — Integrating Fish and Plant Culture.” (2006).
- Somerville, C., Cohen, M., Pantanella, E., Stankus, A. & Lovatelli, A. 2014. Small-scale aquaponic food production. Integrated fish and plant farming. FAO Fisheries and Aquaculture Technical Paper No. 589. Rome, FAO. 262 pp.

7.2 Websites:

- https://extension.okstate.edu/fact-sheets/recirculating-aquaculture-tank-production-systems-aquaponics-integrating-fish-and-plant-culture.html
- https://www.trees.com/gardening-and-landscaping/hydroponics-vs-aquaponics