**ISBN - 978-989-9121-08-9**
**43rd PATTAYA International Conference on "Advances in Science, Engineering & Information Technology" (PASEIT-22)**
*Pattaya (Thailand) Aug. 25-26, 2022*

# Smart and Portable Aquaponics System

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***Abstract*:** *The word Aquaponics can be split into two words, aquaculture and hydroponics. Aquaponics includes growing plants in Coco peats instead of soil. Aquaculture involves fish cultivation by providing the necessary support system for a good yield. Aquaponics is a closed loop system and an ideal organic design. The system sustains by itself and doesn't involve the use of harmful chemicals like pesticide, fungicide or insecticide. In this paper we put in efforts to develop a smart Aquaponics system capable of self-monitoring and reflex. The system employs sensors to measure the pH, temperature and water level which are the essential inputs to the IoT prototype that we have built. A Wi-Fi module is used to transmit the sensed data in real time triggering essential reflex at various instances. Data received from the sensors are uploaded to blynk cloud, an IoT cloud platform that uses real-time information to analyse and visualize data. The need for mobility of the system was recognized and the system made portable and robust using minimum electronic units and minimum power requirement*

***Keywords:*** *aquaponics, hydroponics, IOT, blynk cloud, Matlab, python*

## 1. Introduction

Aquaponics is a self-sustained agricultural technique combined with fish cultivation. It's the best example of a self-sustained closed loop system practised around the world. Aquaponics is the future of food production and fish cultivation. Fish waste or excreta mainly ammonia is converted to plant nutrients by bacteria. This eliminates the need for chemical nutrients which may be harmful to the plant, soil or the consumer. The concept of closed loop is brought about by intelligent electronic units and is automated. In this assignment we have analysed six types of data, which are the main parameters to differentiate between traditional Aquaponics (existing system) and Smart Aquaponics (proposed system).

- Cost comparison.
- Average height of the plant / size of the yield.
- Water consumption.
- Water quality for both fishes and plants.
- pH value and temperature analysis.
- Use of chemical fertilizers, pesticides and insecticides.

## 2. Related Study

The research on aquaphonics sytem is very interseting and recently many papers have been published on aquaphonics which explains about methods used in each approach. The autors in the papaer [1] Survey on Aqua Robotics Urban Farm System,discuss varius automated smart aquaphonics systems used in recent years. M Harish, K S Aishwarya, S Prathibhashree and K Panimozhi [16] proposed a project which based on aquaponics system using IoT technology. The system had automatic fish feeding and automatic water supply to the plants. They used a GSM module to monitor the aquaponics system.

N.S Salahuddin Wanda Vernandhes, Sri Poernomo Sari and A. Kowanda [2] proposed a project based on the IoT technology which in turn help the plants to grow using aquaponics technique. They insist that system lights, changes in temperature and humidity are well suited for an indoor aquaponics system. They also used smartphones to access sensed data with the help of an internet connection, and they also stated that aquaponics is better than traditional farming.

Shuhaizar Daud, Zahari Awang Ahmad, Sazali Mahmud, Phak Len Eh Kan, and Muhamad Asmi Romli [3] proposed a project that works with the help of the fog server to control and regulate water in aquaponics grow bed. Because of the fog server, they were able to collect real-time data and only selected data sent to the cloud, and fog server will have remaining data.

Jasson Gryzagoridis and Fareed Ismail [4] proposed a project based on aquaponics with solar power. They have used photovoltaic for photoelectric and thermal energy generation to maintain the environment that supports the aquaponics system.

U Leatherbury Megumi [5] proposed a project based on VEGILAB plant, an indoor system that uses led lights for growing vegetables and aquaponics. And her project can be installed at industries as well as at home.

S.N. Namratha and M.N. Mamatha [6] proposed a project which depends on elements like temperature, light and fish water for the plants and fish growth. All the necessary nutrients are given to the fishes so that plants grow by absorbing them. Their first technique is to automate fish feeder and to use a filter system to remove waste products for purification. They also used IoT components like the Arduino board and actuators to receive and react to information respectively.

ArmandShahbazian, Shiny Abraham, Kevin Dao, Phillip Thompson and Han Tran[7] stated that aquaponics is a combination of hydroponics and aquaculture. The bond between bacteria, plants, and fishes creates a monitoring water quality technique. They worked with the latest technologies of internet of things, real-time systems and graphical user interface for indications. They used Thingspeak, a cloud platform for visualizing and analyzing data.

Rolf Meinecke and Ralf Biernatzki [8] proposed a project based on a closed greenhouse that focused on the thermal energy system. Their main goal was to maintain energy balance. To do this, they developed a prototype aqua system at the coal mine to use mine water to heat aqua system.

NS M Fadhil, M S A Megat, Z H Noor, Ali M F Saaid [9] proposed a project that depends on elements like temperature, light and fish water for the plants and fish growth. All the necessary nutrients are given to the fishes so that plants will grow by absorbing them. Their first technique is to automate fish feeding and to use a filter system to remove waste products for purification. They also used IoT components like the Arduino board and actuators to receive and react to information respectively.

Analene Montesines Nagayo, Rodrigo S. Jamisola, Cesar Mendoza, Raad K. S. Al Izki and Eugene Vega [10] proposed an aquaponics project based on solar power. Their the primary purpose was to achieve four main goals 1.supply of water from the aquarium to water beds, 2. to control and monitor the aqua system with the help of sensors, 3.to make use of solar power and 4. to watch environmental air that helps to grow fishes and plants.

## 3. Protable smart aqauphonics system design

The main objective was to develop a self-sustainable, closed loop, automated and portable aquaponics system capable of real-time temperature, pH and water level sensing.The system through threshold values initiates necessary reflexes as follows:

- Pumping in water to the fish tank (from external source or from the plants).
- Pumping water to the plants.

- Feeding the fish frequently.
- Temperature regulation.

The data/ information regarding the system obtained through the sensor and stored in the cloud is continuously analysed to obtain conclusions and to compare with the yield of the traditional system.

## 4. System requirements for an ideal smart aquaphonics system

The functional requirements of the protable aquaphonics sytem were designed to be

- A sophisticated feedback control system to pump the water to and fro within the closed loop.
- Efficient sensing unit consuming less power and accurate as per industrial standards.
- Reliable connectivity between the sensing unit and the cloud.
- An effective algorithm or system to compare the yield of traditional and proposed system.
- Fine calibration to keep up with the standards.
- Placing experimental threshold for apt real-time reflexes.

And the non-functional requirements of the protable aquaphonics sytem were considered as listed below.Non-functional requirements play the behavior performance of the system at its critical stages.

- Extra amount of water to cope up with the evaporative losses from the plant due to transpiration.
- Suitable number of I/O ports to accommodate extra sensing elements when required.
- Provision of adding new links and expanding the network in case of saturation.
- A buffer to enrich processing at critical stages.
- Accommodating new load with minimum power consumption.

## 5. Design Process

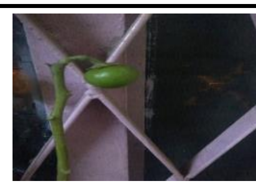
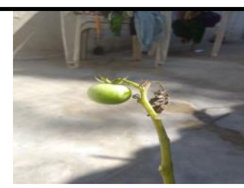
The design process invloved various steps that are discussed as follows:

- Closed loop water pumping- we have followed a closed loop reflexive system wherein water is pumped to the plant from the fish tank and back. The fish excreta are a source of nutrient for the plants. A servo motor conditionally regulates water in the closed loop system. The guiding parameters for regulation are the data from the sensors. Threshold placed guides the system to carryout suitable reflexes.

- Fish feeding- the system is automated to feed the fish frequently and sufficiently. The health and well-being of the fishes in the system directly affects the yield of the plants.

- Analysis- the data stored in the cloud helps in comparing the yield of the smart Aquaponics to that of the traditional system's yield. Table 1 shows the difference between Aquaponics technique and the traditional farming technique. This analysis is crucial for the technical fraternity to measure the success of the model. The Table 5 shows the tomato fruit that was grown using aquaponics and traditional farming method. We see that the plant grows very well in aquaponics system than conventional farming. Water quality parameters are essential for the growth of fishes and plants. İonized(NH3) and unionized(NH4) are the two forms of Ammonia. The ammonia of the unionized way is toxic to fishes. Ammonia has two elements namely nitrite and nitrate; nitrate is very good for plants growth and nitrite are very toxic. For the growth of plants pH value should be less, that is between the range 6-7. İt nitrate less we can add more fishes and increase the amount of nitrate. If pH value is less than 6, we can bring it back to 7 by adding calcium and potassium. All the maintenance is done with the help of the aquaponics system. It cannot be done using traditional farming. We are using goldfish and shark for our project as they exude more, the temperature for both types of fishes should be between the range 18o-30o Celsius. It is maintained in the aquaponics system using sensors and cloud integration system which is not possible in traditional farming.

Table I. Traditional Farming versus Aquaponics

| **No. of days after planting** | **Aquaponics technique** | **Traditional farming** |
|---|---|---|
| 5th day |  |  |
| 25th day |  |  |
| 90th day |  |  |
| 103rd day |  |  |
| 107th days |  |  |

## 5.1. System design

Figure 1 shows the system architecture of a closed loop Aquaponics system. The plants are mounted on the coco peats, and are placed in growing beds filled with water pumped in from the fish tank (use of servo motors) containing nutrients which have been synthesized by the bacteria. The water is fed back to the fish tank when required. Water level detectors monitor the water levels in the system continuously for proper water regulation for both plants and fishes. The pH sensors indicate the acidity of water, for proper plant and fish health. The temperature sensors are essential to maintain ideal temperature for good yield of both fish and plant. The temperature regulator regulates the effective temperature of the system for a balanced ecosystem. Wi-Fi module is used to transmit the data to the cloud for analysis and troubleshooting.

In this model, we have used Arduino nano, sensors and ESP8266 Wi-Fi module for sensing and storing data on to the cloud. Arduino nano contains six power pins, eight analog pins, fourteen digital pins, and two reset pins. Servo motor has three pins. Pin one connected to the ground, one to VCC and another one to digital pin nine. The sensors connected to the ESP8266 Wi-Fi module and data is read from the sensors and stored on to the cloud for future use. A schematic design for monitoring environment as shown in Figure 2. The pH will note the hydrogen-ion activity in the water, indicating its acidic and alkalinity. Water level will detect the level of flow of substances. And the temperature sensor will record the temperature in the aquarium. If the given threshold for any sensors is crossed, a particular action is taken care automatically.

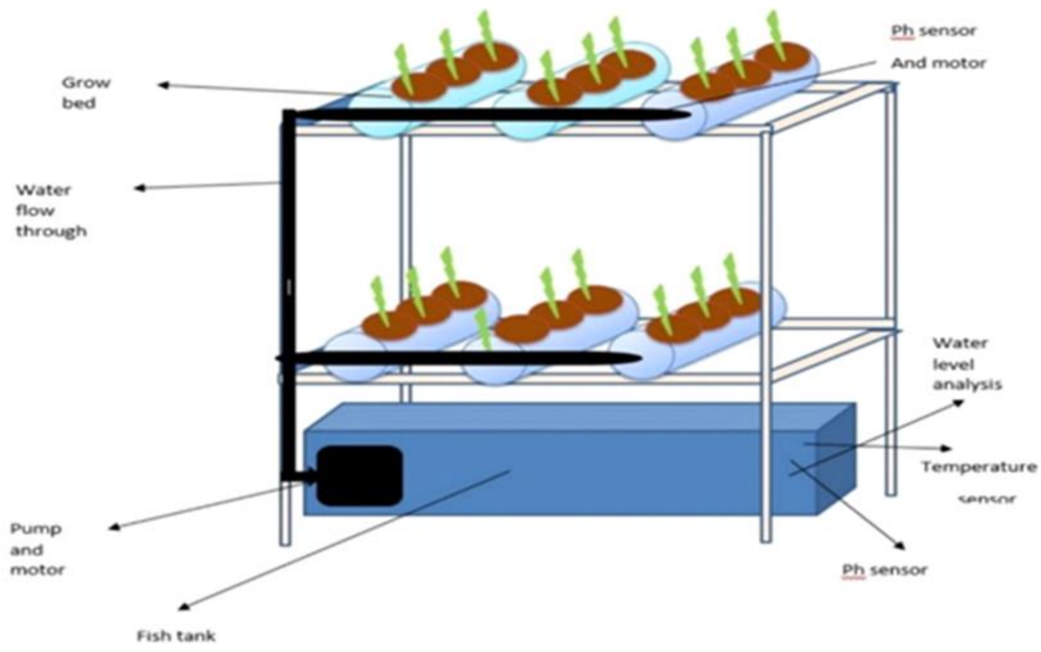



Fig. 1. System design

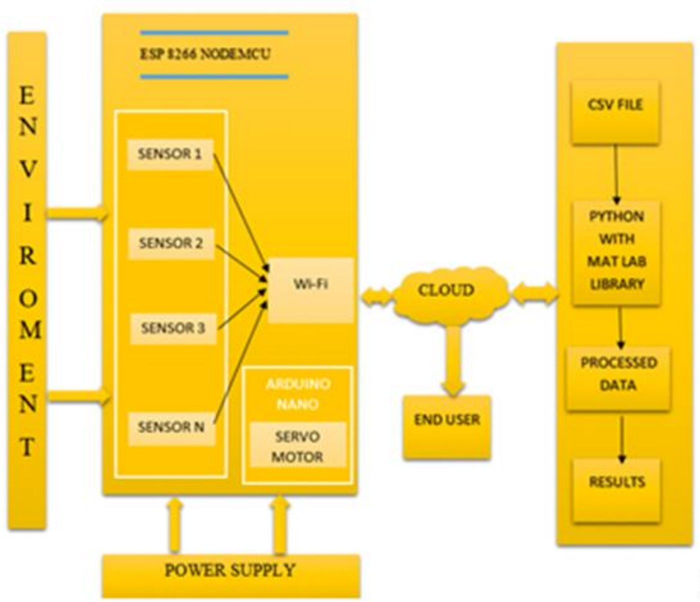



Fig. 2. Schematic diagram of implementation model

The Figure 3. Working of sensors shows how the sensors work. Four modules are implemented. The first module is to feed food to the fishes automatically. The feeding time already set on the code itself. When the precise time comes, the servo will rotate along with the container that is attached to the servo motor also rotates, and food from the bottle. The second and third module is to maintain the water quality parameters like pH and temperature values of the water in the aquarium. If the pH value of water is higher than seven, then water pumped to the aquarium because the favorable value for both plants and fishes should be between the range 6 – 7. İf the temperature value is higher than 30o Celsius, the heater is turned off, and the favorable value for both plants and fishes should be between the range 18℃ – 30℃. The fourth module is to monitor the water level in the aquarium; with the help of a water level sensor.

Matlab(matrix laboratory) provides flexible, two-way integration with many programming languages, including Python. Another Python package is Pandas, which is very popular for data science. It makes data manipulation, analysis easy and provides DataFrame data structures. So the name Pandas comes from Panel Data. With the help of Node MCU, the sensed data sent to the Blynk cloud platform that acts as an application where we can drag and drop widgets to control the Arduino over the internet. The data is then extracted as a CSV file and with the help of Matlab library graphs are plotted using a python script. The live data of pH and temperature values are collected and displayed using Blynk cloud based on minutes, hours or daily basis. We can also see previously collected data. The data is extracted to CSV format and is stored. The file path set in the code. With the help of Matlab library and pandas, we can plot the graphs and display them.

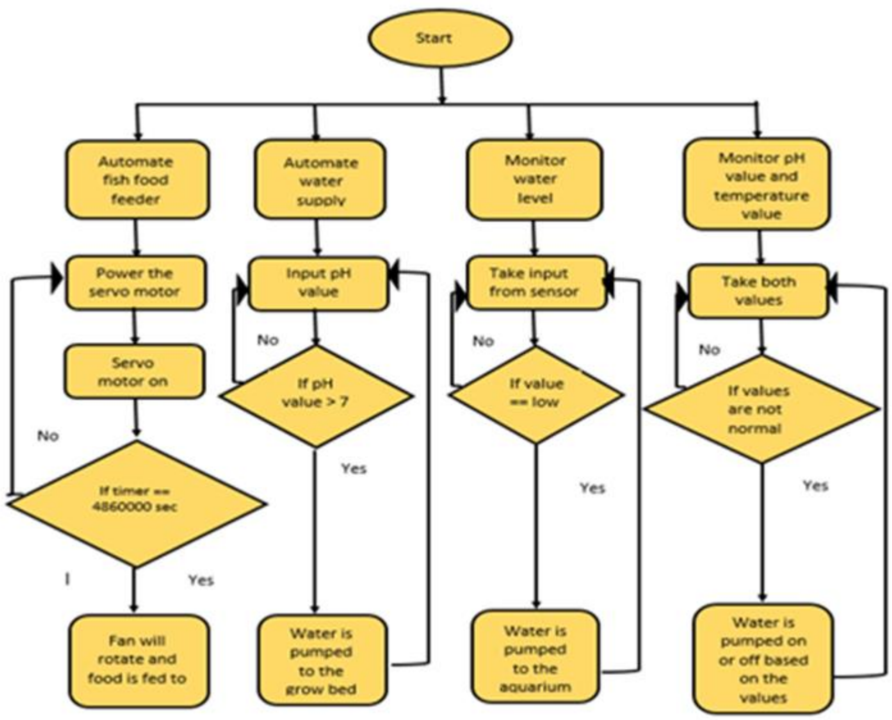



Fig. 3. Flow chart of working of sensors

## 5.2. Computational analysis

**1.Cost analysis**

Table 2 depicted the cost comparison of an existing method and proposed an aquaponics system. The cost of a proposed system is very high when compared to the current system as the order is fully automated. The system consists of features like electric water supply to the plants, aquarium environment control, user interface control, water quality control and environmentally friendly.

Table II. Cost Comparison of an Existing system and a Proposed system

**Cost analysis of an existing system**

| Component | Number of component | Cost |
|---|---|---|
| Arduino | 2 | 330+330=660 |
| Adapter | 1 | 75 |
| USB Cable | 2 | 35+35=70 |
| Servo motor | 1 | 150 |
| Relay | 2 | 90+90=180 |
| Water Level Sensor | 1 | 120 |
| Jumper Wires | 80 | 120 |
| Ph sensor | 1 | 1900 |
| Model Design | 1 | 2500 |
| | | Total :5775 |

**Cost analysis of a proposed system**

| Components used | Number of Pieces | Price |
|---|---|---|
| Arduino Nano | 1 | 200 |
| Bread board | 1 | 70 |
| Jump wires | 3 | 200 |
| PH sensor | 1 | 1800 |
| Resistor | 3 | 30 |
| Servo motor | 1 | 115 |
| Temperature sensor DS1820 | 1 | 125 |
| Water Level Sensor BC548C | 1 | 20 |
| ESP8266 Node MCU | 1 | 310 |
| Labour cost + Model Design | | Gross : Rs.14,903 |

**Water quality parameters for both plants and aquarium**

Table III. Water quality parameters for both plants and aquarium

| Sl.no. | Parameters | Values | Analysis |
|---|---|---|---|
| 1. | PH value | 6-7 | Daily |
| 2. | Temperature | $18^o$-$30^o$ Celsius | Daily |
| 3. | Total ammonium nitrogen | < 1 gm/L | Weekly |
| 4. | Nitrite | < 1 gm/L | Weekly |
| 5. | Nitrate | 5-150 gm/L | Weekly |
| 6. | Dissolved oxygen | 5 gm/L | Daily |

Table 3 shows favorable values for both plants and fishes. For the plants to grow well and for the fish to survive the pH value should be between the range 6-7 and temperature between the range 18o-30o Celsius. The amount of nitrite and nitrate should be low and high respectively. Plants will grow very fast if the amount of nitrate is high and measured in grams per liters.

- **pH value analysis**

Fishes stay healthy between the pH range of 5 to 10. Plants need a pH value less than 6.5. Since, our system is a closed loop ecosystem existing and dependent on each other a pH range of 6-7 is acceptable. Figure 4 shows the measured pH values of the system under observation.


Fig. 4. PH value analysis

- **Temperature analysis**

Average temperature data of one particular day. Figure 5 shows the average temperature data on a particular day.

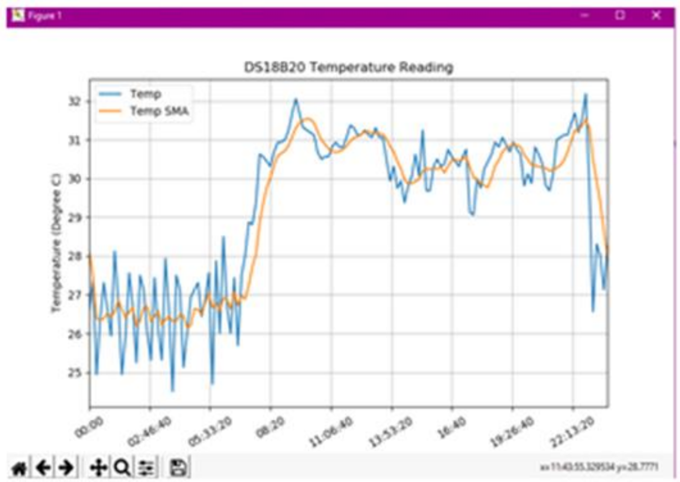



Fig. 5. Analysis of temperature values of one day

- Temperature analysis on hourly basis of a particular day. Figure 6 indicates the same. Realtime analysis requires frequent scrutiny of essential parameters supporting the system.

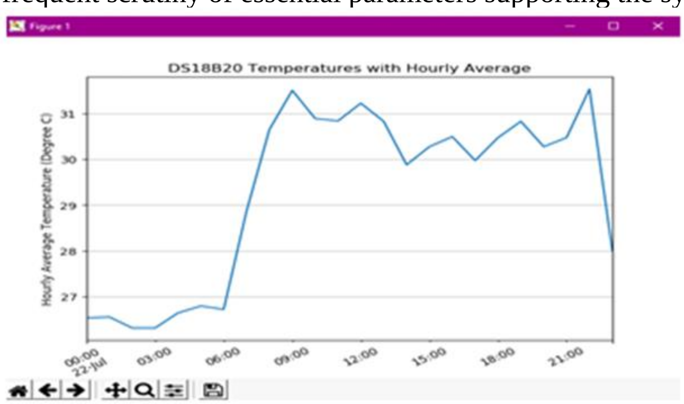



Fig. 6. Average temperature data of one particular day

- Water level analysis

  Figure 7 shows the graph of water levels at various instants.

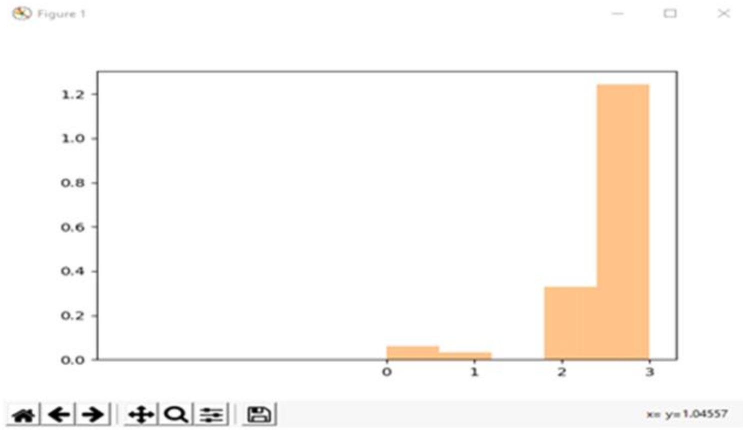



Fig. 7. Water level analysis

- **Simulation results**

Figure 8 and 9 shows the screenshots of live data and previously collected data respectively. Blynk cloud application (a third party application) is used to plot and analyse realtime data and past records


Fig. 8. Live temperature and pH values


Fig 9. Live temperature and pH values

## 6. Conclusion

From the results obtained we can quote that Smart and Portable Aquaponics is the need of the day. Our system automates the traditional system by intelligent reflexes. The threshold placed can be changed anytime resulting in better handling controlling of the system. This initiation is essential in case of varying environmental factors and change to be made in the system, This system is by itself a self-sustaining the and (chemical free organic) agricultural technique A balanced ecosystem combined with automation and human in joints can transform the global agricultural scenario. A better field, would indicate better profit making and sufficient resources to feed the global population which is ever increasing. The quality of the yield is also excellent and &nigh standard. This proposed system has the capability to set new Standards in agriculture and fish Cultivation.

## 7. Acknowledgment

The authors would like to thank BMS College of Engineering and TEQIP III for the support.

## References

[1] Dr.K. Panimozhi Vinutha Raju , S. Yashaswini, “Survey on Aqua Robotics Urban Farm System” International Journal of Computer Sciences and Engineering (IJCSE), Vol.7 Issue .2, pp.614-622, Feb 2019.
https://doi.org/10.26438/ijcse/v7i2.614622

[2] Priyanka R.R., “Crop Protection by an alert Based System using Deep Learning Concept” Isroset-Journal (IJSRCSE), Vol.6, Issue .6, pp.47-49, Dec-2018.

[3] Harmeet Khanuja, “IOT Based Smart Parking System”, Isroset-Journal (IJSRCSE) Vol.6, Issue.6, pp.50-52, Dec-2018.

[4] Chandraprakash Patidar, “E-IRRIGATION: An Automation of Irrigation using Wireless Networks”, Journal (IJSRNSC), Vol.1, Issue.5, pp.18-20, Nov-2013.

[5] V. Parashar, “Use of ICT in Agriculture”, Journal (IJSRNSC) Vol.4, Issue.5, pp.8-11, Oct-2016.

[6] A. S. A.M. Soh, “Development of Aquaponic System using Solar Powered Control Pump”, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)

[7] James E. Rakocy, “Economic Analysis Of A Commercial-Scale Aquaponic System For The Production Of Tilapia And Lettuce”, Shultz University of the Virgin Islands, Agriculture Experiment Station St. Croix, U.S. Virgin Islands.

[8] N. S. M. Fadhil, ”Automated Indoor Aquaponic Cultivation Technique”, 2013 3rd International Conference on System Engineering and Technology, 19-20 Aug. 2013, Shah Alam, Malaysia

[9] Megumi U. Leatherbury Department of Engineering Technology, “VEGILAB and Aquaponics Indoor Growing System“, Weber State University. 2014 IEEE Conference on Technologies for Sustainability. 2016 4th International Conference on Future Internet of Things and Cloud Workshops.

https://doi.org/10.1109/SusTech.2014.7046233

[10] Sandhya Baskaran Senior Software Engineer, “An Autonomous Aquaponics System using 6LoWPAN based WSN.”, Sanjana Hariraj B. Tech, Information Tech. Anna University, Vaishali Krishnan B. Tech, I.T. Anna University, India.

[11] Rodrigo S. Jamisola Jr., “An Automated Solar-Powered Aquaponics System towards Agricultural Sustainability in the Sultanate of Oman.”, Mechanical and energy engineering department, Cesar Mendoza, Analene Montesines Nagayo, raad K.S Al Izki and Eugene Vega Department of Engineering. 2017 IEEE International Conference on Smart Grid and Smart Cities.

[12] https://www.google.com/url?hl=en&q=http://lpulaguna.edu.ph/wpcontent/uploads/2016/10/Fuzzy-Logic-Controller-Implementation-to-an-Arduino-Based-Solar-Powered-Aquaponics-System-

[13] Rolf Meinecke, “Closed greenhouse concept integrating thermal energy storage (TES)”, 2014 49th International Universities Power Engineering Conference (UPEC) publisher is IEEE and conference location: Cluj-Napoca, Romania, 2014.

[14] P.C.AdeSilva, “Ipanera:An Industry 4.0 based architecture for distributed soil-less food production systems”, 2016 (Manufacturing & Industrial Engineering Symposium (MIES) in the year 2016 publisher is IEEE.

https://doi.org/10.1109/MIES.2016.7780266

[15] Jasson Gryzagoridis and Fareed Ismail, “Sustainable development using renewable energy to boost aquaponics food production in needy communities”, 2016 (International Conference on the Industrial and Commercial Use of Energy (ICUE) in the year 2016 publisher is IEEE

[16] KS Aishwarya, M Harish, S Prathibhashree and K Panimozhi, “Survey on IOT Based Automated Aquaponics Gardening Approaches”, Second International Conference on Inventive Communication and Computational Technologies (ICICCT) in the year 2018 publisher is IEEE, India.

https://doi.org/10.1109/ICICCT.2018.8473012

[17] www.blink.com

[18] www.instructables.com

[19] ieeexplore.ieee.org

[20] pethelpful.com

[21] www.theaquaponicsource.com

[22] originhydroponics.com

[23] spectrum.ieee.org