



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 6, June 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Automated Aeroponics System for Indoor Farming Using Arduino

Pooja Aspalli, Divya, Vajrapaali and Geeta

Assistant Professor, Department of Computer Science & Engineering, Poojya Doddappa Appa College of Engineering,
Kalaburgi, Karnataka, India

U.G. Student, Department of Computer Science & Engineering, Poojya Doddappa Appa College of Engineering,
Kalaburgi, Karnataka, India

U.G. Student, Department of Computer Science & Engineering, Poojya Doddappa Appa College of Engineering,
Kalaburgi, Karnataka, India

U.G. Student, Department of Computer Science & Engineering, Poojya Doddappa Appa College of Engineering,
Kalaburgi, Karnataka, India

ABSTRACT An automated aeroponics system is a modern method of growing plants in a controlled environment without soil. It uses a closed-loop system that sprays nutrient-rich water directly onto the roots of the plants, allowing for maximum nutrient absorption and oxygenation. The system is fully automated, with sensors monitoring the pH levels, nutrient levels, and temperature of the water, the applications also used for the observation are temperature, humidity and light. This paper aims to growing plants which are highly efficient, using less water and nutrients than traditional soil-based methods. It is more environmentally friendly, as it eliminates the need for pesticides.

KEYWORDS: closed-loop system, nutrient-rich water, oxygenation, pesticides.

I. INTRODUCTION

Over the years, many agricultural system variations have been developed to better suit changing operations and a diverse range of plants. Population of world is expected to rise by 8.6 billion people by the year 2030. It is estimated that approximately 109 hectares of additional land will be needed to feed them only 75% of the earth land is suitable for farming now. Traditional outdoor agriculture involves planting crops in fields and relying on natural sunlight, rain, and soil nutrients to grow the crops. This method has been used for thousands of years and is still the most common form of agriculture today, outdoor farming is subject to weather conditions, pests, and diseases, which can all impact crop yields. Farmers also have less control over growing conditions such as temperature and humidity, which can limit the types of crops that can be grown in certain regions. Outdoor farming also requires large amounts of land, which can be expensive to purchase and maintain. This can limit the ability of farmers to expand their operations or start new ones. Modern farming refers to the use of advanced technologies, equipment, and techniques to increase agricultural productivity and efficiency. It involves the use of genetically modified crops, precision agriculture, irrigation systems, and mechanized equipment such as tractors, harvesters, and drones. Modern farming also focuses on sustainable farming practices that minimize the negative impact on the environment and promote soil health. This includes crop rotation, reduced tillage, and integrated pest management. Additionally, modern farming often involves the use of data analytics and artificial intelligence to optimize crop yields and reduce waste. Overall, modern farming aims to produce more food with fewer resources while minimizing environmental impact. Indoor agriculture refers to the practice of growing crops indoors, often in controlled environments such as greenhouses or vertical farms. This method of agriculture offers several advantages over traditional outdoor farming, including the ability to grow crops year-round, protection from pests and weather conditions, and the ability to control growing conditions such as temperature, humidity, and light. One popular indoor agriculture technique is vertical farming, which involves growing crops in stacked layers using artificial lighting and hydroponic or aeroponic systems. This method allows for high-density crop production in urban areas where space is limited and land costs are high. A greater quantity of hectares with optimum input is needed every day to feed the rising population. This chain of high priority problem requires a solution, to

manage the use of resources so that human consumption has the priority in its use. The solution to this problem mentioned in through new farming techniques and various methods have been searched among which one of it is aeroponics. Aeroponics is just one example of modern agriculture techniques. Other methods include hydroponics, vertical farming, and precision agriculture. Hydroponics involves growing plants in a nutrient-rich water solution instead of soil. Vertical farming involves growing crops in stacked layers, often in urban environments or indoors. Precision agriculture uses technology such as GPS and sensors to optimize crop growth and reduce waste. These modern techniques offer more efficient and sustainable ways of farming that can help address challenges such as food insecurity, climate change, and limited resources .Aeroponics is a method of growing plants without the soil and less use of water. First used in the 1920s for academic studies of root growth, aeroponics would not become a real contender until the late 1990s, when The National Aeronautics and Space Administration (NASA) began looking at it as an option for growing food in soilless environments—such as in space. While the process is still in its infancy, aeroponics is quickly gaining popularity in places where traditional farming simply isn't an option. The roots are suspended in the air and irrigated with a nutrient dense mist. The nutrient laden/ dense mist provides the necessary nutrients for growth, a nutrient rich mist is sprayed onto the roots of the plants. This mist contains all the essential nutrients that the plants need to grow such as nitrogen, phosphorus, potassium, calcium, magnesium and other trace elements. This mist is highly oxygenated which helps to promotes healthy root growth and nutrient uptake This is alternative method of soilless culture growth-controlled environment such as greenhouse. Aeroponics system has been applied successfully in Korea for potato seed tubes production.

II. RELATED WORK

The detailed summary has been done on the aeroponics system which mainly focuses on showing of plants without soil in a controlled atmosphere.

In [1] the author has proposed smart cities is an automated system in farming without using soil. This system is designed to revolutionize the farming sector in the present era of automation. The outcome of the project is a simple system capable of cultivating plants indoors without using soil, irrespective of external climate condition.

In [2] the author has aimed Aeroponics is the soilless cultivation and it is a process of growing crops suspended in the air or in a mist without using soil. The principles of aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum or soil, but in containers filled with flowing plant nutrition. In these containers' roots can find the best condition regarding oxygenation and moisture. These conditions allow for better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plants. Aeroponics appeared to be a highly feasible method for the production of both aerial parts and roots as raw materials for the herbal dietary supplement and Phyto pharmaceutical industries.

In [3] the author has presented the implementation of an automatic control system for aeroponics. This system contains a latte panda as the main processing unit and an adjustable interface to suit the needs of the cultivated plant. It gets input from temperature sensors, light sensors and humidity sensors and displays the output on the LCD screen module. The system results are simulated with the help of simulation software. And then the evaluation of the experimental results of the control system applied to aeroponics is based on environmental factors, the results show that the system can be more efficient in saving labour and increasing the economic value of the product.

In [4] the author proposed an intelligent control system for an aeroponics-based greenhouse, which consists of data collection/monitoring system, control system, centralized sever, and multiplatform web-based controlling/monitoring application for agricultural facilities. The prototype system for establishing a low-cost aeroponics-based greenhouse control system can be designed based on an open source development board called Raspberry Pi. The system can be used both locally and over the Internet, which has a large set of controlling and monitoring function for the greenhouse. the outcome was simple management and high availability establish by using both the local global system this system helps to evaluate the quality of harvested crops in the various environment conditions treatment through the feasibility test.

In [5] the author proposed or conducted a monitoring system applied to an aeroponic greenhouse based on an IoT architecture that provides user information on the status of the climatic variables and the appearance of the crop in addition to managing the irrigation timing and the frequency of visual inspection using an application developed for Android mobile devices called Aeroponics Monitor. The results of the analysis of the information of the

monitored variables and of the processing of the images are presented in the developed app, with the objective of visualizing the state of the crop and to know the function of the monitoring system in the event of a possible lack of electricity or a service line failure in the fog layer and to avoid the loss of information. An analysis of the VPD is presented that demonstrates a water deficiency from the transplanting of the seedling to the cultivation chamber. The IoT architecture presented in this paper represents a potential tool for the study of aeroponic farming systems through IoT-assisted monitoring.

In [6] the author presents a design and implementation of an Aeroponics system that employs the Internet of Things (IoT) for online and automated monitoring capability. The pH level of the solution in the tank is maintained using a pH sensor and dot sensor are used to sense or measure the temperature and the humidity. The monitoring, control, and delivery of the plants' nutritional and water needs are all done using Internet of Things (IoT) technology the plant growth that is placed in an aeroponics chamber under 15 days.

In [7] the author has proposed the cyber-physical system is an indoor farm that grows plants aeroponically, without soil. It monitors the health of the plants by regulating the water received, and recording the humidity, light, and temperature levels. Sensors connected to an Arduino board and program collect data about (1) the humidity of the enclosed growth chamber, (2) the light supplied by both the ambient light and an overhead light fixture, and (3) the temperature inside the system. Based on researched optimal conditions, the system maintains the best growing environment for the plant.

In [8] the author has demonstrated and implemented a new automatic aeroponics system using IoT devices. Our system is comprised of three main components: a mobile application, service platform and IoT devices with sensors. The IoT device uses sensors within the aeroponics system to control each pump and access data. Our work is a new application in the agricultural industry and is expected to be a promising application that will help the farmer with increasing productivity in farming and reducing carbon footprint. The proposed is expected to be a promising application to help farmer in increasing the production of organic crops in a smart farming system.

In [9] the author has proposed smart farming using automatic aeroponics system to fulfil the growing need of food we are developing this smart farming project using aeroponics technique, and our main objective is to make the aeroponics technique automatic plus making the setup universal for multiple vegetable crops. The automation handles the technical monitoring and controlling of the parameters related to plants growth. This makes the system user friendly and easy to use with the less human efforts, As compared to outside atmosphere the indoor system keeps the setup environment in favourable conditions to the plant growth such as temperature, humidity, light conditions.

In [10] the author developed an automatic monitored aeroponic-irrigation system based on the Arduino's free software platform Analog and digital sensors for measuring the temperature, flow and level of a nutrient solution in a real greenhouse were implemented. The automatic monitored aeroponic-irrigation system based on the Arduino free software platform present good performance when it is implemented in a research greenhouse. This result can be applied in a commercial greenhouse with polyculture or when different nutrient solutions formulation is employed. future work automatically sends alarm signals directly to the final user of the system through mobile devices.

In [11] the author has aimed to improve the efficiency and environment impact of agriculture This technique contains monitoring and automation for proper operation. Automatic monitoring aeroponic-irrigation system is based on IoT and Raspberry Pi. Analog and Digital sensors for measuring the temperature, humidity, pressure, pH, water flow and level of a nutrient solution. Meanwhile, the control system was used to manage actuators. This system will be effective when implemented in the aeroponics agriculture. Delivers nutrients directly to the plant roots. Completely programmable technology conserves energy. Closed-loop system conserves water. Conserves water through runoff absorption into roots. Can be combined with hydroponics. Crops are easier to harvest in the absence of soil. Higher density crops optimizes output. Reduce labour cost through automation.

In [12] the author has proposed "Aeroponic cultivation", focus on growing plants in a soil free medium in the absence of natural sunlight. The method involves indoor gardening techniques ruling out the atmospheric consideration for safe agriculture. Vertical stack farming facility improves yield within a controlled premise. The soil free cultivation environment provides no home for any insects; therefore, pesticides free organic fruits and vegetables are easily harvested. The system involves the consumption of only 10% of water used in the conventional agriculture. The energy needed by a plant from natural sunlight is provided by using special Light Emitting Diode (LED) growth light. Such growth lights emit the specific wavelength range depending on the plant's requirement, therefore enhancing the quality of cultivation. The nutrient solution is chosen carefully to meet all the fertility demands of the plant. Plants for

cultivation must be technically chosen and short listed based on its adaptability to the technique. The technique mainly aims at providing fruits and vegetable at any part of world as it is temperature independent. The controlled process of cropping enhances the quality of the growth and product of the plant.

In [13] the author proposed system that uses concepts of artificial photosynthesis, vertical and zone-wise crops production and the Internet of Things. This increases the productivity. By using the various sensor networks, the environmental parameters can be noted. The retrieved data is stored and displayed on a customized webpage which can be accessed through mobile app. Artificial photosynthesis for the plants using grow-lamps and drip irrigation is implemented to maintain the urban gardens. Using GSM technology systematic alerts regarding the status of garden to the user at regular intervals of time is delivered. An android app interface is also implemented in the proposed system to remotely control the garden functioning hence enhancing the smart way of agriculture.

In [14] the author has aimed to provide an opportunity to grow their own and obtain fresher food with fewer transportation emissions, likewise, it is a strategy to lift people out of food poverty, reduce environmental impact since the use of herbicides and pesticides is minimal and helps to reduce food waste. However, factors such as the time dedicated to the cultivation of plants, and the adequate space inside their houses prevents them from carrying out this activity. This project presents the design of a low cost smart indoor greenhouse design to cultivate herbs and vegetables with minimum human intervention monitored by a web application. The prototype has three systems to control and monitor the main variables involved in the plant's growth such as soil moisture, temperature, and solar light intensity. Likewise, it is suitable for a home with little space and it is easily installable, has low energy consumption, and is cost-efficient.

In [15] the author has proposed the vertical farming is the new generation method of farming which help to maintain the food production chain without disturbing the agricultural misbalance. In this AEROPONICS TECHNIQUE IN VERTICAL FARMING, are monitoring few basic parameters which help in growth of plant to achieve the fresh products using less space with (using coco peat or natural stone fibre in place of soil) soilless farming and maintaining the environmental parameters.

In [16] the smart farming makes a tremendous contribution for food sustainability for 21st century. Our project vertical farming is the practice of producing food in vertically stacked layers, vertically inclined surfaces and/or integrated in other structures using Controlled environment agricultural technology, where all environmental factors are controlled. These facilities utilize artificial control of light, environmental control like humidity, temperature, gases, fertigation. Controlled-environment agriculture (CEA) is a technology-based approach toward food production. The aim of CEA is to provide protection and maintain optimal growing conditions throughout the development of the crop. Production takes place within an enclosed growing structure where the growth conditions are maintained. The crops are grown based on hydroponics method of soilless farming.

In [17] the author has proposed the hydroponic system which is fully automatic that can be integrated into the agricultural curriculum while introducing business skills. The automatic monitoring and control of the environmental events such as light intensity, pH, electrical conductivity, water temperature, and relative humidity is carried out by lodging sensors and actuators onto the system. The maintenance and automated monitoring are done by the intervention of the IoT that are used to transfer and retrieve data to the internet (mass storage) and a mobile app is used to communicate the current status of the hydroponic system to the user through the use of internet to their mobile phones. This futuristic system can use high data analytics and prolonged data gathering to improve the accuracy of reckoning.

In [18] the data were analysed using descriptive and statistical methods to infer relationships between the Internet of Things (IoT), emerging technologies, precision agriculture, agriculture 4.0, and improvements in commercial farming. The recent unexpected and severe weather events have contributed to low agricultural yields and losses; this is a challenge that can be resolved through technology-mediated precision agriculture. Advances in technology have over time contributed to the development of sensors for frost prevention, remote crop monitoring, fire hazard prevention, precise control of nutrients in soilless greenhouse cultivation, power autonomy through the use of solar energy, and intelligent feeding, shading, and lighting control to improve yields and reduce operational costs. However, particular challenges abound, including the limited uptake of smart technologies in commercial agriculture, price, and accuracy of the sensors.

In [19] the author has proposed an automatic system, which consists of the Internet of Thing [IoT] is implemented in providing the controlled environment for the vertical farming. The main purpose of this project is to build a system to monitor the soil moisture and to control water content through the web browser on the laptop, mobile phone and other handheld and compact devices. a soil moisture sensor is used to detect the moisture or water content of the soil in the vertical farm so that the plant can be consecutively monitored and controlled to have enough water. When low moisture level is detected, the signals are sent to the Arduino platform. Then, the data is stored eventually in the Arduino IDE software and simultaneously sent to the web browser through the Ethernet that is connected to the internet router. The user can monitor their plant through the web browser that allows them to read the status of the soil moisture and can control the water valve to release the water to the plant whenever the reading is low or necessary. With this development, the monitoring of the vertical farming has been so helpful and the growth of the plant can be supervised from time to time without having the operator at the event.

In [20] this project involves the evolving Internet of Things (IoT) technologies, which encompass the smart sensors, devices, network topologies, big data analytics, and intelligent decision is believed to be the solution in addressing the key challenges facing the greenhouse farming, such as greenhouse local climate control, crop growth monitoring, crop harvesting and etc.

III.METHODOLOGY

Aeroponics is a technique which uses the nutrient in the water at a required quantity to grow the plants without using soil as a medium. It is a modern technique that is helpful for growing the plants. Here the plants are grown within the controlled atmosphere. The controlled atmosphere refers to the regulation and maintenance of the environment around the plants, such as temperature, humidity and light etc. This is important because usually in traditional plant growing system, the plants are rooted in soil which provide a natural buffer against environmental fluctuations. In order to optimize plant growth and health without soil the atmosphere in the aeroponic system must be carefully controlled and monitored. The controlled atmosphere can be achieved by the use of sensors and automated system that adjusted environment conditions as needed By maintaining a stable and optimal atmosphere, plants in aeroponic system can grow faster and produce higher yields compared to traditional soil based methods The steps involved in growth of plants using aeroponics method are as follows:

1.Choose a suitable location: The first step in showing plants using aeroponics is to select a suitable location that has access to a reliable source of electricity, water and proper ventilation. Aeroponic systems require a constant supply of water and nutrients to maintain plant growth, so a water source and electricity supply are essential. The location should be free from pests and diseases that could damage the plants. Aeroponic systems are highly susceptible to pest infestations, so it is important to choose a location that is well-protected from insects and other pests. The location should have access to natural light or artificial lighting systems. Preferably natural light. Plants require light for photosynthesis, so it is important to ensure that they receive adequate light to promote healthy growth.

2.Set Up the System

2.1. Design and planning: The first step in setting up an aeroponic system is to design and plan the system. This includes determining the size and scale of the system,

2.2. Construction: Once the design is finalized, the next step is to construct the system. Constructing involves installing the plumbing and electrical systems, and setting up the misting nozzles.

3.Select the plants: Choosing the plant which can be grown using this technique or system such as leafy greens herbs and potatoes are popular choices for aeroponic system. the selection of the plants in aeroponics should be able to tolerate high level of nutrients in the solution being damaged. The plants which can be grown within the short duration has to be selected as they can produce high yields in small space in a short amount of time, useful for small scale agriculture .

4.Preparing the nutrients solution: A nutrient-rich solution according to the specific need of the plants that are to be grown. The solution should be pH balanced and free of contaminants. The nutrient solution typically consists of a mixture and water and essential plant nutrients such as nitrogen phosphorous and potassium. It is important to observe

monitor the nutrient solution regularly to ensure that the plants are receiving the proper balance of nutrients. The pH level should be maintained and the nutrient level should be adjusted as needed based on the growth stage of the plants.

5.Plant the seeds or cuttings: To plant the seeds or cuttings into the aeroponic system first prepare the growing container by cleaning sterilizing it. Then insert the seeds or cuttings into the net pots or foam cubes that will hold them in the place. Now fill the container with the nutrient solution and adjust the pH and nutrient level as needed. Set up the misting system to mist the roots of the plants regularly. Monitoring the plant closely for the first few weeks to ensure they are adopting well to the system and receiving enough nutrients.

6.Maintain and monitor the system: It is important to regularly check the nutrient solution levels and pH level. The nutrient solution should be changed every 1-2 weeks to ensure that the plants are receiving the fresh and balanced nutrients. the misting system should also be checked regularly to ensure that it is functioning properly and misting the roots of the plants evenly, if any clogs and blockages occur they should be cleared immediately to prevent damage to the plants. it is also important to monitor the plants themselves for any signs of nutrient deficiencies or pest infestation regularly cleaning and sterilization of the container should be done as it is necessary to prevent the build-up of algae, bacteria or other contaminants that can harm the plants.

7.Harvesting the plant: -Once the plants have matured, harvest them as needed the aeroponic system can produce higher crop yields and faster growth rates than the traditional farming method. Harvesting plants in aeroponics involves carefully removing the mature plants from the growing system without damaging the roots. The roots of the plants are typically intertwined with the misting nozzles and other equipment, so care must be taken to avoid damaging the system. Once the plants have been removed, they are typically washed to remove any excess nutrient solution and debris. The plants can then be used for consumption or sold at market. In some cases, the plants may be replanted in the aeroponic system for further growth and production. This is often done with plants that have a longer growing cycle, such as herbs or leafy greens.

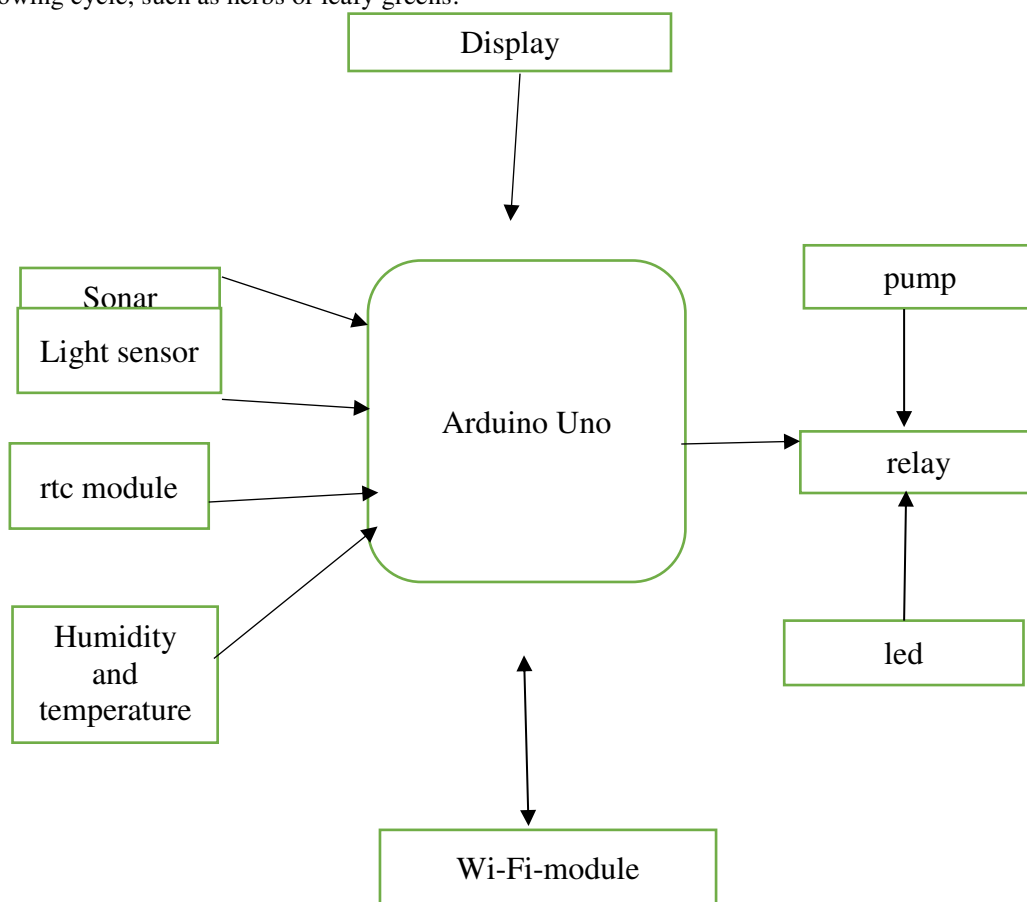


Fig 1: Block diagram of automated aeroponics system.

The fig 1 explains the block diagram of the automated aeroponics system , the hardware and software components are connected to the arduino.

IV. EXPERIMENTAL RESULTS

In the work of automated aeroponics systems for indoor farming using Arduino has several benefits, including increased plant yields, reduced water usage, and improved nutrient delivery. The rectangular board used here for settingup an aeroponic system the hardware components are fixed to the board. The container is used for the nutrients solution that is sprayed using the misters. The nutrient solution is prepared using NPK fertilizer the others nutrients can also be used such as Calcium, Zinc, Magnesium, Iron etc.

In this paper, experimentation is conducted using the coriander plants.

In traditional plant growing system we observe that the coriander plant is grown in the soil, where the seed generally takes 7-10 days to sprout. It may vary depending on the parameters such as temperature, humidity and light. The seeds or plants need fertilizers to get the nutrients which helps them to have faster growth and higher yields. The livestock manure (cow dung / cow manure) is used as it is rich in nutrients and is suitable for plant growth.

In our work we are growing plant in Aeroponic system where the nutrient solution is used here as follows: -

- Nitrogen (N): 50-100 ppm
- Phosphorus (P): 20-40 ppm
- Potassium (K): 100-200 ppm
- Calcium (Ca): 50-100 ppm
- Magnesium (Mg): 20-40 ppm
- Iron (Fe): 2-5 ppm
- Manganese (Mn): 0.5-2 ppm
- Zinc (Zn): 0.5-2 ppm
- Copper (Cu): 0.1-0.5 ppm

These nutrient levels can be adjusted based on the specific needs of the coriander plants, and can be monitored and controlled using an Arduino-based automated aeroponics system.

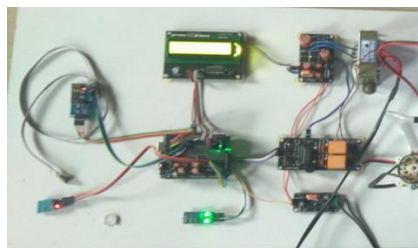


Fig 2: hardware components

The above fig 2 explains hardware components used in automated aeroponics system. The hardware components include arduino board ,rectifier ,filter capacitor ,Wi-Fi module, and sensors ,bilge pump and pump driver.

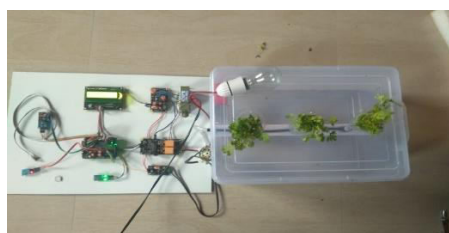


Fig 3: Developed Module of Automated Aeroponics

The fig 3 explains the fully developed module containing the hardware components and the container to hold the nutrient solution. The pump driver is connected to the pump and the water supply is given to the spray misters to spray the water to the roots dangling in the pots .



Fig 4: Blynk application

The fig 4 is about the Blynk application alternative to the ThingSpeak Portal used for observing the parameters to grow the plants. The parameters observed in this system are light intensity, water level, humidity and temperature, these parameters are essential for growing the plants.

V. CONCLUSION

Aeroponics is a modern and innovative farming technique that offers numerous benefits over traditional agriculture. It is a sustainable and eco-friendly method of farming faster growth rates and higher yields. Aeroponics uses less water and space, reduces the risk of pests and diseases, and allows for year-round cultivation. As a result, it can contribute to food security and reduce the carbon footprint of agriculture. With these advantages, aeroponics has the potential to revolutionize the way we grow food and address the challenges of feeding a growing global population while preserving our planet's resources.

REFERENCES

- Priyanka B J1 Rohan Sharm2 Somanna A G Sathyamurthy S K4 Dr Aruna M5, "Digital farming using aeroponic" [2020 JETIR October 2020, Volume 7, Issue 10].
- P Gopinath, P. Irene Vethamoni and M. Gomathi, "Aeroponics Soilless Cultivation System for Vegetable Crops", Chem Sci Rev Lett 2017, 6(22), 838-849 Article CS072048042.
- Iwan Fitrianto Rahmad Lili Tanti, Ratih Puspasari, Evri Ekadiansyah, Vidi Agung Fragastia, "Automatic Monitoring and Control System in Aeroponic Plant Agriculture", The 8th International Conference on Cyber and IT Service Management (CITSM 2020) On Virtual, October 23-24, 2020.
- .P Mithunesh, K. Gupta, S. Ghule, Prof. S. Hule, "Aeroponic Based Controlled Environment Based Farming System", IOSR Journal of Computer Engineering, [2015 Vol. 17, No. 6,] Ver. II, 2015, PP. 55-58.
- Hugo A. Méndez-Guzmán, José A. Padilla-Medina 2, Coral Martínez-Nolasco 1, Juan J. Martínez-Nolasco 3, Alejandro I. Barranco-Gutiérrez 2, Luis M. Contreras-Medina 4 and Miguel Leon-Rodríguez 5 Doctorado en Ciencias de la Ingeniería, Tecnológico Nacional de México/Instituto Tecnológico d, Sensors 2022, 22, 5646. <https://doi.org/10.3390/s22155646> <https://www.mdpi.com/journal/sensors>.
- Issac K Joy, Christy V Vazhappilly "Smart Aeroponics Using IoT"(2022), Volume: 09.
- .Jonas P, Maskara A, Salguero A and Truong A, "A cyber physical aeroponics system for indoor farming", (2017).
- Stephen C. Kerns, Joong-Lyul Lee Doi:10.19044/esj.2017.c1p10 [URL:http://dx.doi.org/10.19044/esj.2017.c1p10](http://dx.doi.org/10.19044/esj.2017.c1p10).
- Karan D. Gohel1, Nilesh R. Vispute2, Suraaj S. Satpute3, H. P. Chaudhari 4, "SMART FARMING USING AUTOMATIC AEROPONICS SYSTEM", 2018 IJCRT | Volume 6, Issue 2 April 2018 | ISSN: 2320-2882.
- A P Montoya, F A Obando, J G Morales and G Vargas, "Automatic aeroponic irrigation system based on Arduino's platform", IOP Conf. Series: Journal of Physics: Conf. Series 850 (2017) 012003.
- .Raut R., Varma H., Mulla C. Pawar V.R, "Soil Monitoring, Fertigation, and Irrigation System Using IoT for Agricultural Application." (2018), In: Hu YC., Tiwari S, Mishra K., Trivedi M. (eds) Intelligent Communication and Computational Technologies. Lecture Notes in Networks and Systems, vol 19. Springer, Singapore. DOI:10.1007/978-981-10-5523-2_7 Corpus ID: 134452631.



12. Manju Barkavi. S1, Mohammed Ibrahim Mubeen A.S2, Moneesha. V3, Naveen. K4, Sathya.Y5, “Urban based Agriculture using Aeroponic Technology”,International Research Journal of Engineering and Technology (IRJET),Volume: 06 Issue: 03 | Mar 2019.
13. 1P. Bhuvanewari ,2Priyanka M.G.*, 3Sandeep S,4Sridhar R, 5Swaroop R, “SMART INDOOR VERTICAL FARMING MONITORING USING IoT”,DOI: 10.47750/cibg.2021.27.03.224.
14. Melisa Acosta-Coll, Daniel Anaya, Luis Ojeda-Field, Ronald Zamora-Musa , “LOW-COST SMART INDOOR GREENHOUSE FOR URBAN FARMING.”
15. Ms. Gaikwad Suvarna 1, Ms. Patil Priyanka2, Mr. Pawar Prathamesh3, Prof.D.O.Shirsath4 ,“Monitoring Parameters of Plants in Vertical Farming using Aeroponics Technique”,Volume: 07 Issue: 05 | May 2020.
16. Aju G Nair1, Akhil Chacko2, Ganga Mohan 3, Tony K Francis ,“Smart Vertical Farming Using Hydroponics”,ISSN: 2278-1676,p-ISSN: 2320-3331.
17. Sudharsan S1, Vargunan R2, Vignesh Raj S3, Selvanayagan S4, Dr. Ponmurugan P5 “IoT Based Automated Hydroponic Cultivation System” .ISSN 0973-4562 Volume 14, Number 11, 2019 (Special Issue).
18. Chrysanthos Maraveas,Thomas Bartzanas. “Application of Internet of Things (IoT) for Optimized Greenhouse Environments”. AgriEngineering 2021, 3(4), 954-970; <https://doi.org/10.3390/agriengineering3040060>.
19. Karishma Moharathal, Kartika Sahoo2, Smurtirekha Jena3, Sakti Prasad Jen4,Kirtiraj Mohalik5,6Prof. Sushree Monali ,Swain6, Prof Monali Madhusmita7, Dr. Satyananda Swain8 SSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538 Volume 10 Issue V May 2022- Available at www.ijraset.com.
20. Rakiba Rayhana,Gaozhi (George) Xiao,Zheng Liu. Internet of Things Empowered “Smart Greenhouse Farming” volume:4 issue: 3.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.423



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 **6381 907 438** **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details