Designing And Implementing Arduino Based Nutrition Feeding Automation System Of A Prototype Scaled Nutrient Film Technique (NFT) Hydroponics Using Total Dissolved Solids (TDS) Sensor

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ABSTRACT

Hydroponics is a new breakthrough in farming because it no longer uses soil as a planting medium, and uses water instead. In the hydroponic system, the fertilizer used is mixed into water, which is then referred to as hydroponic nutrition or nutrient solution. The nutrient concentration in the solution, which is then indicated by the electrical conductivity (EC), is very influential on crop production. The nutrient concentration usually mixed manually by combining the fertilizer and the water in the right amount. Therefore, through this research, a nutrition feeding automation system of a prototype scaled Nutrient Film Technique (NFT) hydroponics is prepared. The system is designed with a control center using the NODE MCU R3 board. The system is equipped with SR04 proximity sensor as a water level detector, TDS sensor as a detector of electrical conductivity of the nutrient solution, and servo motor as an opening device of the faucet in the nutrient container. The research resulted that the system is capable of performing water delivery automatically when the water level is less than the minimum level, and add the nutrients automatically when the nutrient solution concentration is below 800ppm.

***Keywords*: Arduino, NFT, TDS, Hydroponics.**

I. INTRODUCTION

Extreme weather changes and contaminated soil air are the cause of plant production problems in open field crop production. Hydroponics is applied as a new breakthrough in farming because it no longer uses soil as a planting medium, and uses water instead. In the hydroponic system, the fertilizer used is mixed into water, which is then referred to as hydroponic nutrition or nutrient solution. The nutrition is distributed to the hydroponic system to be absorbed by the roots of the plant. The concentration of the nutrients in the solution is very influential on crop production. It is related to the amount of EC (Electrical Conductivity) from the nutrient solution. Electrical Conductivity, which is also known as CF (Conductivity Factor), is an indicator of salinity in a nutrient solution. The EC value gives an indication to the farmer about the nutrients contained in the solution and which is absorbed by the roots. A low EC will give a low yield, which then increases to the maximum when EC is increased .

EC measurement aims to find out how much concentration of nutrients is absorbed. EC that is too high to cause plants cannot absorb nutrients because it is too saturated. The nutrient solution that is flowing only passes without being absorbed by the roots. If the concentration of nutrient EC solution is too high then there will be poisoning and cells will experience plasmolysis. EC nutrient solution can increase along with time. This is presumably because nutrient solution loses some water due to evapotranspiration, so the nutrient solution becomes more concentrated.The plant growth is affected by the appropriate water and nutrient type and adequate aeration support. These factors can increase nutrient uptake to produce energy. The energy required to produce sufficient oxygen in the solution will be used by the roots to respiration and generate energy to absorb water and nutrients from the solution. This affects the smooth process of respiration so that more nutrients can be absorbed by plants. Excess water will reduce the amount of oxygen in the nutrient solution. Increased nutrient intake will increase plant growth. The development of science and technology, especially computer technology occurs rapidly. The scope of application of technology is also increasingly widespread, covering various aspects of human life so that efforts to meet human needs are increasing and complex. Computer technology can be positively correlated to improving the quality of life and human well-being.

Rapid and accurate system automation is an important requirement that encourages the creation of automated tools. Devices that are integrated with various peripherals and other supporting devices make the performance of these technologies become more applicable and functional. In 2014, Qalyubi, Pudjojono and Widodo conducted an experiment on the effects of water discharge and the provision of nutrients to the growth of kale plants (Ipomoea aquatica forsk) in the hydroponics NFT system. The results revealed that the EC or the concentration of hydroponic nutrition is very influential on the growth of kale plants. EC amounted to 460 ppm indicates the deficit of solution concentration, so that the kale plants grow slowly.

The weakness in the experiment will be improved, and the ideas in the experiment will be supported by designing the automatic NFT (Nutrient Film Technique) hydroponics nutrition system, using the Arduino microcontroller, equipped with SHARP GP2Y0A21 as a water level sensor, servo motor actuators, and TDS (Total Dissolved Solids) sensors. The TDS sensor is used to detect the concentration of the nutrient solution, so it can be precisely detected when the solution requires additional nutrients.

II. LITERATURE SURVEY

2.1 Literature Review

[1] Reimagining Farming: An Arduino-Powered IoT Aeroponics System for Indoor Cultivation by A. Patel, R. Gupta, S. Sharma in 2019

This research presents an innovative and advanced IoT aeroponics system tailored for indoor cultivation, driven by Arduino technology. The system introduces a paradigm shift in smart farming practices by integrating cutting-edge sensors that continuously monitor and optimize the indoor environmental conditions. Actuators are employed to precisely control irrigation and lighting, ensuring optimal growth conditions for crops. Moreover, the system is equipped with internet connectivity, allowing real-time data access remotely. This seamless integration of technology fosters an efficient and sustainable approach to indoor crop cultivation, offering potential solutions to food security challenges in the face of a changing climate.

[2] Towards Sustainable Vertical Farming: An IoT-Enhanced Aeroponics System by L. Wang, C. Li, K. Zhang in 2021

This article presents an innovative IoT-enhanced aeroponics system aimed at fostering sustainable vertical farming practices. Utilizing a network of sensors, the system intelligently tracks the indoor farming environment, while actuators efficiently manage irrigation and lighting. By combining IoT technology with aeroponics, this approach strives to optimize plant growth, resource usage, and overall productivity.

[3] Enhancing Crop Resilience: An IoT-Driven Automated Aeroponics Solution by J. Lee, K. Kim, H. Park in 2023

This study details the design and implementation of an IoT-driven automated aeroponics solution with a focus on enhancing crop resilience. Through the integration of advanced sensors and actuators, the system effectively monitors and controls the growing environment, promoting optimal plant health and adaptability to varying stresses. By empowering farmers with remote data access, this approach contributes to sustainable and climate-resilient indoor farming.

[4] Intelligent Cultivation: An IoT-based Aeroponics System for Precision Farming by M. Anderson, S. Thompson, R. Martinez in 2020

This research showcases an intelligent IoT-based aeroponics system tailored for precision farming in indoor environments. Leveraging state-of-the-art sensors and actuators, the system autonomously regulates crucial factors like irrigation and lighting to achieve optimal growth conditions. By integrating artificial intelligence, the system further refines cultivation practices, enabling resource-efficient and sustainable indoor crop production.

2.2 Problem Statement

The problem lies in the need for efficient and sustainable indoor farming solutions to address the pressing challenges faced by traditional agricultural practices. With the global population steadily rising and climate stress affecting traditional farming methods, the demand for food production is at an all-time high. However, conventional outdoor farming faces limitations due to weather fluctuations, limited land availability, and resource-intensive practices. Indoor farming offers a promising alternative, but it requires precise control over all growth factors, including light, temperature, humidity, carbon dioxide concentration, water, and nutrients, to ensure optimal plant growth. Additionally, indoor farming must operate independently of solar light and other outdoor conditions to provide consistent and reliable yields year-round.

2.3 Objectives

The objective of this project is to design and implement a state-of-the-art multilayer indoor plant production system that precisely controls all growth factors, creating an optimal environment for year-round production of high quantities of high-quality fresh produce. By harnessing advanced IoT technology and Arduino-based automation, the system will efficiently manage essential parameters such as light intensity, temperature, humidity, carbon dioxide concentration, water, and nutrient levels. This integrated approach aims to overcome the limitations of traditional outdoor farming, ensuring consistent crop yields and minimizing the impact of external factors such as weather and seasonal changes.

III. OVERVIEW OF DESIGNING AND IMPLEMENTING THE ARDUINO-BASED NUTRITION FEEDING AUTOMATION SYSTEM OF A PROTOTYPE SCALED NUTRIENT FILM TECHNIQUE (NFT) HYDROPONICS USING TOTAL DISSOLVED SOLIDS (TDS) SENSOR

This section explains the needs and methods used in system development. There are four stages: needs analysis, system design, system implementation, and system testing. The first stage in system development is the identification of the system requirements. At this stage the data related to the needs of system design is collected, such as selecting the sensors that will be used on the system. This stage is also a stage where the data related to the experiments and literature studies is collected. The result of this stage is the list of functional and non-functional requirements of the system.

The functional requirements in the system design are the system is capable to keep the value of electrical conductivity of the nutrient solution not less than 800 ppm. The system is capable to add water automatically to the A-B Mix nutrient solution for NFT hydroponic. [9]. The system will perform data readings when the water level is sufficient and the sensor plate is immersed in a nutrient solution. The system is capable of adding fertilizer A and B fertilizer automatically to the
hydroponic nutrient solution until it reaches sufficient nutrient concentration. The system is capable to detect the electrical conductivity levels in a NFT hydroponic nutrient solution container to determine when nutrients need to be added. The system is able to detect the distance from the sensor to the water level on the NFT hydroponic nutrient solution container to determine when the nutrient solution should be added. The system is able to adjust the amount of nutrients A and B that must be spent to achieve ideal conditions. Non-functional requirements in designing this system are the system using ATMega 328 microcontroller on Arduino board as control center to read sensor output value.

The system runs with a 9V/1A power supply. The system gets input from existing sensors, and does not require input from user. The entire system is one system that installed and connected directly to the NFT hydroponic nutrient solution container. The second stage is system design. This stage is the result of the identification stage of the system needs performed previously. The data obtained is then used as the design of nutritional automation systems on a prototype-scaled NFT hydroponic to fit between the design of software and hardware. The result of this step is the hardware block diagram and the flowchart of the software.

In the system design is also done the determination of an equation to convert analog voltage values to PPM units on TDS sensors. The experiment was carried out by taking 11 solution samples with different amounts of dissolved solids. First, the PPM value of each sample is measured using TDS sensors and TDS meters. Each sample was measured 5 times to determine the average of the value measured. This repetitive reading is done because the value displayed by the sensor or TDS meter is fluctuating or changing very quickly. The comparison of the average data measured by sensors and TDS meter is shown in Table

Table 3.1: Solution Sample of Measurement Data

TABLE I. SOLUTION SAMPLE OF MEASUREMENT DATA

No.	Sample	Average value from Sensor TDS	Average value from TDS Meter
1	I	180.8	488.6
2	II	200.8	680.8
3	III	203.8	736.8
4	IV	214.2	892
5	V	224.8	1031.2
6	VI	233.2	1175.2
7	VII	235.6	1240.2
8	VIII	240.2	1392
9	IX	248.2	1528.2
10	X	251.2	1622
11	XI	253.6	1760

The third stage in system development is system implementation. At this stage hardware is assembled and software is created to be uploaded into the system. The hardware used is an NODE MCU R3 board with an ATMega 328 microcontroller equipped with SHARP GP2Y0A21 proximity sensor , TDS sensor , and MG996R servo motor actuator . The SHARP GP2Y0A21 output range sensor is used to detects the water level in the hydroponic nutrient solution container which then determines the TDS sensor reading schedule which is when the water level is sufficient to immerse the TDS sensor plate. The TDS sensor is used as the main sensor of the system to detect the electrical conductivity or solute content of the hydroponic nutrient solution in Part per Million (PPM) units. Both of these sensors determine when the servo motor actuators that are mounted on 3 containers of water or fertilizer will move to open the faucet head or close the faucet head. The software used is Arduino IDE version 1.6.5 running on the Windows 10 operating system to program the system hardware.

The last stage in system development is system testing. At this stage data is taken to test the hardware as well as the system software. Then the data obtained from previous stages (design and implementation system) is analyzed. Tests undertaken at this stage are testing of input devices, testing of external devices, and testing based on functional requirements of the system.

3.1 PROPOSED SYSTEM:

Proposed Vertical farming System

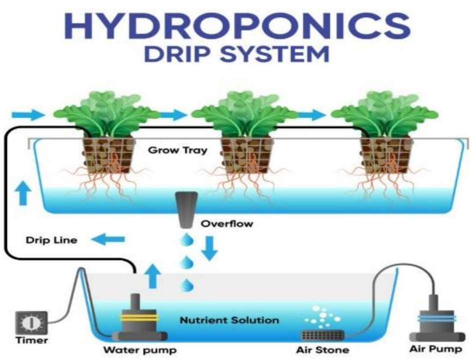

Fig: 1:Hydroponics Drip System

This figure shows hydroponics drip system ,a soilless cultivation method with components like nutrient tank, water pump, and grow tubes.

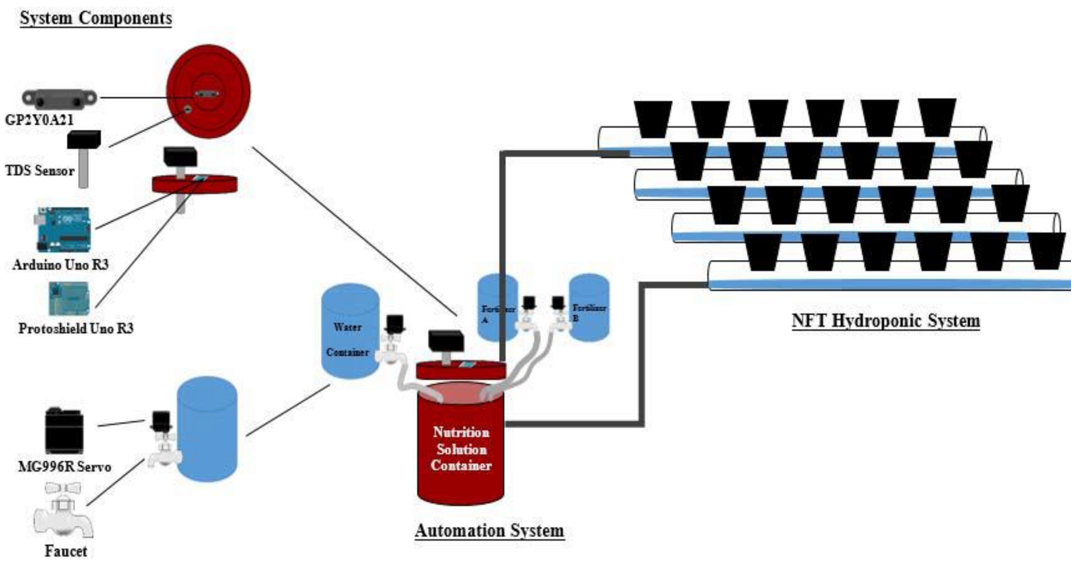

Fig 2. Illustration of installation of the system components

The testing of the system is conducted by reading the value of each sensor and other input devices. Then, the testing is conducted to the outlet devices of the systems, and the last is a testing of the system as a whole to meet all the functional requirements of the system.

The testing of TDS sensor is conducted by comparing the sensor output with a measuring instrument that is TDS meter. The TDS reading is the conversion value of the analog voltage generated by the sensor to the PPM unit using equation (1) obtained from the observed value of the output voltage of the sensor compared to the value measured by the TDS meter. The variable x in equation (1) is implemented in the software as the measured TDS value, whereas the y variable is inputted with the ppm value in the TDSCheck()function.

3.2 HARDWARE REQUIREMENTS:

What is NodeMcu ESP8266 ?

NODEMCU

NodeMCU is an open source IoT platform. Which includes firmware which runs on the ESP8266 Wi-Fi Module from Espressif Systems,and hardware which is based on the ESP-12 module. The term “NodeMCU” by default refers to the firmware rather than the dev kits. NodeMCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in NodeMCU.

Fig 3:NodeMcu ESP8266

The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and microcontroller capability produced by

Shanghai-based Chinese manufacturer, Espressif.

Comparison of rectifier circuits

Parameter	Type of Rectifier		
	Half wave	Full wave	Bridge
Number of diodes	1	2	4
PIV of diodes	Vm	2Vm	Vm
D.C output voltage	Vm/z	2Vm/ π	2Vm/ π
Vdc at no-load	0.318Vm	0.636Vm	0.636Vm
Ripple factor	1.21	0.482	0.482
Ripple frequency	f	2f	2f
Rectification efficiency	0.406	0.812	0.812
Transformer Utilization Factor(TUF)	0.287	0.693	0.812
RMS voltage Vrms	Vm/2	Vm/√2	Vm/√2

Full-wave Rectifier:
From the above comparison we came to know that full wave bridge rectifier as more advantages than the other two rectifiers. So, in our project we are using full wave bridge rectifier circuit.
Bridge Rectifier:
A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.
A bridge rectifier makes use of four diodes in a bridge arrangement as shown in fig (a) to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

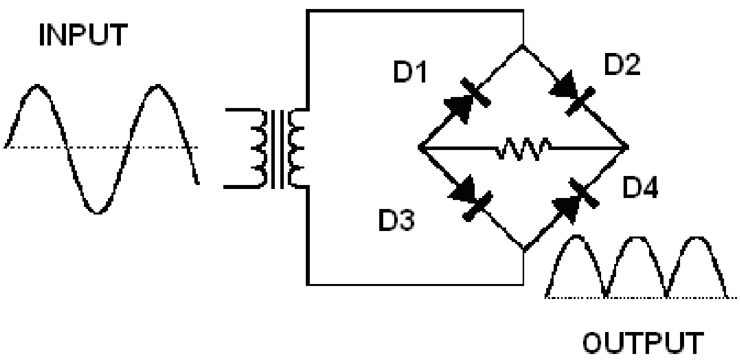

Fig 4: Bridge Rectifier

Operation: During positive half cycle of secondary, the diodes D2 and D3 are in forward biased while D1 and D4 are in reverse biased. The current flow direction is shown in the fig (b) with dotted arrows.

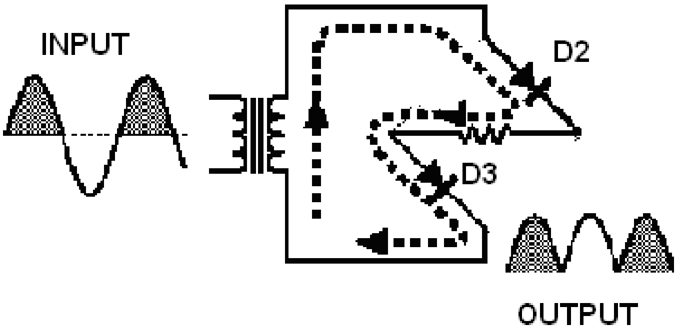

Fig 5: Operation

During negative half cycle of secondary voltage, the diodes D1 and D4 are in forward biased while D2 and D3 are in reverse biased as shown in the fig(c). The current flow direction is shown in the fig (c) with dotted arrows.

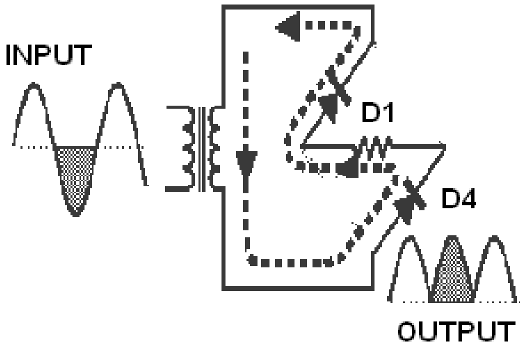

Fig 6: Filter

FILTER:

A Filter is a device which removes the ac component of rectifier output but allows the dc component to reach the load.

REGULATOR:

Voltage regulator ICs is available with fixed (typically 5, 12 and 15V) or variable output voltages. The maximum current they can pass also rates them. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). Many of the fixed voltage regulators ICs have 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. The LM7805 is simple to use. You simply connect the positive lead of your unregulated DC power supply (anything from 9VDC to 24VDC) to the Input pin, connect the negative lead to the Common pin and then when you turn on the power, you get a 5 volt supply from the output pin.

Fig 7 A Three Terminal Voltage Regulator

The Bay Linear LM78XX is integrated linear positive regulator with three terminals. The LM78XX offer several fixed output voltages making them useful in wide range of applications. When used as a zener diode/resistor combination replacement, the LM78XX usually results in an effective output impedance improvement of two orders of magnitude, lower quiescent current. The LM78XX is available in the TO-252, TO-220 & TO-263packages,

Features:

- Output Current of 1.5A
- Output Voltage Tolerance of 5%
- Internal thermal overload protection
- Internal Short-Circuit Limited

- Output Voltage 5.0V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 24V.

LM78XX SERIES VOLTAGE REGULATOR

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level.

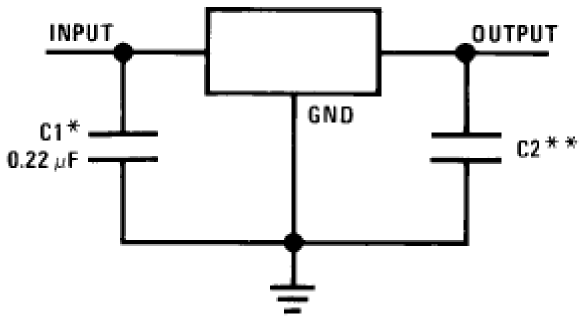

Fig 8: LM78XX SERIES VOLTAGE REGULATOR

In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible.

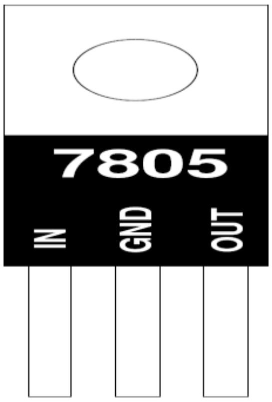

Fig 9: Voltage regulator

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, Hi-Fi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

ANALOG TDS SENSOR:

Overview

TDS (Total Dissolved Solids) indicates how many milligrams of soluble solids are dissolved in one liter of water. In general, the higher the TDS value, the more soluble solids are dissolved in water, and the less clean the water is. Therefore, the TDS value can be used as one reference point for reflecting the cleanliness of the water. This can be applied to domestic water, hydroponic and other fields of water quality testing and monitoring.

What is "TDS"?

TDS is an abbreviation for Total Dissolved Solids in a liquid, including organic and inorganic substances in a molecular, ionic, or micro-granular suspended form. TDS is generally expressed in parts per million (ppm) or as milligrams per liter (mg/L). TDS is directly related to the quality **of** water i.e., the lower a TDS figure, the purer the water. As an example, reverse **osmosis** purified water will have a TDS between 0 and 10, whereas tap water will vary between 20 and 300, depending on where you live in the world.

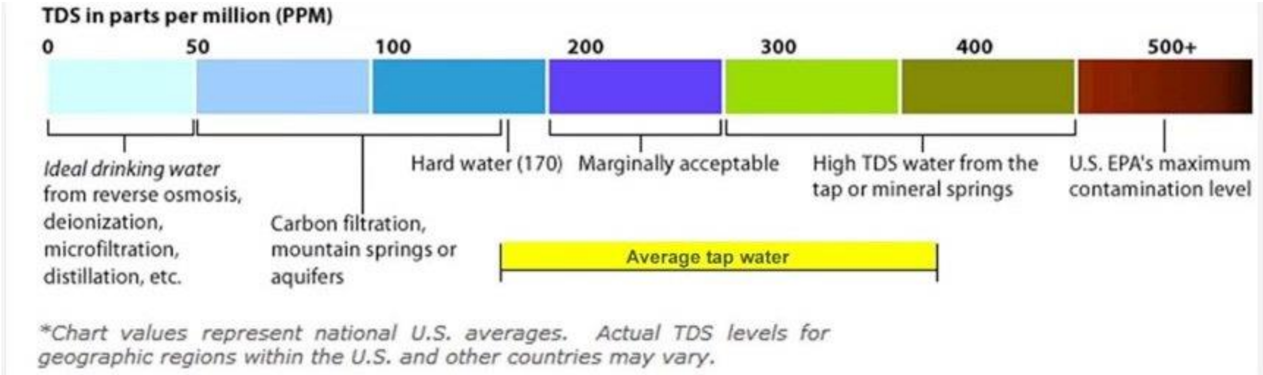

Fig 10:TDS

The materials that constitute dissolved solids in water include materials such as minerals, salts, anionic and cationic substances**.** They can also include pollutants such as heavy metals**,** and other substances such as organic materials that may have leaked into your water supply system.

What is a TDS meter and how does it work?

A TDS meter is basically an electrical charge (EC) meter whereby two electrodes equally spaced apart are inserted into water and used to measure charge. The result is interpreted by the TDS meter and converted into a ppm figure.

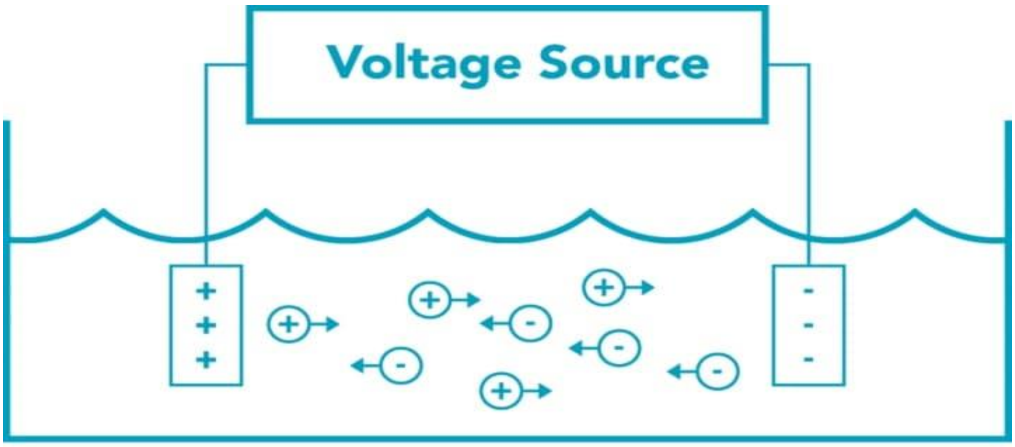

Fig 11: TDS meter

If the water contains no soluble materials and is pure, it will not conduct a charge and will, therefore, have a 0 ppm figure. Conversely, if the water is full of dissolved materials, it will conduct a charge, with the resulting ppm figure being proportional to the number of dissolved solids. This is because all dissolved solids have an electrical charge, which allows conduction of electrical charge between the electrodes.

IV. RESULTS AND DISCUSSIONS

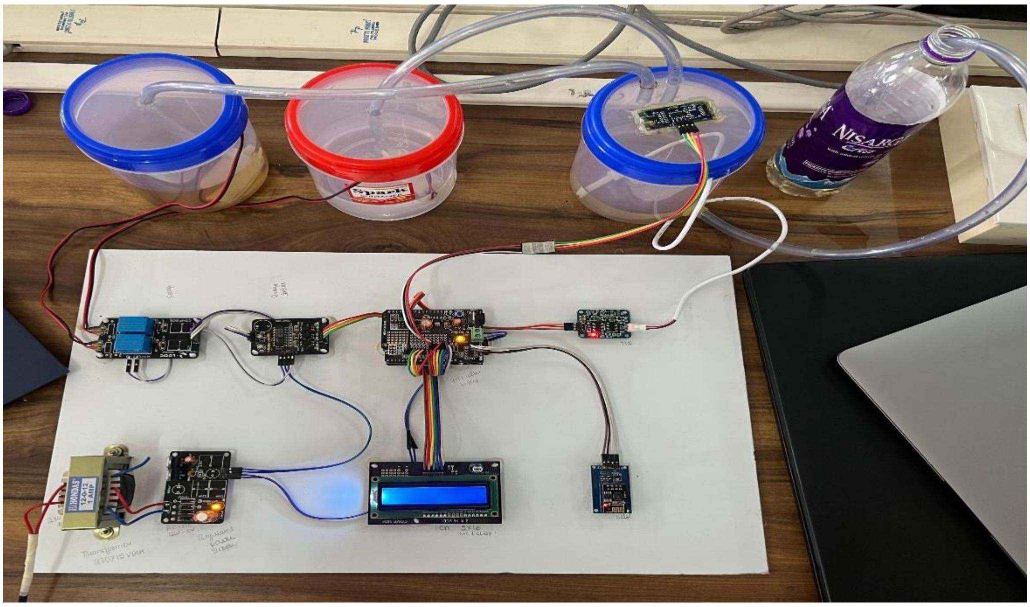

Fig 12: Hydroponics Setup

The figure shows connection of the Arduino-based NFT hydroponics system is designed to monitor and control the hydroponic environment for optimal plant growth. It automates nutrient delivery and shows data for analysis.

Fig 13: TDS values on 2x16 LCD display

The figure shows the current values of TDS on 2X16 LCD display, providing real-time feedback on the system's performance.

Fig 14: Blynk dashboard

The figure shows Blynk app dashboard ,consists of two guages i.e.,TDS and Water level for tracking the concentration of dissolved substances in the water and the current water level in the system .

V. CONCLUSION AND FUTURE SCOPE

This research attempts to examine the design and application of the automatic NFT hydroponic at a prototype-scale using TDS sensors. The research revealed that this system is able to detect the level of electrical conductivity or solute in nutrient solution using TDS sensor in a PPM unit. This prototype scale NFT hydroponics system could deliver nutrients automatically so that the nutrient content in the solution is not less than the minimum limit of 800 ppm. The accuracy of the TDS sensor based on the voltage unit to PPM conversion formula is 97.8%. The software developed could control the hardware systems according to the results of the system requirement as identified. The design and application of the nutritional automation systems on NFT hydroponics could meet all the functional requirements as planned. The system can also be enhanced by installing roof top solar panel for electricity generation that will help to meet electricity requirements as well as if the generation is more than the requirement for greenhouse and can supply the same to grid. Internet of Things can also be connected to greenhouse. Then from any places in the world, the greenhouse can be monitored and controlled easily without others help or man power. These constitute to the future scope of this proposed system.

REFERENCES

1. Reimagining Farming: An Arduino-Powered IoT Aeroponics System for Indoor Cultivation by A. Patel, R. Gupta, S. Sharma in 2019
2. Towards Sustainable Vertical Farming: An IoT-Enhanced Aeroponics System by L. Wang, C. Li, K. Zhang in 2021
3. Enhancing Crop Resilience: An IoT-Driven Automated Aeroponics Solution by J. Lee, K. Kim, H. Park in 2023
4. Intelligent Cultivation: An IoT-based Aeroponics System for Precision Farming by M. Anderson, S. Thompson, R. Martinez in 2020
5. Data-Driven Indoor Agriculture: IoT-controlled Aeroponics System for High-Yield Crops by A. Smith, E. Johnson, T. Miller in 2021
6. Harnessing Microgreens: IoT-Enabled Aeroponics System for Nutrient-Dense Crop Cultivation by K. Brown, J. Roberts, M. Nguyen in 2022
7. R. Chen, Q. Wu, Y. Zhang (2022). "Automation and Control in Smart Aeroponics: A Review of Recent Advancements."
8. S. Kim, J. Park, H. Lee (2021). "IoT-Based Environmental Monitoring in Indoor Farming: A Case Study on Aeroponics."
9. P. Gupta, V. Sharma, S. Kumar (2023). "Energy Efficiency and Sustainability in Aeroponics: A Comparative Study."

10. T. Chen, H. Wang, X. Li (2020). "Smart Farming Technologies for Indoor Crop Production: A Review."
11. Priyanka Kulkarni, & Dr. Swaroopa Shastri. (2024). Rice Leaf Diseases Detection Using Machine Learning. Journal of Scientific Research and Technology, 2(1), 17–22. https://doi.org/10.61808/jsrt81
12. Shilpa Patil. (2023). Security for Electronic Health Record Based on Attribute using Block-Chain Technology. Journal of Scientific Research and Technology, 1(6), 145–155. https://doi.org/10.5281/zenodo.8330325
13. Mohammed Maaz, Md Akif Ahmed, Md Maqsood, & Dr Shridevi Soma. (2023). Development Of Service Deployment Models In Private Cloud. Journal of Scientific Research and Technology, 1(9), 1–12. https://doi.org/10.61808/jsrt74
14. Antariksh Sharma, Prof. Vibhakar Mansotra, & Kuljeet Singh. (2023). Detection of Mirai Botnet Attacks on IoT devices Using Deep Learning. Journal of Scientific Research and Technology, 1(6), 174–187.
15. Dr. Megha Rani Raigonda, & Shweta. (2024). Signature Verification System Using SSIM In Image Processing. Journal of Scientific Research and Technology, 2(1), 5–11. https://doi.org/10.61808/jsrt79
16. Shri Udayshankar B, Veeraj R Singh, Sampras P, & Aryan Dhage. (2023). Fake Job Post Prediction Using Data Mining. Journal of Scientific Research and Technology, 1(2), 39–47.
17. Gaurav Prajapati, Avinash, Lav Kumar, & Smt. Rekha S Patil. (2023). Road Accident Prediction Using Machine Learning. Journal of Scientific Research and Technology, 1(2), 48–59.
18. Dr. Rekha Patil, Vidya Kumar Katrabad, Mahantappa, & Sunil Kumar. (2023). Image Classification Using CNN Model Based on Deep Learning. Journal of Scientific Research and Technology, 1(2), 60–71.
19. Ambresh Bhadrashetty, & Surekha Patil. (2024). Movie Success and Rating Prediction Using Data Mining. Journal of Scientific Research and Technology, 2(1), 1–4. https://doi.org/10.61808/jsrt78
20. Dr. Megha Rani Raigonda, & Shweta. (2024). Signature Verification System Using SSIM In Image Processing. Journal of Scientific Research and Technology, 2(1), 5–11. https://doi.org/10.61808/jsrt79
21. Dr. Megha Rani Raigonda, & Shweta. (2024). Signature Verification System Using SSIM In Image Processing. Journal of Scientific Research and Technology, 2(1), 5–11. https://doi.org/10.61808/jsrt79
22. Jyoti, & Swaroopa Shastri. (2024). Gesture Identification Model In Traditional Indian Performing Arts By Employing Image Processing Techniques. Journal of Scientific Research and Technology, 2(3), 29–33. https://doi.org/10.61808/jsrt89
23. M Manoj Das, & Dr. Swaroopa Shastri. (2025). Machine Learning Approaches for Early Brain Stroke Detection Using CNN . Journal of Scientific Research and Technology, 3(6), 243–250. https://doi.org/10.61808/jsrt248
24. Abhishek Ashtikar, & Dr. Swaroopa Shastri. (2025). A CNN Model For Skin Cancer Detection And Classification By Using Image Processing Techniques. Journal of Scientific Research and Technology, 3(6), 251–263. https://doi.org/10.61808/jsrt250
25. Dr. Megha Rani Raigonda, & Anjali. (2025). Identification And Classification of Rice Leaf Disease Using Hybrid Deep Learning. Journal of Scientific Research and Technology, 3(6), 93–101. https://doi.org/10.61808/jsrt231
26. Bhagyashree, & Dr. Swaroopa Shastri. (2025). A Machine Learning Approach To Classify Medicinal Plant Leaf By Using Random Forest And KNN. Journal of Scientific Research and Technology, 3(7), 100–115. https://doi.org/10.61808/jsrt261