A Major-Project Report

On

HYDROCULTURE USING IOT

Submitted in partial fulfillments for the Degree of B. Tech.

In

Artificial Intelligence

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CERTIFICATE

This is to certify that the project report entitled "**Hydroculture using IOT**" submitted by **Donthula Vaishnavi (20911A3521), Sattu Chaithrika Patel (20911A3555), Bhukya Saritha (20911A3570) and Erukala Soujanya (21915A3505)** to Vidya Jyothi Institute of Technology(An Autonomous Institution), Hyderabad, in partial fulfilment for the award of the degree of B. Tech. in Artificial Intelligence a *bonafide* record of project work carried out by us under my supervision. The contents of this report, in full or in parts, have not been submitted to any other Institution or University for the award of any degree.

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DECLARATION

We declare that this project report titled **Hydroculture using IOT** submitted in partial fulfilment of the degree of B. Tech in Artificial Intelligence is a record of original work carried out by us under the supervision of **Ms. K. Nirosha**, and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice of reporting scientific information, due acknowledgements have been made wherever the findings of others have been cited.

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ABSTRACT

Technological developments today make the combination of science very common, including in Computer Science and Agriculture, where both sciences complement each other. This project aims to develop an automated control system for managing nutrient flow, environmental conditions (temperature control using artificial light), and water management in hydroponic plants, employing an Arduino microcontroller. Specifically, we utilize an Arduino Uno microcontroller to automate the management of environmental conditions and water supply using if-else logic and ph. sensor to control ph. value of the solution. The system detects the height of the nutrient solution (water) through a water level sensor and monitors the temperature around the plants using a temperature sensor. Data from these sensors are transmitted to the Arduino Uno, enabling it to adjust the nutrient solution level and environmental conditions as necessary.

Additionally, we plan to integrate this hydroponic system with HTML for recording sensor readings and providing recommendations. This integration will allow users to monitor the system remotely, access historical data, and receive real-time recommendations for optimizing plant growth. By combining hardware automation with web-based interfaces, we aim to create a comprehensive solution for modern hydroponic farming practices.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Hydroponic farming stands at the forefront of modern agricultural practices, offering efficient and resource-conscious methods for cultivating crops. In the pursuit of maximizing yields and sustainability, the fusion of computer science and agriculture has emerged as a potent avenue for innovation. This project encapsulates the essence of this interdisciplinary approach by harnessing the power of Arduino microcontrollers to automate and optimize hydroponic systems.

The primary objective of this endeavor is to develop an automated control system capable of precisely managing crucial parameters such as nutrient distribution, environmental conditions, and water levels within hydroponic setups. Leveraging the versatility and programmability of Arduino Uno microcontrollers, our system orchestrates the intricate dance between plant physiology and technological precision. By integrating sensors to monitor factors like water levels and ambient temperature, coupled with logic-based decision-making, the Arduino Uno acts as the brain of the operation, ensuring optimal growing conditions for hydroponic plants [2].

Beyond the realm of hardware automation, we aspire to extend the functionality of our hydroponic system through integration with HTML. This pivotal step will enable users to remotely monitor sensor readings, access historical data, and receive actionable insights for enhancing crop productivity.[1] Through the convergence of hardware and web-based interfaces, we endeavor to democratize hydroponic farming, empowering enthusiasts and professionals alike to embark on a journey of sustainable agriculture bolstered by cutting-edge technology.

1.2 Germination

Hydroculture is often used as a research tool in plant nutrition studies because of the precise control of root-zone conditions and detailed monitoring of root health. Liquid culture hydroponics does not use a solid substrate and therefore has no adsorption and desorption of nutrients, which can complicate nutritional studies. These systems work well with the mass-balance approach as nutrients are either in the solution or in the plant. Rapid, uniform germination is essential for research in hydroponic systems. Few seeds can germinate submerged in water and thus cannot be planted directly into the nutrient solution in liquid hydroponics. Submersion in water inhibits oxygen diffusion across seed membranes and prevents germination. For maximum uniformity, seeds should be germinated separately and transplanted into the main system when roots are long enough to be in contact with the nutrient solution immediately after transplanting [12]. Reduced time for germination is beneficial so plants can be subjected to treatments in hydroponics systems for a larger percentage of their lifecycle.

1.3 Inert media

Plant roots take up nutrients. Roots absorb these nutrients as ions. For this reason, another important characteristic of soilless media is the *cation exchange capacity (CEC)*. This refers to the ability of the media to hold and release cations, which are positively charged ions. An ion is an atom or molecule with an electric charge resulting from the gain or loss of electrons. In most hydroponics, the nutrients are already supplied in ionic form mixed with water. The CEC will determine if the media is able to hold nutrients. In hydroponics, a media with no or low CEC is desirable so that nutrients are directly fed to the plants without chemically binding to the growing media. Many media types have low CEC so nutrients are not stored in the media. When using media without CEC, all the nutrients are supplied through the nutrient solution. However, some media have a higher CEC and therefore can bind and store nutrients. Plants can sometimes access stored nutrients in the media, and these should be accounted for in fertilization programs. In other cases, the binding of nutrients to the media can make some nutrients unavailable to the plants.

Another important factor that will influence fertilization is the *pH* of the media, which is the measure of how many hydrogen (H) ions are in a solution. This can affect the availability of nutrients to the plant. When preparing your nutrient solution, you must adjust the pH of the solution to meet the needs of the plant. Most plants require a pH of around 5.5–7 to be able to take up nutrients. Certain plant species might prefer a different pH range [3]. At higher and lower pH than the ideal range, plants might not be able to absorb nutrients, even if they are present. The pH of the media can influence the overall pH of the nutrient solution.

Media selection and hydroponics system selection go hand in hand. Not all hydroponics systems are well suited for utilization of media, while other systems require specific media so as not to compromise the system. For example, recirculating hydroponics systems must consider clogging of pumps and irrigation emitters and should not use fine or loose particle media.

1.4 Essential Nutrients

Plants cannot properly function without 17 essential nutrients. These nutrients are needed so that processes critical to plant growth and development can occur. For example, magnesium is a critical component of chlorophyll. Chlorophyll is a pigment used to capture energy from light that is needed in photosynthesis. It also reflects green wavelengths and is the reason most plants are green. Magnesium is the center of the chlorophyll molecule. Table 1 lists the plant roles of essential nutrients.

Essential nutrients can be broadly categorized as macronutrients and micronutrients. Macronutrients and micronutrients are both essential for plant growth and development. Macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium. Micronutrients include iron, manganese, zinc, boron, molybdenum, chlorine, copper, and nickel. The difference between macro- and micronutrients is the amount required by plants. Macronutrients are required in higher amounts than micronutrients. Table 1 shows the approximate plant content of essential nutrients[4].

Plants get carbon, hydrogen, and oxygen from air and water. The rest of the nutrients are from soil or in the case of hydroponics from nutrient solutions or aggregate media. Sources of nutrients available to plants are listed in Table 1.

Nutrient (Chemical solution)	**Approximate content of plant (%dry weight)**	**Roles in plants**	**Source of nutrient available to plant**
Carbon (C), hydrogen (H), oxygen (O)	90+%	Components of organic compounds	Carbon dioxide (CO_2) and water (H_2O)
Nitrogen (N)	2–4%	Component of amino acids, proteins, coenzymes, nucleic acids	Nitrate (NO_3^-) and ammonium (NH_4^+)
Sulfur (S)	0.50%	Component of sulfur amino acids, proteins, coenzyme A	Sulfate (SO_4^-)
Phosphorus (P)	0.40%	ATP, NADP intermediates of metabolism, membrane phospholipids, nucleic acids	Dihydrogen phosphate ($H_2PO_4^-$), Hydrogen phosphate (HPO_4^{2-})
Potassium (K)	2.00%	Enzyme activation, turgor, osmotic regulation	Potassium (K^+)
Calcium (Ca)	1.50%	Enzyme activation, signal transduction, cell structure	Calcium (Ca^{2+})

Magnesium (Mg)	0.40%	Enzyme activation, component of chlorophyll	Magnesium (Mg^{2+})
Manganese (Mn)	0.02%	Enzyme activation, essential for water splitting	Manganese (Mn^{2+})
Iron (Fe)	0.02%	Redox changes, photosynthesis, respiration	Iron (Fe^{2+})
Molybdenum (Mo)	0.00%	Redox changes, nitrate reduction	Molybdate (MoO_4^{2-})
Copper (Cu)	0.00%	Redox changes, photosynthesis, respiration	Copper (Cu^{2+})
Zinc (Zn)	0.00%	Enzyme cofactor-activator	Zinc (Zn^{2+})
Boron (Bo)	0.01%	Membrane activity, cell division	Borate (BO^{3-})
Chlorine (Cl)	0.1–2.0%	Charge balance, water splitting	Chlorine (Cl^-)
Nickel (Ni)	0.000005–0.0005%	Component of some enzymes, biological nitrogen fixation, nitrogen metabolism	Nickel (Ni^{2+})

Table 1.4: Essential nutrients.

1.5 pH

It is impossible to discuss plant nutrition without considering pH. In hydroponics, we are primarily concerned with the pH of the water used to make up nutrient solutions and irrigate plants. pH is a measure of the relative acidity or hydrogen ion concentration and it plays an important role in plant nutrient availability. It is measured using a 0- to 14-point scale where 0 is the most acidic, 7 is neutral, and 14 is the most alkaline. The scale is logarithmic, and each unit represents a 10-fold change. This means that small changes in values are large changes in pH. For example, a value of 7 is 10 times higher than 6 and 100 times higher than 5. In general, the optimal pH range for growing vegetables hydroponically is 5.0 to 7.0[1].

Along the bottom of the chart are different pH values between 4.0 and 10.0. At the top of the chart, the relative acidity or alkalinity is shown. Within the chart, relative nutrient availability is represented by a bar. The wider the bar is, the more the nutrient is relatively available. For example, the nitrogen bar is widest between a pH of 6.0 to 7.5. This is the pH where it is most available to plants. It is very narrow between 4.0 and 4.5 and not as readily plant available.

It is also important to consider the alkalinity of the water. Alkalinity is a capacity measure. It measures the capacity of the water to neutralize the acid. This is due primarily to the combined amount of carbonate (CO_3) and bicarbonate (HCO_3), but hydroxide, ammonium, borate, silicate, and phosphate can also contribute.

When total alkalinity is low, the water has low buffering capacity. As a result, its pH will readily change depending on what is added to it. When total alkalinity is high, the pH of the water is high. Acid can be injected with irrigation water to decrease high pH water. The amount of acid needed depends on the alkalinity of the water.

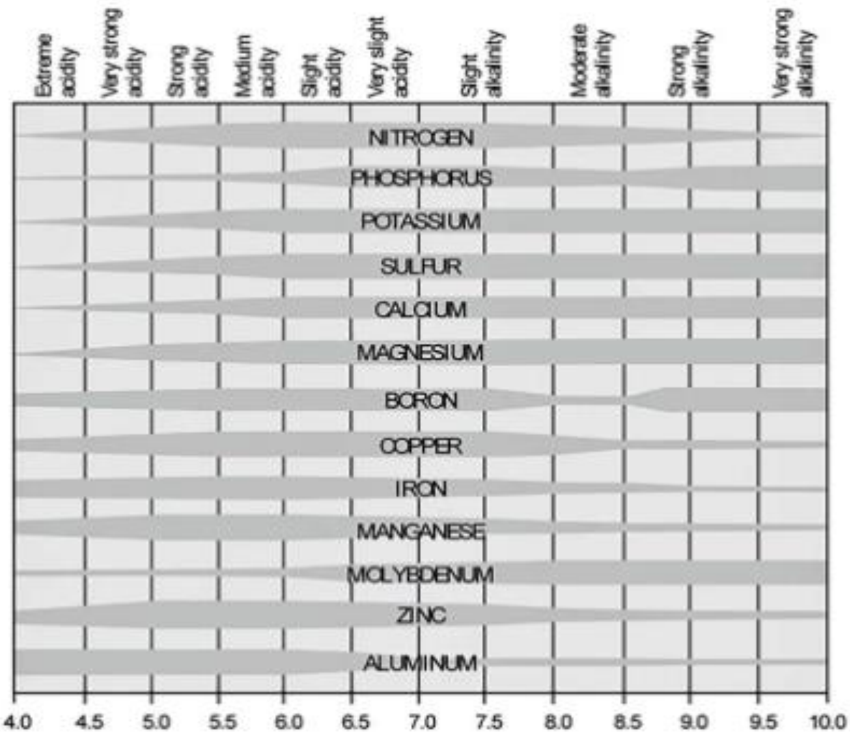


Fig 1.5: Nutrients ph chart

1.6 HTML Integration

In addition to its hardware automation capabilities, our hydroponic system is poised to embrace the digital realm through seamless integration with HTML. This integration represents a crucial step towards enhancing user accessibility and data management. By incorporating HTML, users will gain the ability to remotely access and interact with the hydroponic system via web-based interfaces. Through a user-friendly dashboard, individuals can monitor real-time sensor readings, track historical data trends, and receive tailored recommendations for optimizing plant growth. This integration not only facilitates greater convenience for users but also fosters a deeper understanding of hydroponic farming practices by providing valuable insights derived from data analysis. By bridging the gap between hardware automation and digital interfaces, our holistic approach to hydroponics aims to empower users with the tools and knowledge needed to cultivate thriving crops in an increasingly interconnected world[8].

CHAPTER 2
LITERATURE SURVEY

This complete work endeavours at automating the hydroponics system along with providing the possibility of distance monitoring and controlling the system using IoT. The hardware of the system along with the sensors, actuators and the software system all work towards obliterating the cumbersomeness of the entire producing process. This system not only breaks through the traditional methods of farming and improves the entire process but also makes it self-sufficient enough to produce anything at any time of the season. The software is integrated to the hardware of the actual system such that it displays the various parameters like Temperature, Humidity, pH levels etc. on the application that can be downloaded on the smartphones. Hydroponics helps in faster growth of plants and along with our regulating, monitoring and automated system, described diffusely in this article it obliquely meets the demand of the market. The traditional farming techniques can easily be replaced by these methods and can be implemented on scales desired by the producer depending on the amounts of produce to be expected.

IoT technology can completely transform the way hydroponic systems are managed and regulated, providing important advantages over conventional manual techniques. A thorough and effective monitoring and control system can be built using sensors and communication protocols, providing real-time data on the conditions of the hydroponic environment and enabling automatic modifications to be performed in response. An IoT-based system has the potential to adjust the temperature, humidity, pH level, and EC level in real time, improving agricultural output and environmental control. This potential is highlighted by the data in the table. Remote monitoring and management of the hydroponic environment are one of the main advantages of an IoT-based monitoring and control system. Real-time data utilization enables proactive environmental improvements by helping farmers to make more educated decisions and identify patterns that may affect crop development[7]. The system also depends on an uninterrupted and dependable internet connection, which might not be available everywhere.

Additionally, the system needs to be managed by trained employees, and technology suppliers must continue to offer support. Despite these drawbacks, an IoT-based monitoring system for hydroponic systems has several advantages, and it is anticipated that this approach will increase in the future. The system's efficiency is expected to rise as technology develops, lowering implementation costs and opening up access to hydroponic growers of all sizes. The application of the IoT approach in hydroponic systems appears to have a promising future, and this is an exciting time for the sector.

Table 2.1: Literature survey.

S. No.	Title	Methodology	Metrics	Limitations
1	"IoT-Based Smart Hydroponic System for Urban Agriculture"- *John Smith*	Deployed sensors for monitoring pH levels, nutrient concentrations, temperature. Integrated with cloud platform for remote monitoring and analytics.	real-time monitoring, data analysis	High initial costs associated with sensor deployment and networking infrastructure.
2	"Internet of Things Enabled Hydroponic Cultivation System"- *Emily Johnson*	Utilized sensors for monitoring pH levels, nutrient concentrations, temperature, and humidity.	Real-time monitorin g, Efficiency	Reliability concerns with system reliability.
3	"Smart Hydroponic Farming System Using IoT and Machine Learning" - *David Williams*	Employed sensors for monitoring pH levels, nutrient concentrations, temperature, and humidity.	predictive modeling, mobile app integration	High upfront costs for sensor deployment.
4	"Wireless Sensor Network-Based Smart Hydroponics System" - *Sarah Brown*	Implemented wireless sensor network for monitoring pH levels, nutrient concentrations, temperature, and humidity. Employed actuators for automatic adjustments.	Flexibility, Scalability, real-time monitoring	Complexity in system setup and configuration.

The proposed system in this paper is an automated smart hydroponics system, whereby this system will be able to add and implement Internet of Things concept and functionality to the current existing hydroponics system. A GUI that allows the user to control and monitor real time data has been successfully achieved by developing a user interface node for the NodeRed and linked with the real-time sensor data. Moreover, it is hosted on the cloud at Nodered.MohamedDjama.com to make accessible from everywhere. Nginx server was used to forward traffics from port 1880 to 80 which HTTP but to add more security an SSL certificate has been issued and added therefore traffics are redirected to 443 which is HTTPS. Internet of things concept is implemented to the system to ease the process of growing food hydroponically by easing the process of growing and monitoring via secure cloud. By adding the internet of things, it solves one the key challenges in automation today which is maintenance, by providing a platform for monitoring the entire system from cloud, thus reducing the cost of maintenance by fraction. Lastly, the performance of the smart hydroponic system is evaluated. The automated smart hydroponics system is designed for indoor usage, for a bigger scale using Wi-Fi isn't the ideal wireless network, and the system is a success and implemented successfully[11]. However, future work that can be done for further improvement will be by Integrating Data Analytics to the system or machine learning to develop algorithms to predict outcomes, add more sensors to get more accurate data and help the Artificial Intelligence system to predict the outcome better and by using intel C1000 microprocessor which comes built in with image processing for the crops health.

CHAPTER 3

METHODOLOGY

3.1 Existing System:

In the existing system the hydroponics cultivator can only monitor the necessary conditions required for plant growth such as humidity, temperature, water level, light intensity only by using some traditional cultivating methods. The most valuable measurement for your hydroponic system is its pH level. We need to have a top-notch pH meter and monitor the levels at least once a day. The cultivator can know the increase or decrease in necessary parameters and control it only if he is physically present at the sight[5]. This system has a disadvantage because the user can't control these parameters if he is in distance, since the system needs constant monitoring and control. The existing system doesn't satisfy the control of this agriculture completely.

Fig 3.1 Image of Existing hydroponic System

Limitations of Existing System:

Initial Cost:

Setting up a hydroponic system can involve higher initial costs compared to traditional soil-based methods.

Expenses include infrastructure, pumps, nutrient solutions, and monitoring equipment.

Complexity:

Hydroponic systems can be complex and require a certain level of technical knowledge. Beginners may find it challenging to set up and maintain an efficient hydroponic system.

Dependency on Technology:

Hydroponic systems heavily rely on technology, such as pumps, sensors, and controllers. Power outages or technical failures can disrupt the system, potentially impacting plant health.

Risk of System Failures:

Mechanical failures, such as pump malfunctions or clogging in nutrient delivery systems, can occur. These failures may lead to inadequate nutrient supply, affecting plant growth.

Sensitivity to Environmental Factors:

Hydroponic systems are sensitive to environmental factors like temperature and humidity. Fluctuations in these conditions can impact nutrient uptake and plant growth.

Disease Spread:

While hydroponic systems can reduce the risk of soil-borne diseases, they are not immune to pathogens. Diseases can still spread through water systems, affecting multiple plants.

Nutrient Imbalance:

Maintaining the correct balance of nutrients is crucial in hydroponics. If not properly monitored and adjusted, nutrient imbalances can occur, leading to deficiencies or toxicities in plants.

Dependency on Electricity:

Hydroponic systems often rely on electricity to power pumps, lights, and environmental control systems. Dependence on electricity poses a vulnerability, especially in regions with unreliable power infrastructure.

Skill and Knowledge Requirements:

Successful hydroponic cultivation demands a certain level of expertise and ongoing attention. Novice growers may struggle to grasp the nuances of nutrient management, pH control, and environmental optimization.

Limited Crop Variety:

While hydroponics can accommodate a variety of crops, some plants may still prefer or require the complexity of soil ecosystems. Root crops, for example, might be more challenging to grow hydroponically.

3.2 Proposed methodology:

A proposed hydroponic system is designed to revolutionize traditional cultivation methods by leveraging advanced techniques for optimal plant growth. This comprehensive hydroponic system aims to create a controlled environment where plants receive precisely measured nutrients, water, and light, maximizing their growth potential. The system includes several key components, starting with a nutrient reservoir that houses a precisely balanced solution of essential minerals, allowing for efficient nutrient uptake by plant roots. pH is strategically placed within the reservoir, ensuring constant monitoring and adjustment to maintain an ideal nutrient environment. The proposed system incorporates a network of drip irrigation or nutrient film technique (NFT) channels to deliver the nutrient solution directly to plant roots, promoting uniform distribution and minimizing water wastage. To regulate environmental factors, temperature and humidity sensors are integrated, enabling real-time adjustments to create an optimal climate for plant growth. Additionally, a light sensor system, paired with energy-efficient LED lights, ensures that plants receive the right spectrum and intensity of light for photosynthesis. The entire system is controlled by a smart automation system that utilizes data from sensors to manage nutrient delivery, irrigation schedules, and lighting cycles. With its emphasis on precision, resource efficiency, and automation, this proposed hydroponic system aims to enhance crop yields, shorten growth cycles, and offer a sustainable and controllable alternative to traditional soil-based agriculture [9].

3.2.1 Arduino:

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.

1.Microcontroller Platform:

Arduino is based on a simple microcontroller platform, making it accessible for both beginners and experienced makers.

2.Programming Language:

It uses a simplified version of the C++ programming language, making it easy for individuals without extensive coding experience to get started.

3.Open-Source Hardware:

Arduino boards are open-source, allowing users to examine, modify, and share the design, fostering a collaborative community of developers.

4. Versatility:

Arduino is versatile, supporting a wide range of sensors, actuators, and shields, making it suitable for diverse projects, from simple blinking LED setups to complex robotics.

5. Community Support:

The Arduino community is robust, providing forums, tutorials, and vast resources that facilitate learning and troubleshooting for users of all levels.

6. Rapid Prototyping:

Arduino excels in rapid prototyping, enabling users to quickly build and test electronic prototypes for various applications.

7. Integration with Sensors:

Arduino seamlessly integrates with sensors and modules, allowing users to easily collect and process data from the physical world.

8. IDE (Integrated Development Environment):

The Arduino IDE provides a user-friendly interface for writing, compiling, and uploading code to Arduino boards, simplifying the programming process.

9. Compatibility:

Arduino boards are compatible with a range of operating systems, including Windows, macOS, and Linux, enhancing accessibility for users on different platforms.

10. Education and Learning:

Arduino serves as a valuable educational tool, introducing users to electronics, programming, and the Internet of Things (IoT), fostering innovation and creativity in the field of embedded systems.

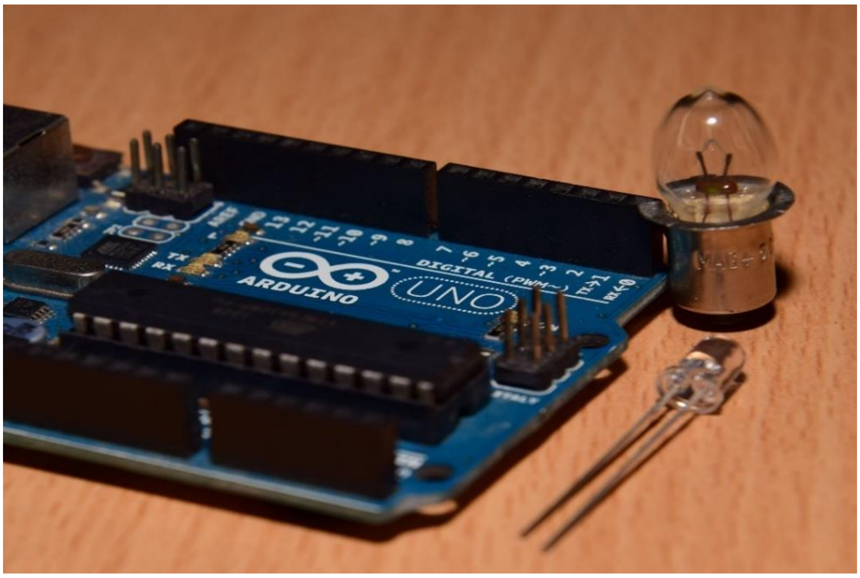


Fig 3.2 Arduino Uno

3.2.2 pH Sensors:

pH sensors in hydroponics are typically used in combination with pH controllers, which automatically adjust the pH of the nutrient solution by adding acids or bases as needed.

These sensors are available in various types, including glass bulb sensors and solid-state sensors, each with its advantages and suitable applications.

Monitoring and maintaining the pH level of the nutrient solution is essential for preventing nutrient lockout, a condition where plants are unable to absorb certain nutrients due to unfavorable pH levels.

In hydroponic systems, pH fluctuations can occur due to factors such as nutrient uptake by plants, evaporation, and the introduction of new nutrient solution. Regular monitoring helps prevent these fluctuations.

pH sensors are often integrated into larger hydroponic monitoring systems, providing growers with real-time data on pH levels alongside other important parameters such as temperature, humidity, and nutrient concentration.

Proper calibration and maintenance of pH sensors are crucial for accurate readings and reliable operation. Regular cleaning and calibration ensure consistent performance.

pH sensors can help identify and rectify problems in hydroponic systems, such as nutrient deficiencies or imbalances, before they affect plant health and yield.

Advanced pH sensors may offer features like remote monitoring and alerts, allowing growers to track pH levels and receive notifications on their mobile devices, ensuring timely intervention.

pH sensors are an integral part of precision agriculture in hydroponics, enabling growers to optimize nutrient delivery and pH levels for different plant species and growth stages, ultimately maximizing crop yield and quality.

Integration with Automation Systems: pH sensors can be integrated with automation systems to automate pH adjustment processes, further enhancing efficiency and precision in nutrient delivery[30].

Data Logging and Analysis: pH sensors can log pH data over time, allowing growers to analyse trends and make informed decisions to optimize nutrient solution management and plant health.

Fig 3.3 pH Sensor

3.2.2 Temperature Sensors:

Temperature sensors in hydroponics monitor both the nutrient solution and the surrounding environment. Maintaining an optimal temperature range (typically 18-24°C or 65-75°F) is critical for enzymatic activity, nutrient uptake, and overall plant metabolism.

These sensors allow growers to identify and rectify temperature fluctuations that could negatively impact plant growth and health.

Proper temperature control also helps mitigate the risk of pathogens, as many thrive in specific temperature ranges.

Temperature sensors can be integrated with remote monitoring systems, allowing growers to monitor and adjust temperature settings from a distance, improving convenience and efficiency.

Sensors can log temperature data over time, providing growers with valuable insights into temperature trends and fluctuations, which can help optimize growing conditions.

Temperature sensors can be used to automate environmental control systems, such as adjusting fans, heaters, or cooling systems, based on temperature readings, reducing manual intervention. Temperature sensors can be integrated with other sensors, such as pH and nutrient sensors, to provide a comprehensive view of the growing environment and ensure optimal conditions for plant growth.

Temperature sensors can serve as an early warning system for potential issues such as equipment malfunction or environmental changes, allowing growers to take proactive measures to protect their crops.

By maintaining a consistent temperature range, growers can improve energy efficiency by reducing the need for excessive heating or cooling, which can lead to cost savings.

Consistent monitoring and control of temperature using sensors can lead to enhanced plant development, including improved root growth, flowering, and fruiting, ultimately resulting in higher yields and better-quality produce.

Fig 3.4 Temperature Sensor

3.2.3 Humidity Sensor:

Humidity sensors track the moisture content in the air within the hydroculture environment.

Controlling humidity levels is essential for preventing mold and mildew, which can thrive in high humidity conditions.

Maintaining the right humidity range (usually 50-70%) influences transpiration rates and water uptake by plants.

Humidity sensors help growers create an environment that minimizes the risk of fungal diseases and supports healthy plant growth.

Humidity sensors help maintain optimal growth conditions by ensuring that humidity levels are within the ideal range for plant growth and development[3].

Proper humidity control can help prevent pest infestations, as many pests thrive in high humidity environments.

By controlling humidity levels, growers can improve nutrient uptake by plants, leading to healthier and more productive crops.

Maintaining the right humidity range helps reduce water stress on plants, particularly in dry environments, by minimizing transpiration rates.

Humidity sensors can be used in conjunction with ventilation systems to enhance air circulation, which is crucial for preventing stagnant air and mold growth.

Humidity sensors can act as an early detection system for issues such as leaks or malfunctions in irrigation systems, allowing growers to address them promptly.

Humidity sensors aid in optimizing plant resilience by helping growers maintain an environment that minimizes stressors such as excessive humidity, which can weaken plants and make them more susceptible to diseases.

Proper humidity control facilitated by humidity sensors can lead to improved nutrient absorption by plants, as optimal humidity levels support the efficient uptake of nutrients from the nutrient solution.

DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND

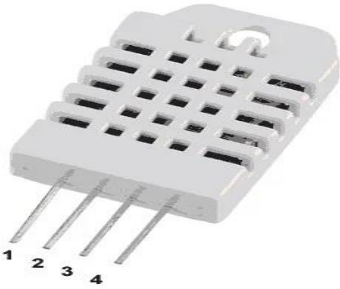


Fig 3.5 Humidity Sensor

3.2.4 Water level Sensor:

The water level sensor, often connected to an analog pin, measures the depth of the nutrient solution in the reservoir.

It provides real-time data on the water level, ensuring continuous monitoring of the nutrient solution's availability to the plants.

The sensor's readings dictate the activation or deactivation of the water pump based on predefined thresholds.

A higher water level indicates ample nutrient solution, triggering the water pump to turn off.

Conversely, a lower water level signals the need to activate the water pump, replenishing the nutrient solution.

Water level sensors help prevent the water pump from running dry by signalling when the nutrient solution is low, protecting the pump from damage.

By accurately measuring the water level, these sensors help conserve water by ensuring that only the necessary amount of nutrient solution is used.

Water level sensors automate the watering process by controlling the water pump based on the nutrient solution's availability, reducing manual intervention.

These sensors optimize the usage of nutrient solution by ensuring that plants receive an adequate amount without wastage.

Water level sensors can be integrated with monitoring systems to provide growers with real-time alerts and notifications about water levels, improving efficiency.

These sensors are designed to be adaptable to different reservoir sizes, making them suitable for a variety of hydroponic setups.

Water level sensors help prevent overwatering by ensuring that plants receive just the right amount of nutrient solution, avoiding waterlogged conditions that can lead to root rot and other issues.

By maintaining optimal nutrient solution levels, water level sensors contribute to improved plant health, ensuring that plants receive consistent access to the nutrients they need for growth and development.

Fig 3.6 Water level Sensor

3.2.5 Water pump:

The water pump, controlled by a dedicated pin, is responsible for circulating the nutrient solution through the hydroponic system.

It activates when the water level sensor detects a decrease in the nutrient solution below a specified threshold.

The pump ensures a continuous flow of nutrient-rich water to the plant roots, promoting optimal nutrient absorption.

Once the nutrient solution reaches an acceptable level, as indicated by the water level sensor, the pump deactivates to prevent overfilling.

This dynamic interaction between the water level sensor and pump is vital for maintaining a consistent and efficient hydroponic environment.

Water pumps in hydroponics are designed to be energy-efficient, ensuring that they consume minimal power while effectively circulating the nutrient solution.

Many water pumps allow for adjustable flow rates, giving growers the flexibility to customize the nutrient delivery based on plant needs.

Water pumps are compatible with various hydroponic systems, including deep water culture, nutrient film technique, and drip systems.

Water pumps are typically reliable and durable, providing consistent performance over extended periods with minimal maintenance.

Most water pumps are easy to install and operate, requiring simple setup procedures that can be done by growers without extensive technical knowledge.

Some water pumps come with safety features such as automatic shut-off mechanisms to prevent damage in case of malfunction or water shortages.

Water pumps contribute to enhanced oxygenation of the nutrient solution by creating movement and agitation, which helps oxygen dissolve into the water and reach plant roots, promoting healthy root development.

Water pumps help prevent stagnation in the nutrient solution, which can lead to the buildup of algae and other pathogens, by ensuring continuous circulation and aeration.

Fig 3.7 Water pump

3.2.6 Relay:

A single channel 5V relay module generally includes a coil, and two contacts like normally open (NO) and normally closed (NC).

A 5v relay is an automatic switch that is commonly used in an automatic control circuit and to control a high-current using a low-current signal. The input voltage of the relay signal ranges from 0 to 5V.

It is known as a single channel because only one relay is used and it operates on 5V.

Relay module consists of six pins such as normally open pin, normally closed, common, signal, VCC and ground pins.

Signal Pin: It is used to control the relay. This pin can be active low or active high.

High Current Capability: Despite being operated by a low-current signal, the relay can control high-current devices, making it suitable for various applications.

Versatile Applications: Single-channel 5V relay modules are versatile and can be used in a wide range of applications, including home automation, robotics, and industrial control systems.

Easy to Use: These relay modules are easy to use and can be interfaced with microcontrollers such as Arduino and Raspberry Pi without complex circuitry.

Protection Features: Some relay modules come with protection features such as diodes to protect the circuit from voltage spikes and reverse current.

Compact Size: The compact size of single-channel 5V relay modules make them suitable for applications where space is limited.

Cost-Effective: These relay modules are cost-effective and offer a reliable solution for switching high-current loads using a low-current signal.

Fig 3.8 Relay

Advantages:

Many hydroponics benefits make this an attractive farming method for the modern world. Such systems benefit the planet, offer ways to feed the growing population, and offer food supply protections against climate change. We'll describe ten of the most prominent benefits of hydroponics below.

1. Needs No Soil

The first and most clear benefit of hydroponics is that this growing method needs no soil. Why does this matter? Land degradation is a serious problem facing agriculture and the world today. As soil degrades, it becomes more and more difficult to farm in it.

Land degradation happens through both physical and chemical methods. Physical degradation relates to natural erosion and physical disturbance, as farming equipment may cause. Chemical degradation happens due to pollution and other types of contamination. Both kinds of degradation result in soil with fewer nutrients and less suited to growing healthy crops.

Hydroponic crops don’t contribute to soil degradation, so they can help slow land degradation. These crops aren’t affected by the results of this crisis either since they don’t rely on healthy topsoil for their nutrients.

2. Conserves Water

Water conservation is a primary concern in today’s world. It may seem counterintuitive to replace soil with water in a hydroponic system. In reality, such a system uses far less water than traditional, soil-based growing methods because the water used can be recycled repeatedly.

Outdoor farms lose a lot of water to evaporation and runoff. Pesticides and chemical fertilizers may also contaminate their water. A hydroponic greenhouse equipped to remove humidity from the air wastes very little water because the system recycles it. Such an approach doesn’t need dangerous chemicals to protect the plants from pests. Proper filtration and treatment allow the water to remain clean.

3. Facilitates a Micro-Climate

Technology in a hydroponic greenhouse allows growers to create the perfect conditions for each crop. Appropriate climate control in an enclosed system allows growers to program ideal micro-climates around each type of crop they grow.

One part of a hydroponic greenhouse may keep spinach at a chilly 55º F. Another area may house romaine lettuce closer to 70º F. When growers control micro-climates around each crop, they can produce more varieties in a single system.

4. Predictability and Seasonality

Most crops only grow in certain climates and during specific seasons. When people want summer crops in the dead of winter, grocers import them from other parts of the world. This contributes to the greenhouse gas crisis in transit.

Another issue revolves around predictability. So many factors contribute to crop yield. An early frost, drought, flood, or storm can destroy an entire field of crops and there is often nothing the farmer can do to stop it.

Indoor hydroponic farms allow growers to harvest predictable yields year-round. These crops grow all year long, regardless of weather or climate. And since they're protected from problems that can cause crop failure, the yields are far more predictable.

5. Crops Grow Faster

One promising development in hydroponic technology is the ability to harvest crops faster than in other methods. When each plant has optimal growing conditions, crops can grow faster and larger.

Many hydroponic growers report that their crops grow in half the time (or even less) of soil-grown versions of the same crops. This speed is most prominent in green leafy vegetables, but there are gains for nearly every variety of hydroponic plant.

6. Maximizes Space

If you're planning to go into soil-based farming on a large scale, you're going to need a lot of space to do it. Most traditional farms are in rural areas because the cost of land in densely populated areas is too high to make the effort profitable. Again, this leads to the need to move crops across the country from where they are grown to where they will be consumed.

When you grow crops in an urban or suburban area you must maximize the available space to make the operation profitable. For urban growers, hydroponic vertical farming is an excellent choice. By stacking plants vertically, you can grow more at one time in the same amount of space. When you add in the faster growing time of hydroponic plants, this is an exceptional way to maximize the space you have.

7. Produces Higher Yields

Global food shortages are common enough that we should prepare for them as a matter of routine. A hydroponic greenhouse allows growers to produce healthy food in less time and with far greater yields.

Yes, hydroponic greenhouses grow crops faster and maximize the use of space. But they also rarely lose crops to problems like pests and contamination. All this leads to more crops to harvest, greater profits for growers, and the ability to feed people more predictably.

8. Require Less Labor

Soil-based farming is labor intensive and can be grueling. While many parts of this growing method can be mechanized, steps like harvesting delicate crops still need a human touch.

While hydroponic greenhouses also use human labor, the compact nature of the facilities allows these tasks to be done more efficiently, meaning you can get more done with fewer people. Not only that, workers at these facilities are not subjected to dangerous chemical pesticides. Hydroponic careers take place in laboratory-like conditions that avoid the dangers of typical farm work and instead offer decent wages and benefits.

9. Shortens the Supply Chain

One of the greatest difficulties in our supply chain for fresh foods is the distance they must travel from the rural areas where they are harvested to the grocery store shelves where they are sold. If you're a fan of your local farmer's market, you probably understand how much better fresh fruits and vegetables taste. Hydroponic farming offers the opportunity to grow fresh foods within minutes or hours of the consumers who will eventually enjoy them.

Hydroponic farms allow grocers to stock fresher foods, often harvested within hours or days. They can also partner with hydroponic greenhouses to create white-label food options like bagged salads and fresh herbs. This shortened supply chain allows them to cut out middlemen and offer foods direct from the farm, straight to their customers.

10. Produces Higher Quality Food

Many people believe that food grown in a hydroponic system will taste watered down and lack essential nutrients. While this may be true for some home-based hydroponic growing systems, commercial hydroponic farms typically offer higher-quality crops than their soil-based counterparts.

Hydroponic crops enjoy carefully controlled environments and scientifically balanced nutrients in their water supply. They are not subjected to pollutants, pesticides, and other contaminants. Finally, they tend to be grown close to the areas where they will be consumed, so they are typically much fresher when they reach your table. All of this leads to crops that not only taste delicious but are at least as healthy as traditionally-grown crops of the same type.

3.3 Proposed model for Hydroculture using IOT:

3.3.1 Physical Structure

Open-air tower structure, approximately 3 feet tall with the water reservoir mounted underneath the base of the structure containing about 10 gallons of water. Main tower structure contains about 15-20 plant bays for plants to grow out of. The plant bay will be slightly slanted outwards at an angle from the center of the tower. This configuration allows for gravity to assist in water drainage back into the reservoir. The system should have ease of mobility via wheels mounted to the underside of the main hydroponic tower. Weather-proof LED light fixtures mounted to the structure and properly aimed towards the plant bays. TODO LED light wavelength. An even amount of light should be projected to all plants on the tower. The tower structure should be able to easily support 100lbs of constant, downward force to adequately remain standing while supporting the load of running water and plant growth.

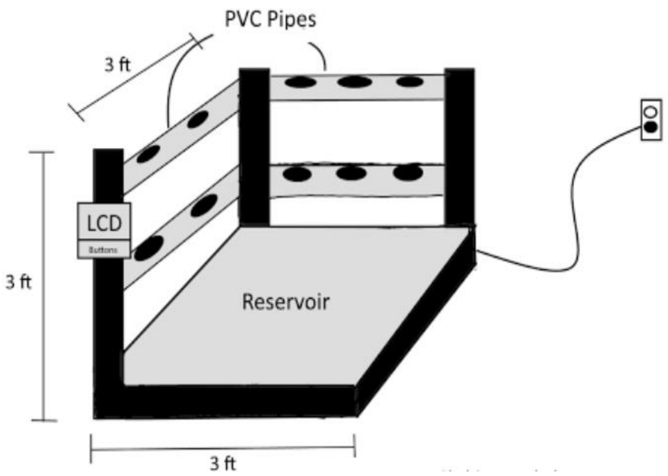


Fig 3.9 Physical Structure of reservoir

3.3.2 Water Level Management

The water pump must be strong enough to pump water up and through the tower system. Experts recommend that the system volume should be pumped completely every two hours. This implies that for a ten-gallon system, the water pump should be able to pump at the minimum rate of five gallons per hour at a head height of about 6ft. The ideal pH range for most hydroponic plants is between 5.5 and 6.5. The ideal water temperature range is between 65- and 80-degrees Fahrenheit. The nutrient strength levels generally range from 800 to 1500 ppm, depending on the current growth phase cycle that the plant is in. An oxygen stone will be needed to reside in the water reservoir in order to properly oxygenate the water as it is pumped to the plants.

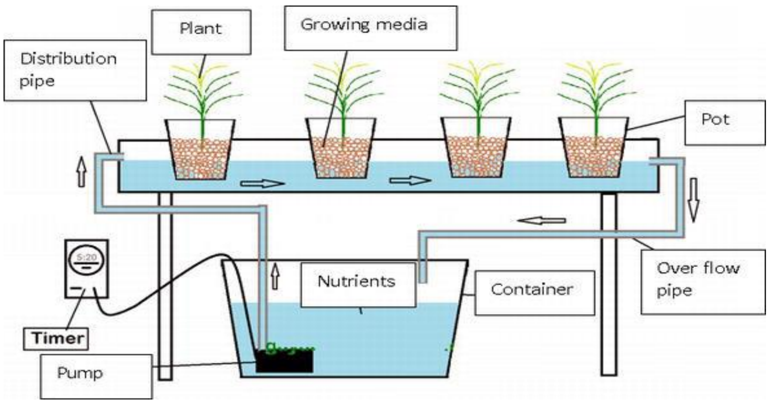


Fig 3.10 Diagram of hydroculture

3.3.3 Environment control

Maintain an optimal temperature range for the specific plant species being grown. This range can vary but is typically between 68°F (20°C) and 78°F (26°C). Use heating systems (e.g., heaters or radiant heating) to raise temperatures during cooler periods. Provide appropriate lighting conditions for plant growth, especially when using indoor hydroponic systems. Utilize high-quality LED grow lights that offer customizable spectrum and intensity control. Set up timers or automated systems to control the duration of light exposure, typically based on the temperature.

3.3.4 Nutrient Management

In hydroculture is a critical aspect of maintaining healthy plant growth and maximizing crop yields. Unlike traditional soil-based farming, where plants extract nutrients from the soil, hydroponic plants rely on nutrient solutions delivered directly to their root systems. Effective nutrient management involves providing the right balance of essential nutrients, monitoring nutrient levels, and maintaining proper pH levels. Implement continuous pH and EC monitoring to detect and correct deviations in real time. Utilize automated controllers to adjust pH and EC as needed based on sensor readings. Maintain the pH of the nutrient solution within the recommended range for the specific plant species (commonly between 5.5 and 6.5). pH levels affect nutrient uptake; deviations can lead to nutrient imbalances and plant stress. Use pH meters and pH-adjusting chemicals to control and adjust pH as needed.

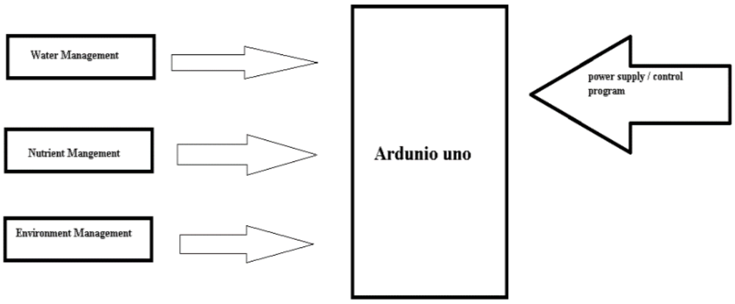


Fig 3.11 Image of System Design

3.4 Hardware Setup:

Gather all the parts shown in the image.

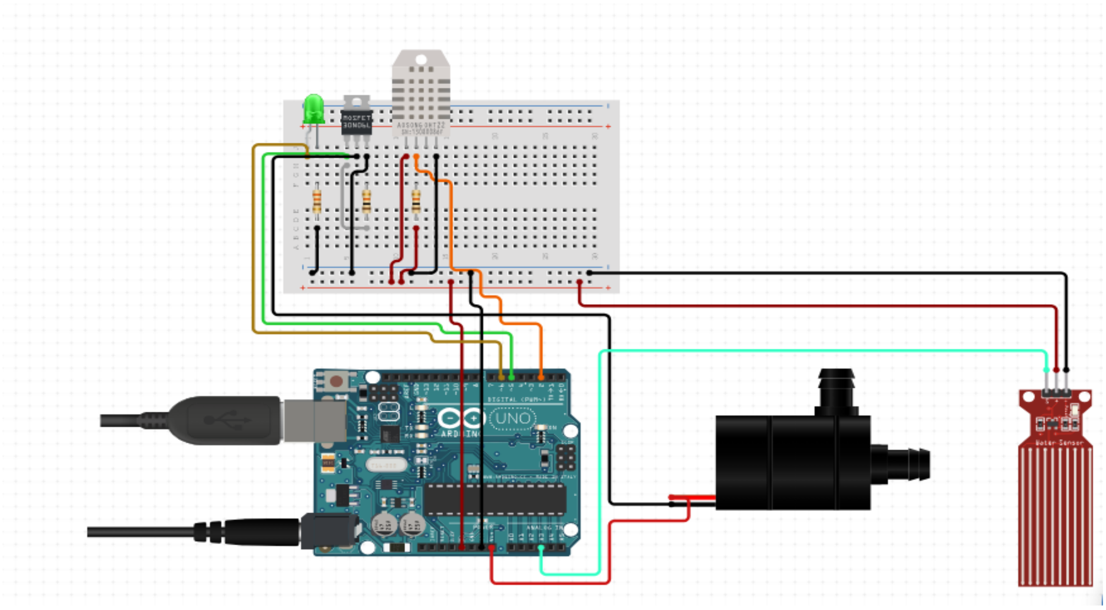


Fig 3.12 Circuit Diagram for implementation

3.4.1 Connections for Hardware setup

Temperature sensor

Connect + to 5v of Arduino

Connect out to 8 of Arduino

Connect - to GND of Arduino

Water Level Sensor

Connect Signal(S) to A0 of Arduino

Connect + to 5v of Arduino

Connect - to GND of Arduino

pH Sensor

Connect O/P (+) to A2 of Arduino

Connect O/P (-) to GND of Arduino

Connect Sensor (+) to 5v of Arduino

Connect Sensor (-) to GND of Arduino

Relay Module, Water Pump & AC bulb

Connect + of Water pump to Normally Open terminal (IN1) of relay module

Connect - of Water pump to GND of Arduino

Connect Common terminal (IN1) of relay module to 5v of Arduino

Connect VCC of relay module to 5v of Arduino

Connect IN1 of relay module to 7 pin of Arduino

Connect GND of relay to GND of Arduino

Connect IN2 of relay module to A1 of Arduino

Connect Normally Open terminal (IN2) to wire of plug(socket)

Connect relay module Common terminal (IN2) to wire of bulb

Keep the plug of bulb in the socket

Connect Arduino to Laptop using Cable

3.4.2 Algorithm

Read analog input from the pin connected to the water level sensor.

Check the water level:

If the water level is above a specified threshold and the pump flag indicates the pump is on:

Turn off the water pump.

Update the pump flag.

Introduce a delay.

If the water level is below a specified threshold and the pump flag indicates the pump is off:

Turn on the water pump.

Update the pump flag.

Introduce a delay.

If neither condition is met, introduce a longer delay.

Read temperature from the DHT sensor.

Check the temperature:

If the temperature is within a specified optimal range or below a minimum threshold:

Turn on the light.

If the temperature is outside the specified range:

Turn off the light.

Introduce a delay between sensor readings.

3.4.3 Flow Chart:

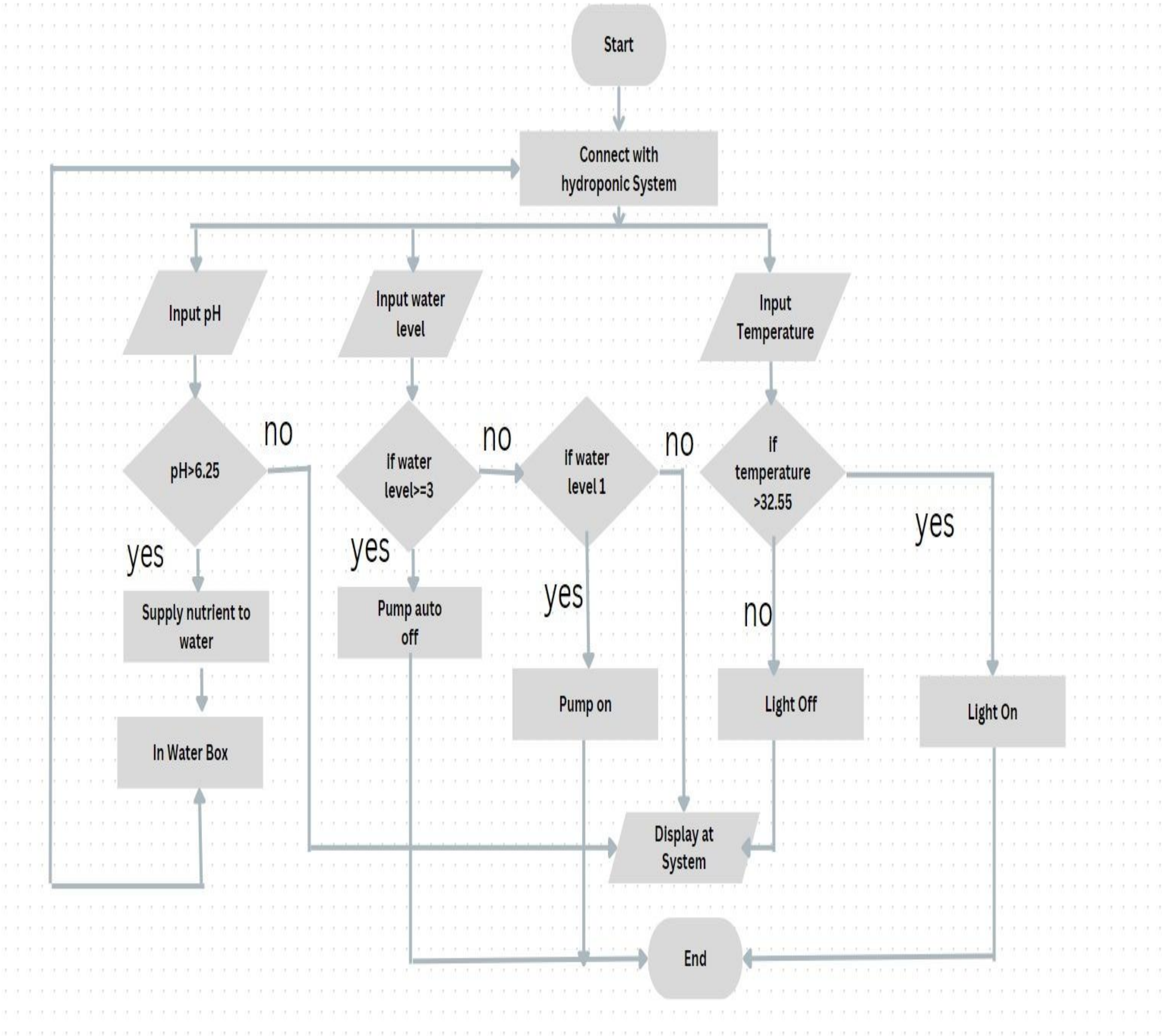


Figure 3.1: Proposed model flow diagram.

CHAPTER 4

RESULTS & DISCUSSIONS

In this section, we delve into a comprehensive examination of the proposed hydroponics approach, maintaining the right temperature is crucial for plant growth in hydroponic systems. The IoT system ensure that the temperature is controlled automatically, reducing the risk of heat stress or cold damage to the plants. By setting appropriate temperature thresholds, the system can optimize plant growth and yield. Proper light management is essential for photosynthesis and plant development. The IoT system responds dynamically to temperature changes. This feature prevents unnecessary energy consumption by turning on the lights only when required, reducing electricity costs and environmental impact.

Maintaining the correct water level is critical for plant nutrient delivery and overall system stability. The IoT system's ability to detect low water levels and activate the water pump ensures continuous nutrient circulation and prevents plant dehydration. This feature also helps conserve water by avoiding overflows. The IoT-based hydroponic system contributes to environmental sustainability by optimizing resource usage. Efficient temperature and light control reduce energy consumption, making the system eco-friendlier. Proper water management minimizes water wastage and promotes responsible water use.

In addition to this, The IoT-based hydroponic system contributes to environmental sustainability by optimizing resource usage. Efficient temperature and light control reduce energy consumption, making the system eco-friendlier. Proper water management minimizes water wastage and promotes responsible water use.

Fig 4.0 Image of bulb glow

4.1 Evaluation Metrics:

The evaluation of the hydroculture project model encompasses various metrics aimed at assessing its effectiveness, sustainability, and economic viability. Firstly, the growth of plants serves as a fundamental metric, with parameters such as growth rate, yield, and quality of harvested produce being crucial indicators. These metrics allow for comparisons between hydroponic cultivation and traditional farming methods, providing insights into the system's efficacy in supporting plant growth and development.

Resource utilization metrics focus on optimizing the efficient use of water, nutrients, and energy within the hydroponic system. Water usage efficiency measures the amount of water required per unit of crop yield, highlighting the system's ability to conserve water resources. Similarly, nutrient efficiency evaluates the system's effectiveness in utilizing nutrients for plant growth, while energy consumption metrics assess the energy efficiency of the system's components such as lighting and pumps.

Assessment of the environmental impact considers factors such as carbon footprint, water pollution, and land use efficiency. By quantifying carbon emissions, potential water contamination risks, and land utilization efficiency, the project can evaluate its environmental sustainability and minimize negative ecological impacts.

Performance evaluation metrics focus on the reliability, accuracy, and responsiveness of the hydroponic system. Reliable operation ensures consistent maintenance of optimal environmental conditions for plant growth, while accurate sensor readings enable precise monitoring and control. Additionally, evaluating the system's response time to environmental changes provides insights into its effectiveness in adapting to dynamic conditions.

Economic viability metrics assess the cost-effectiveness and return on investment of the hydroponic system. Cost-effectiveness considerations include initial investment costs and ongoing operational expenses compared to conventional farming methods. Calculating the return on investment involves analyzing financial returns generated from crop yields and market prices, as well as assessing market acceptance and demand for hydroponically grown produce.

Finally, user satisfaction and accessibility metrics focus on ensuring the system's ease of use, remote monitoring and control capabilities, and provision of adequate training and support to users. By evaluating these metrics comprehensively, stakeholders can make informed decisions regarding the implementation, optimization, and scalability of the hydroculture project model.

4.1 Code for Implementation:

```
#include <DHT.h>

#define relayPin A1    // Pin for controlling the light (relay)
#define DHTPIN 8        // Pin where the DHT22 is connected
#define DHTTYPE DHT22   // DHT22 sensor model
#define pumpPin 7       // Pin for controlling the water pump

DHT dht(DHTPIN, DHTTYPE);
int pH_Value;
float Voltage;

void setup() {
  Serial.begin(9600);
  pinMode(relayPin, OUTPUT);
  pinMode(pumpPin, OUTPUT);
  digitalWrite(pumpPin, HIGH);  // Turn off the pump initially
  dht.begin();
  pinMode(pH_Value, INPUT);
}
```

This Arduino code is a comprehensive solution for managing a hydroponic system. It integrates sensors and control mechanisms to monitor and adjust key environmental parameters crucial for plant growth. The code reads temperature and humidity data from a DHT22 sensor, ensuring that the climate within the hydroponic environment remains conducive to plant health. It also employs a water level sensor to maintain the appropriate water level in the reservoir, controlling a pump to add or drain water as needed. The pH sensor functionality allows the system to monitor the acidity of the nutrient solution, crucial for ensuring optimal nutrient uptake by the plants. Additionally, the code regulates a light source based on temperature readings, ensuring that plants receive adequate light for photosynthesis. Serial communication is used to provide real-time feedback on sensor readings and system status, enabling efficient monitoring and management of the hydroponic system. Overall, this code provides a robust solution for automating and optimizing the hydroponic growing process, ultimately leading to healthier and more productive plants.

```
void loop() {
  // Water Level Control
  int waterLevel = analogRead(A0);
  static int pumpFlag = 0;
  Serial.print("wl:");
  Serial.print(waterLevel);
  if (waterLevel >= 300 && pumpFlag == 1) {

    digitalWrite(pumpPin, HIGH); // Turn off the pump
    pumpFlag = 0;
    Serial.println("Pump off");
    delay(1000);
  } else if (waterLevel < 300 && pumpFlag == 0) {
    digitalWrite(pumpPin, LOW); // Turn on the pump
    pumpFlag = 1;
    Serial.println("Pump on");
    delay(1000);
  } else {
    delay(2000);
  }
```

Description about the library and functions used in the code

DHT.h: This library is used for interfacing with DHT temperature and humidity sensors. It provides functions to read temperature and humidity values from the sensor.

DHT: This is an instance of the DHT class defined in the DHT.h library. It is used to communicate with the DHT sensor connected to pin 8 of the Arduino board.

Serial: This is not a library, but a feature of Arduino that allows communication between the Arduino board and a computer or other devices over the serial port. It is used here for debugging and printing sensor values to the serial monitor.

pinMode (): This function is part of the Arduino core library and is used to set the mode of a pin (input or output).

digitalWrite (): This function is used to write a digital value (HIGH or LOW) to a specific pin.

analogRead (): This function reads the analog voltage value from an analog pin (A0, A1, A2, etc.).

analogWrite (): This function writes an analog value (PWM signal) to a PWM-capable pin, allowing for varying the intensity of the light (relay) connected to pin A1.

delay (): This function pauses the program for a specified number of milliseconds.

4.2 Output:

```
Water Level:64
Temperature: 31.80
Light ON
7.41
Water Level:70
Temperature: 32.00
Light ON
7.41
```

```
Water Level:53
Pump on
Temperature: nan
Light OFF
7.44
```

This Arduino sketch is designed for controlling a hydroponic system, integrating sensors to monitor and manage key aspects of the setup. The code includes functionality for reading a DHT sensor to monitor temperature and humidity, as well as sensors to measure water level and pH value.

The setup uses a relay connected to pin A1 to control a light source and a water pump connected to pin 7. The DHT sensor is connected to pin 8, and the pH sensor is connected to pin A2.

In the loop function, the code continuously reads sensor data and takes actions based on predefined thresholds. For instance, it monitors the water level and turns the pump on or off to maintain the desired level. It also regulates the light source based on temperature readings to ensure optimal conditions for plant growth. Additionally, it calculates the pH value based on the sensor's voltage reading and provides this information for monitoring and control purposes. The code includes serial communication to provide real-time feedback on sensor readings and control actions.

4.3 Html code:

```
index.html ×
<!DOCTYPE HTML>
<html>
<head>
    <title>Hydroponics using Arduino</title>
    <meta charset="utf-8" />
    <meta name="viewport" content="width=device-width, initial-scale=1, user-scalable=no" />
    <link rel="stylesheet" href="assets/css/font-awesome.min.css">
    <link rel="stylesheet" href="assets/css/main.css" />
    <link rel="stylesheet" href="assets/css/normalize.min.css">
    <link rel="stylesheet" href="assets/css/style.css">
    <noscript><link rel="stylesheet" href="assets/css/noscript.css" /></noscript>
</head>

<body class="is-preload">
    <div id="wrapper">
        <header id="header">
            <div class="logo">
                <span class="icon fa fa-tree"></span>
            </div>
            <div class="content">
                <div class="inner">
                    <h1>Hydroponics</h1>
                    <p>An automated Arduino-based Hydroponics system.</p>
                </div>
            </div>
            <nav>
                <ul>
```

The above code contains a title "Hydroponics using Arduino" and navigation links. It uses CSS for styling and includes a responsive design.

```
                    <li><a href="#intro">Intro</a></li>
                    <li><a href="#work">Work</a></li>
                    <li><a href="#about">About</a></li>
                    <li><a href="#join_us">Join Us</a></li>
                </ul>
            </nav>
        </header>

    <!-- Main -->
        <div id="main">

        <!-- Intro -->
            <article id="intro">
                <h2 class="major">Intro</h2>
                <span class="image main"><img src="images/hydroponics_introduction1.jpg" alt="" /></span>
                <span class="image main"><img src="images/hydroponics_introduction.jpg" alt="" /></span>
                <p>Hydroponics is a subset of hydroculture, the method of growing plants without soil, using mineral nutrient sol
                </br>Growing with hydroponics comes with many advantages, the biggest of which is a greatly increased rate of gro
                </br>Plants in a hydroponic system grow more quickly because they have food and water available to them all the t
                </br>All of this is possible through careful control of the nutrient solution and pH levels. A hydroponic system
            </article>

        <!-- Work -->
            <article id="work">
                <h2 class="major">Work</h2>
```

The above code defines sections for "Intro" and "Work" in the webpage, with navigation links to these sections. It includes images and descriptions related to hydroponics, highlighting its advantages and methods.

```html
            <span class="image main"><img src="images/image3.jpg" alt="" /></span>
            <!-- <span class="image main"><img src="images/breadboard.jpeg" alt="" /></span> -->
        </article>

    <!-- About -->
        <article id="about">
            <h2 class="major">About</h2>
            <span class="image main"><img src="images/nft.jpg" alt="" /></span>
            <p>The entire system mainly consists of a grow box, a water reservoir, a water pump and few sensors. </br>
            </br>The water pumps are attached to the nutrient solution, reservoir, water reservoir and the pH up down sol
            </br>When the EC sensor detects low-salt levels it indicates nutrient deficiencies. Therefore, in such situat
            </br>Overlooking pH control can be perilous for plants, particularly those that rely on water supplies with h
            The pH of the nutrient solution is a major factor in determining the uptake rate of many essential nutrient i
            The pH sensor detects the pH level of the water and prompts the pH up/ pH down pump to balance out the pH leve
            </br>The grow box has a drainage system which allows continous flow of nutrient solution runs over the plants
            </br>This type of system works very well because the roots of a plant absorb more oxygen from the air than fr
        </article>

    <!-- Join Us -->
        <article id="join_us">
            <h2 class="major">Join Us</h2>
            <div class="form">
            <ul class="tab-group">
                <li class="tab active"><a href="#signup">Sign Up</a></li>
                <li class="tab"><a href="#login">Log In</a></li>
            </ul>
```

The above code includes sections for "Work" and "About," displaying images and descriptions related to hydroponics. It also features a "Join Us" section with tabs for signing up and logging in.

```html
    <div class="tab-content">
        <div id="signup">
        <h1>Sign Up for Free</h1>
        <form action="index.html#join_us" method="post">
                <div class="top-row">
            <div class="field-wrap">
                <label>
                    First Name<span class="req">*</span>
                </label>
                    <input type="text" required autocomplete="off" name ="firstname" value=""/>
            </div>
            <div class="field-wrap">
                <label>
                    Last Name<span class="req">*</span>
                </label>
                    <input type="text" required autocomplete="off" name="lastname" value="" />
            </div>
            </div>
            <div class="field-wrap">
            <label>
                Email Address<span class="req">*</span>
                </label>
                    <input type="email" required autocomplete="off" name="email" value=""/>
            </div>
            <div class="field-wrap">
            <label>
                Set A Password<span class="req">*</span>
                </label>
```

The above code defines a "Sign Up" form with fields for first name, last name, email address, and password.

It uses CSS classes for styling and includes validation for required fields.

```html
                </label>
                    <input type="password" name="password" required autocomplete="off" />
            </div>
            <button type="submit" class="button button-block" name="reg_user" />Get Started</button>
        </form>
        </div>

        <div id="login">
        <h1>Welcome Back!</h1>
        <form action="ajax.html#login" method="post">
            <div class="field-wrap">
            <label>
                Email Address<span class="req">*</span>
                </label>
            <input type="email" name="email" required autocomplete="off" />
            </div>
            <div class="field-wrap">
            <label>
                Password<span class="req">*</span>
                </label>
            <input type="password" name="password" required autocomplete="off" />
            </div>
            <!-- <p class="forgot"><a href="#">Forgot Password?</a></p> -->
            <button class="button button-block" name="login_user"/>Log In</button>
        </form>
        </div>
    </div>
```

The above code includes a "Sign Up" form for new users and a "Log In" form for existing users. It uses CSS for styling and includes validation for required fields.

```
            <!-- /form -->
                <script src='http://cdnjs.cloudflare.com/ajax/libs/jquery/2.1.3/jquery.min.js'></script>
                <script  src="assets/js/index.js"></script>
            </article>
        </div>

    <!-- Footer -->
        <!-- <footer id="footer">
            <p class="github"><a href="https://github.com/kylelobo/Hydroponics" class="icon fa-github"> Gi
    </footer> -->
    </div>

<!-- BG -->
    <div id="bg"></div>
<!-- Scripts -->
    <script src="assets/js/jquery.min.js"></script>
    <script src="assets/js/browser.min.js"></script>
    <script src="assets/js/breakpoints.min.js"></script>
    <script src="assets/js/util.js"></script>
    <script src="assets/js/main.js"></script>

</body>
</html>
```

The above code includes a footer section and scripts for jQuery and custom JavaScript files for functionality. It also includes a background element ("bg") for styling purposes.

```
ajax.html
C: > Users > souja > Downloads > Hydroponics-master > Hydroponics-master > Hydroponics-master > ajax.html > ...

<!-- <?php
  session_start();
  if (!isset($_SESSION['username'])) {
    $_SESSION['msg'] = "You must log in first";
    header('location: index.php#join_us');
  }
?> -->

<!DOCTYPE html>
<html>
<head>
  <title>Sensor Data</title>
  <meta name="viewport" content="width=device-width, initial-scale=1, user-scalable=no" />
  <link rel="stylesheet" href="assets/css/font-awesome.min.css">
  <link rel="stylesheet" href="assets/css/main.css" />

</head>

<style>
body {
    background-image: url("https://www.treehugger.com/thmb/0fMEOKO5kN3rsZoTKaD3KZhw6qE=/1500x0/filters:no_upscale():max_bytes(150000):strip
    background-size: cover;
    /* background-position: center;  */
  }
table, th, td {
  border: 1px solid black;
  border-collapse: collapse;
}
```

The code defines a webpage for displaying sensor data, with a background image and styling for a responsive layout. It includes a table with borders collapsed for displaying the sensor data.

```
th, td {
  padding: 5px;
}
</style>

<body>

    <h1 align="center" >Welcome <strong></strong></h1>
    <p align="right"> <button type="button"><a href="index.html" style="color: white;"  >logout</a></button> </p>



  <br><h2 align = "center">Sensor Data</h2><br>

  <p align = "center">
    <button type="button" ><a href="displaydata.html" onclick="loadDoc()"> Display Data</button>
    <button type="button"><a href="home.html" style="text-decoration : none;">View Graphs</a></button>
  </p>
  <br><br>

  <table id="demo"></table>

  <script>
    function loadDoc() {
      var xhttp = new XMLHttpRequest();
      xhttp.onreadystatechange = function() {
```

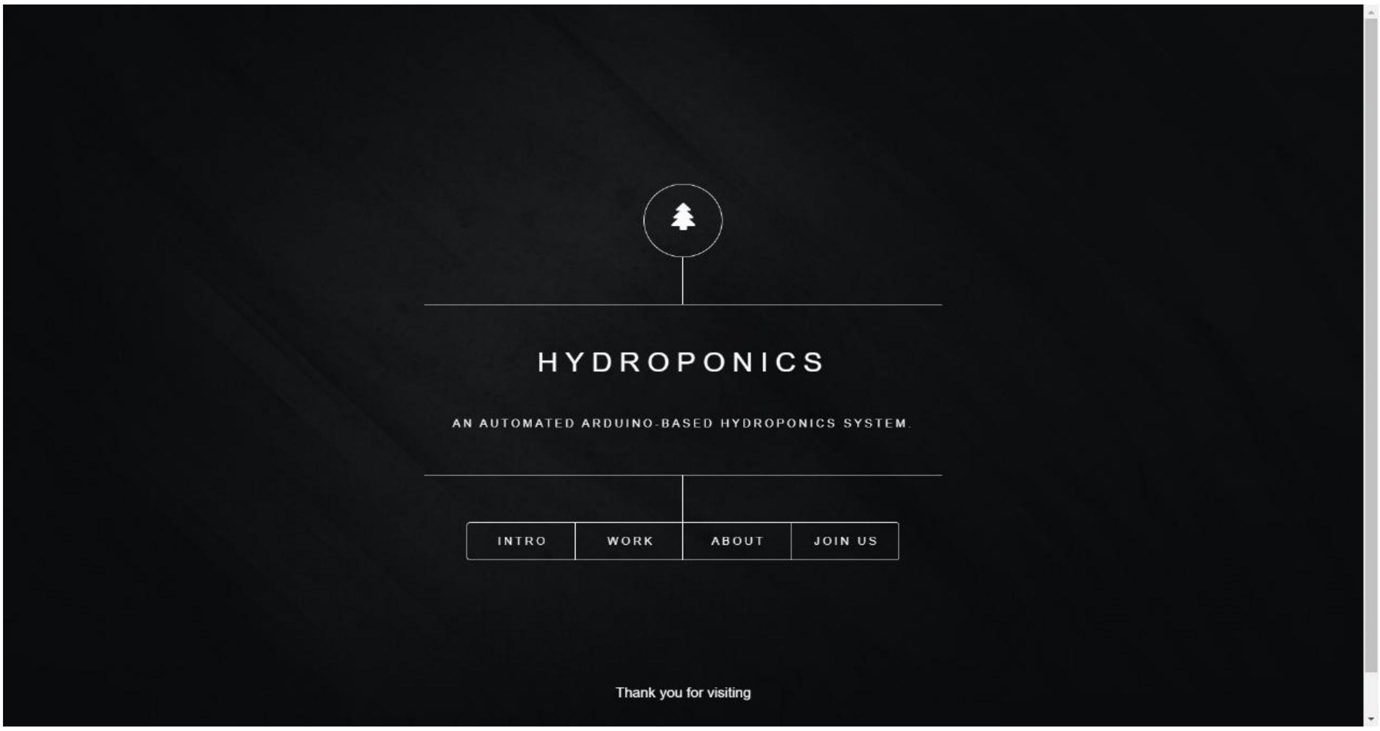
The code aligns the heading and buttons on the webpage, and it uses JavaScript to make an XML HttpRequest to fetch and display sensor data in a table.

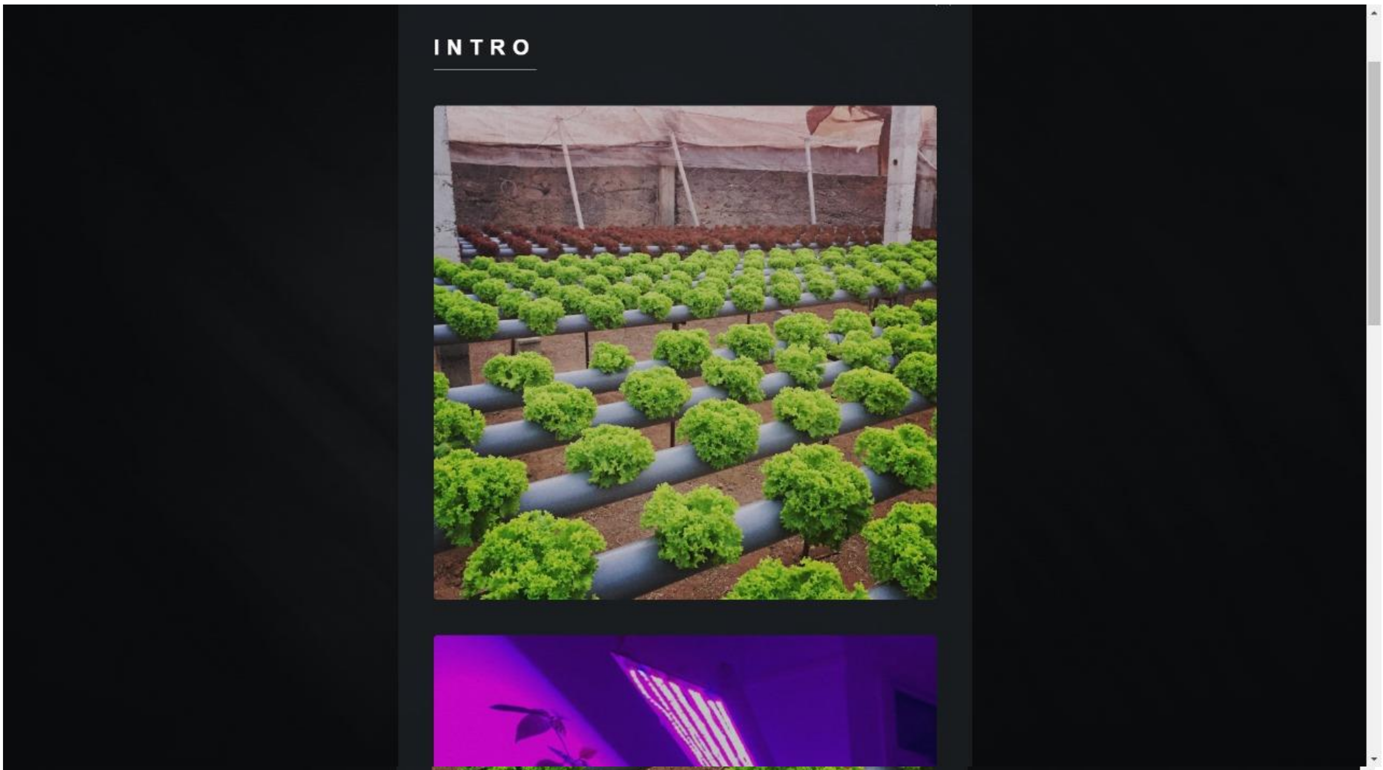
```
Click to add a breakpoint s.readyState == 4 && this.status == 200) {
          myFunction(this);
        }
      };
      xhttp.open("GET", "http://api.thingspeak.com/channels/593974/feeds.xml", true);
      xhttp.send(null);
    }
    function myFunction(xml) {
      var i;
      var xmlDoc = xml.responseXML;
      var table = "<tr><th>Temperature</th><th>Humidity</th><th>pH</th><th>Water Level</th><th>Water Temp</th><th>Soil Moisture</th></tr>";
      var x = xmlDoc.getElementsByTagName("feed");
      for (i = 0; i <x.length; i++) {
        table += "<tr><td>" + x[i].getElementsByTagName("field1")[0].childNodes[0].nodeValue +
        "</td><td>" + x[i].getElementsByTagName("field2")[0].childNodes[0].nodeValue +
        "</td><td>" + x[i].getElementsByTagName("field3")[0].childNodes[0].nodeValue +
        "</td><td>" + x[i].getElementsByTagName("field4")[0].childNodes[0].nodeValue +
        "</td><td>" + x[i].getElementsByTagName("field5")[0].childNodes[0].nodeValue +
        "</td><td>" + x[i].getElementsByTagName("field6")[0].childNodes[0].nodeValue +
        "</td></tr>";
      }
      document.getElementById("demo").innerHTML = table;
    }
  </script>

</body>
</html>
```

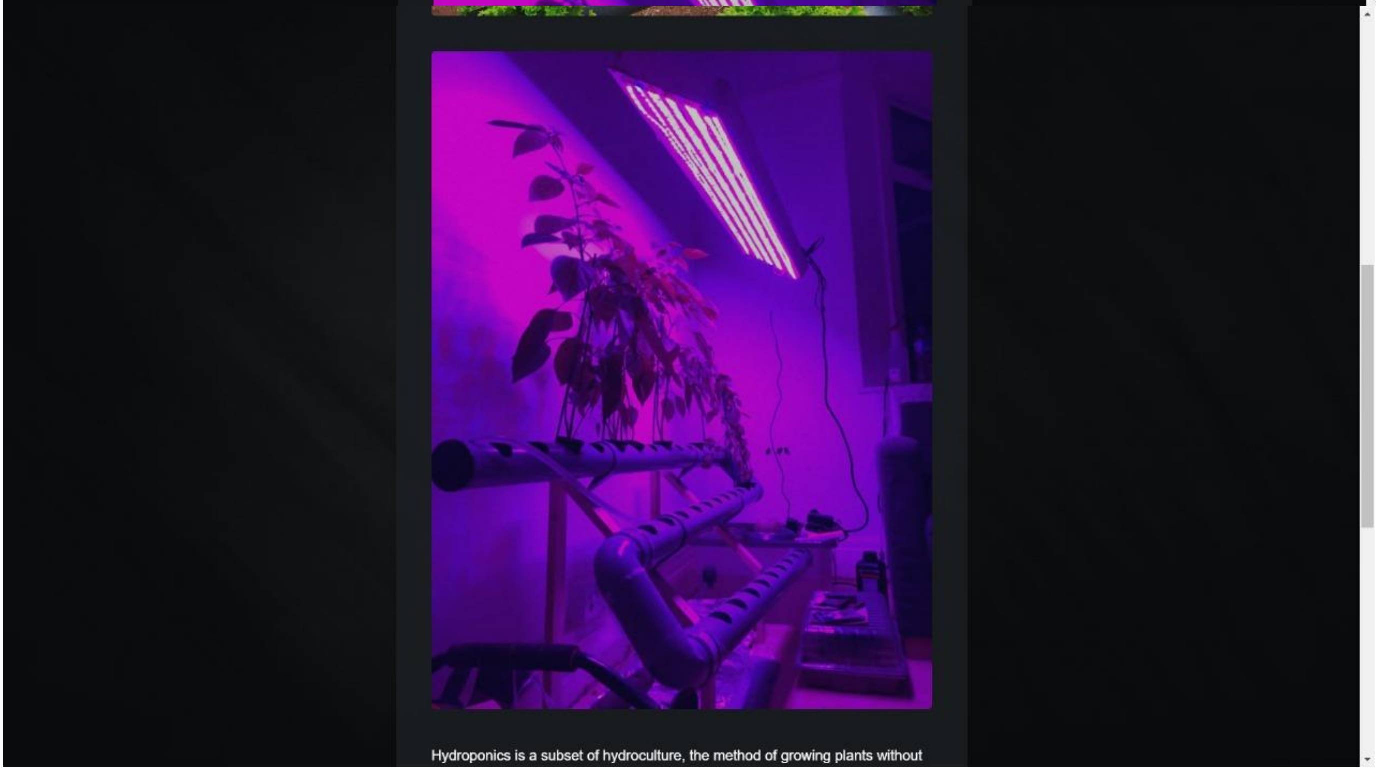
The code checks the status of an XMLHttpRequest and, if successful, parses the XML response to display sensor data in a table on the webpage. It fetches data from a specific URL and dynamically updates the table with sensor readings for temperature, humidity, pH, water level, water temperature, and soil moisture.

4.4 Implementation of Webpage:

The static webpages created for smart hydroponics to log in users offer a user-friendly interface for accessing and managing the hydroponic system. The login page provides a secure entry point where users can authenticate their identity using a username and password. Upon successful login, users are directed to a personalized dashboard displaying real-time data on crucial parameters like temperature, humidity, water level, and pH levels. A navigation menu facilitates easy access to different sections, including monitoring, control, and settings. The monitoring page presents detailed insights through graphs and tables, enabling users to track historical data and trends. The control page empowers users to adjust settings such as lighting and water pump activation. Additionally, a settings page allows customization of preferences. The webpages are designed with responsiveness in mind, ensuring a seamless experience across devices. Security measures, including HTTPS and password hashing, safeguard user data and system integrity, enhancing the overall user experience and system reliability.




INTRO


Hydroponics is a subset of hydroculture, the method of growing plants without

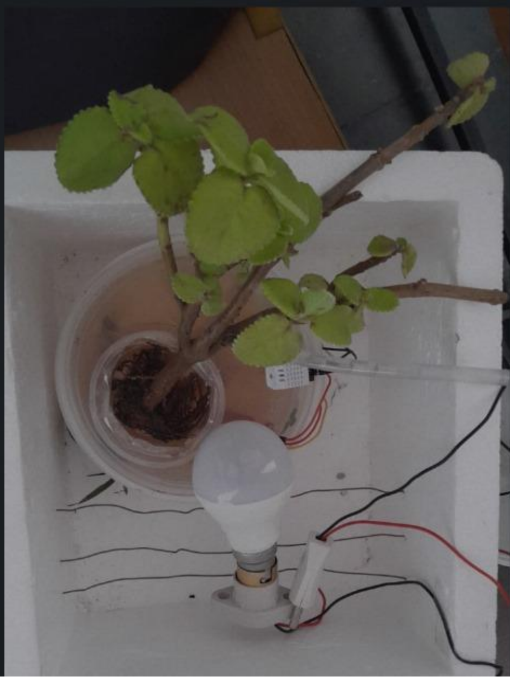
Hydroponics is a subset of hydroculture, the method of growing plants without soil, using mineral nutrient solutions in a water solvent. Terrestrial plants may be grown with only their roots exposed to the mineral solution, or the roots may be supported by an inert medium, such as perlite or gravel. The nutrients in hydroponics can come from an array of different sources; these can include but are not limited to byproduct from fish waste, duck manure, or commercial fertilisers.

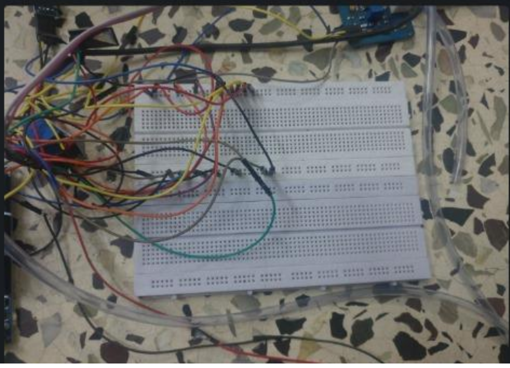
Growing with hydroponics comes with many advantages, the biggest of which is a greatly increased rate of growth in your plants. With a proper setup, your plants will mature up to 25% faster and produce up to 30% more than the same plants grown in soil.

Plants in a hydroponic system grow more quickly because they have food and water available to them all the time. They produce bigger crops because they can devote their energy to producing their crop rather than producing large roots such as would be needed in soil to seek out water and nutrients. Hydroponically-grown plants have smaller root systems because the roots do not need to go out looking for nutrients and water.

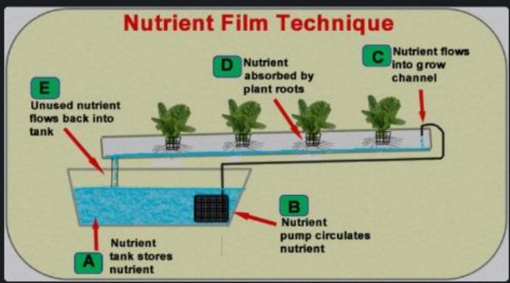
All of this is possible through careful control of the nutrient solution and pH levels. A hydroponic system will also use 70-90% less water than soil based plants because the system is enclosed, which results in less evaporation. Hydroponics is better for the environment because it reduces waste and pollution from soil runoff.

WORK





ABOUT

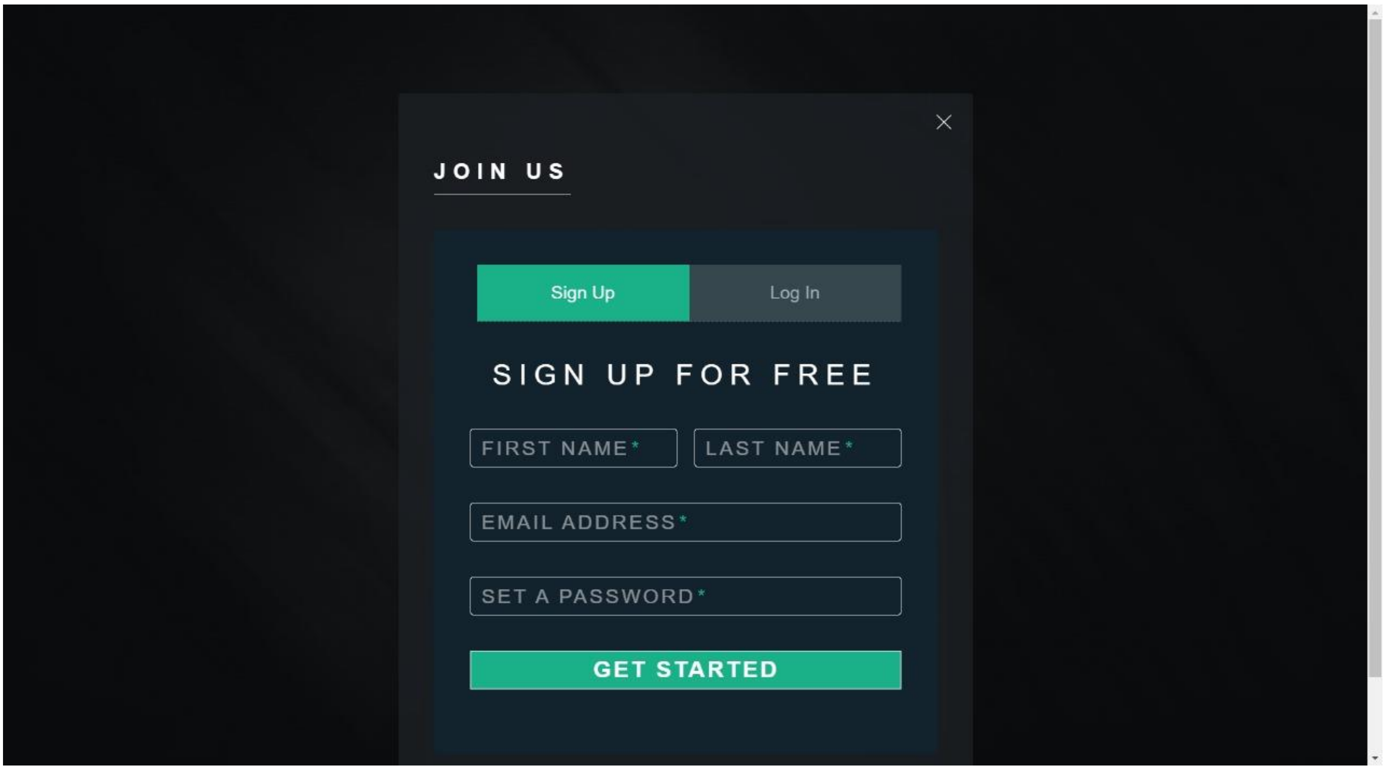


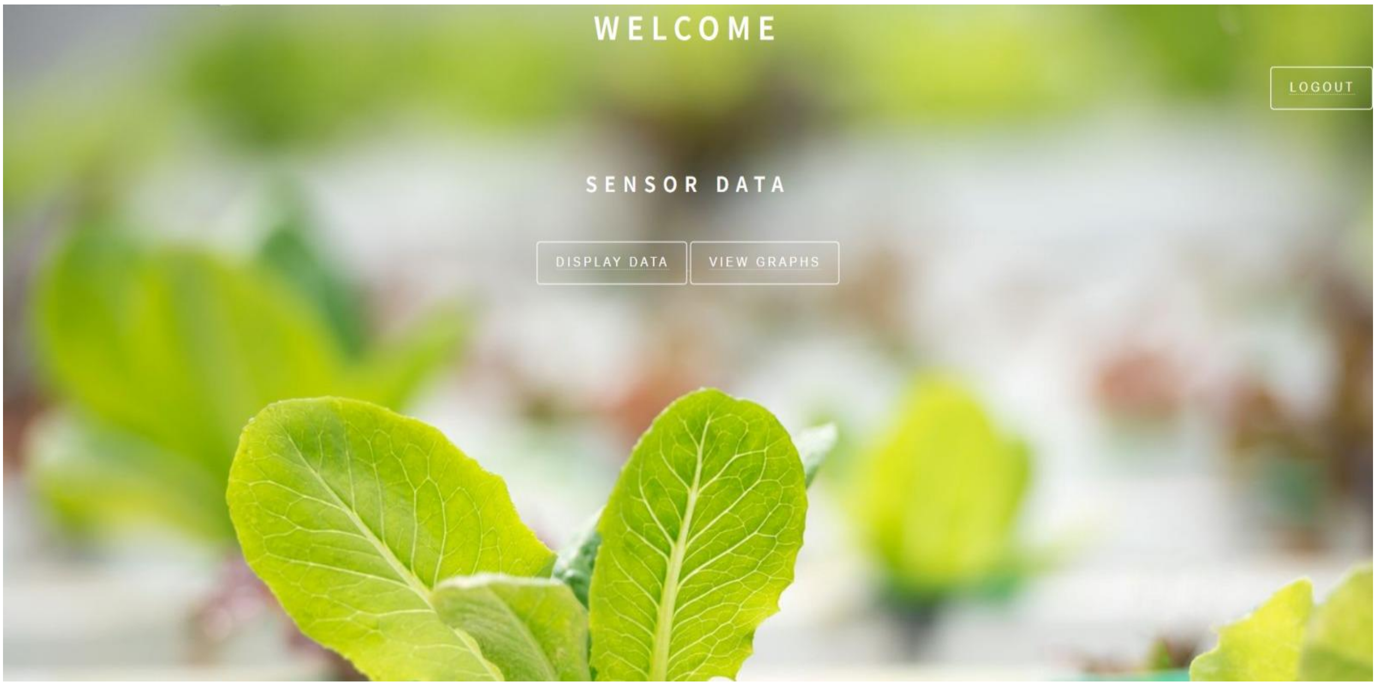
The entire system mainly consists of a grow box, a water reservoir, a water pump and few sensors.

The water pumps are attached to the nutrient solution, reservoir, water reservoir and the pH up down solutions. The water level sensor, temperature sensor, EC sensor, pH sensor are installed in the reservoir.

When the EC sensor detects low-salt levels it indicates nutrient deficiencies. Therefore, in such situations, the water pump pumps the nutrient solution to the reservoir. The presence of high salt levels/low water levels indicates that fresh water needs to be pumped to the reservoir.

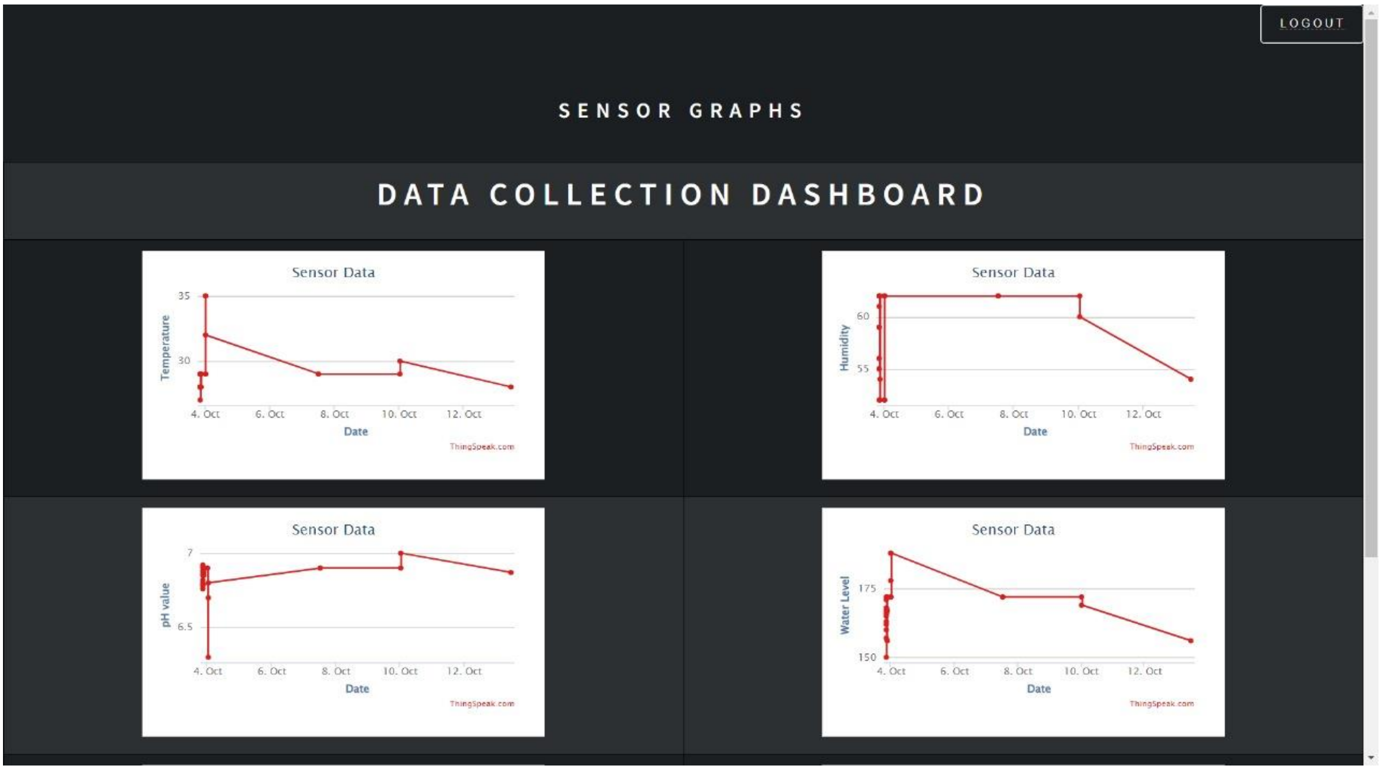
Overlooking pH control can be perilous for plants, particularly those that rely on water supplies with high alkalinity.
The pH of the nutrient solution is a major factor in determining the uptake rate of many essential nutrient ions. Run pH too high and the dreaded nutrient


JOIN US
Sign Up
Log In
SIGN UP FOR FREE
FIRST NAME*
LAST NAME*
EMAIL ADDRESS*
SET A PASSWORD*
GET STARTED


WELCOME
LOGOUT
SENSOR DATA
DISPLAY DATA
VIEW GRAPHS

DISPLAY DATA

Temperature	Humidity	pH	Water Level
28	55	6.92	150
28	56	6.90	163
28	59	6.91	160
29	62	6.86	157
28	59	6.88	162
27	55	6.79	168
28	59	6.8	168
28	62	6.76	172
28	61	6.78	165
29	62	6.79	166
29	62	6.79	166
28	56	6.82	171
29	52	6.85	167
29	52	6.85	167



The above webpage provides comprehensive information about hydroponics and an automated Arduino-based hydroponics system. It includes sections on the introduction to hydroponics, the working principles, advantages, and components of a hydroponic system. This information is valuable for individuals interested in learning about or implementing hydroponics for agriculture or hobbyist purposes.

Additionally, the webpage offers a platform for community engagement through the "Join Us" section, where visitors can sign up and participate in discussions or collaborate on hydroponics projects. The inclusion of a login and signup feature suggests the possibility of a community-driven platform where users can share experiences, ask questions, and learn from each other.

In a real-time scenario, this webpage could serve as an educational resource for students, teachers, and researchers studying hydroponics. It could also inspire DIY enthusiasts and hobbyists to create their own automated hydroponic systems using Arduino. Overall, the webpage provides a valuable resource for anyone interested in learning about or engaging with hydroponics.

CHAPTER 5
CONCLUSION

5.1 Conclusion

In this project, we have introduced a novel model of automation system for hydroponic plant irrigation using Arduino Uno Microcontroller based on Android is presented in this paper. Nutritional water flow system by utilizing sensor distance has been successfully done. The water level in the hydroponic tube can be adjusted according to the need of hydroponics, and this is made into a basic guideline for watering or not. The sensor results are sent to Arduino Uno microcontroller and communication with an Android smartphone. Likewise, the temperature setting has been successfully done well. The room temperature can be determined according to his needs. In our experiments, it was shown that the mixture of water and nutrients was automatically transferred to plant roots in hydroponic tubes. The water level is maintained up to 6 cm in hydroponic tubes because the system will drain water periodically if there is a water shortage.

5.2 Future Work

For future extension deals with the integration of a Wi-Fi module, allowing for enhanced monitoring and control capabilities. This addition enables growers to remotely manage key parameters such as nutrient solution levels, pH, temperature, and humidity using a smartphone or computer. Data logging and analysis become more accessible, facilitating the tracking of trends over time and the optimization of growing conditions for improved plant health and productivity. Alerts and notifications can be configured to alert growers of any deviations from optimal conditions, ensuring timely intervention. Furthermore, integration with smart home systems enables seamless control through voice commands and automation, enhancing the overall efficiency and convenience of hydroponic cultivation.

Fig 5.2 WiFi Module

WiFi module facilitates wireless communication between the hydroponic system and the internet, enabling remote monitoring and control. It connects to the Arduino microcontroller and transmits sensor data to a web server or cloud platform. Users can access a web-based interface from any device with internet access to view real-time sensor readings and adjust system settings. This integration enhances convenience and flexibility, allowing users to manage the hydroponic system remotely and optimize plant growth efficiently.

In addition to monitoring, the WiFi module enables remote control capabilities, allowing users to adjust system settings, such as nutrient dosages, lighting schedules, and environmental conditions, through the web interface. This remote-control functionality enhances convenience and flexibility for users, as they can make real-time adjustments to optimize plant growth and productivity without being physically present at the hydroponic system.

Furthermore, the integration of the WiFi module opens up possibilities for data logging, analytics, and notifications. Sensor data can be logged and stored in a cloud-based database, allowing users to track historical trends, analyse performance metrics, and make informed decisions for system optimization. Notifications can also be configured to alert users of critical events or deviations from desired parameters, ensuring timely intervention and proactive management of the hydroponic system.

Overall, the integration of a WiFi module into the HTML hydroponics project enhances connectivity, accessibility, and functionality, empowering users with remote monitoring, control, and management capabilities for efficient and sustainable hydroponic farming practices.

CHAPTER 6
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