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Smart hydroponic greenhouse enhanced with the application of the internet of things

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ABSTRACT

Rapid population growth and the urbanisation of agricultural areas to meet society's industrial and housing demands, have reduced the amount of land available for cultivation. Modern research has shown that the production of crops can be exponentially increased by providing the optimum conditions and essential nutrients, which differ for each type of crop. Seasonal crops that can only be grown during a particular time of the year can now be grown at any time. It has been shown that storing produce over a long period of time leads to a loss in the nutritional value of the food. Hence producing seasonal crops throughout the year can be achieved by creating a controlled environment. Hydroponics is a soilless method of growing plants, where nutrients are delivered to the plants via a water-based solution. In these systems, various aspects of the plant growth process, such as nutrient delivery, lighting, and temperature control, are managed by computerized systems. An automated hydroponic greenhouse with a nutrient monitoring system combines hydroponics with the IoT to create a smart, automated growing environment. One of the main benefits of using the IoT in automated hydroponics is the ability to collect and analyse data in real time. Hydroponic systems with IoT capabilities can be controlled and monitored via smartphones and computers. Producers may use the IoT to receive notifications on their mobile devices about potential issues such as low nutrient levels or pH imbalances, allowing them to take quick action to resolve the issue. This study describes an automated hydroponic greenhouse system that uses Internet of Things (IoT) technology to monitor and regulate the plant growing environment. To automate the greenhouse's environmental control and fertilizer supply systems, the system incorporates numerous sensors, controllers, and actuators.

KEYWORDS Automated hydroponics; internet of things (IoT); smart cultivation; cloud-based; greenhouse; message queue telemetry transport (MQTT)

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1. Introduction

Hydroponics is a method of growing plants that does not use soil and instead nourishes plants in nutrient-rich water solutions (Keerthana, 2018; Rajeswari and Saipriya, 2018; Sardare and Admane, 2013; Wang and Liu, 2014; Vijayakumar and Ramya, 2015). This approach is taken a step further in automated hydroponics, which uses technology to automate and improve the whole hydroponic process.

Sensors and controls in automated hydroponic systems often monitor and adjust the temperature, humidity, pH level, nutrient level, and light cycle within the growing environment. This technique may be utilised to produce the perfect growing conditions for many plant varieties, resulting in quicker growth rates, bigger yields, and higher-quality products.

Drip irrigation systems, nutrition film method systems, deep water culture systems, and aeroponic systems are examples of typical automated hydroponic systems. Each of these systems opts for a unique way to deliver nutrients and water to plants. But they all share the common goal of automating the hydroponic process for optimal results.

2. Related work

One of the most common agricultural approaches is hydroponics. In comparison to the old approach, the hydroponic method is cleaner and simpler. Hydroponics, according to experts, is the miraculous answer for growing plants in all types of environments, even dry deserts. It can assist people in learning about urbanised land and the fast growth of cities. Also, because the traditional approach requires such complicated soil, space might be an excellent source of food (Ezzahoui et al., 2021). The architecture, uses, and problems of IoT technology are explored in this article. Many applications for environmental and agricultural monitoring are presented (Saraswathi et al., 2018).

2.1. Improvisation of automated hydroponics

Using innovative technology to automate and enhance many components of the growing process is required to modernise automated greenhouse hydroponics. Some of the essential aspects that can increase the efficiency and productivity of a hydroponic greenhouse include:

2.2. Automatic nutrient supply

Hydroponic growth requires a precise nutrient delivery system, and automating this process can save time and costs. The hydroponic system can monitor nutrient levels and change supply as needed using sensors, software, and automation tools.

2.3. Climate control

To produce the optimal growth environment for plants, an automated greenhouse should be able to adjust the temperature, humidity, and lighting conditions. Sophisticated sensors and software can monitor and alter these variables as needed to achieve maximum plant growth and output.

2.4. Data analytics

Gathering information on plant growth, nutrient levels, and ambient factors can assist farmers to refine their hydroponic growing systems. The analysis of this data can uncover trends and insights that can be used to improve the growing techniques.

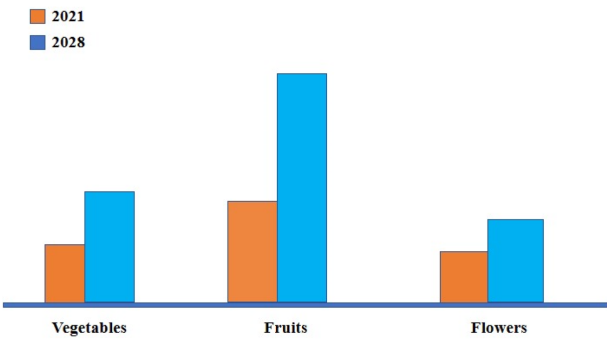

Figure 1. Data analytics of the hydroponics market.

2.5. Remote monitoring

The remote monitoring of automated greenhouse systems allows farmers to check on their plants and change the growth conditions from anywhere via an internet connection. This can help farmers save time and money on labour.

2.6. Artificial intelligence (AI)

This may be used to monitor plant health, anticipate production, and optimise the growing conditions. Machine learning algorithms can find trends and recommend changes by analysing the data on plant growth and nutrient levels.

3. Requirements and working of automated hydroponics

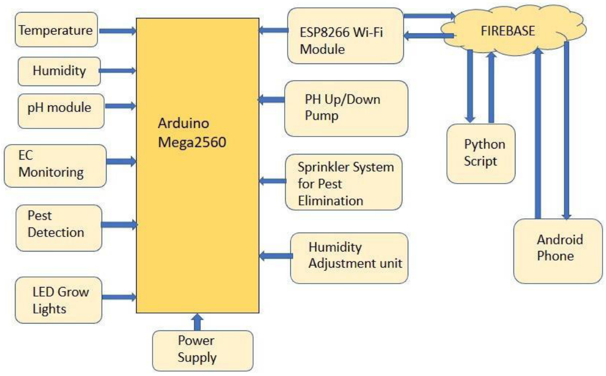

Figure 2. Block diagram of hydroponics.

An automated hydroponic system's fundamental operation includes the following components:

Equipment: The following needs must be met for the controller to be utilised for growth and automation, as well as for humans to use it.

(a) Arduino Mega 2560: The Arduino Mega 2560 is utilised as a controller. Many sensors are connected to the board. It includes up to 54 digital I/O pins, 16 analogue pins, a crystal frequency of 16MHz, and four hardware serial connections. It features interrupt pins and EEPROM, which means permanent storing is available; hence, it meets the interface requirements.

(b) Temperature and humidity sensor: DHT11 oversees this task. They have an accuracy of 0.1% and a reaction time of 2 seconds for temperatures up to 80 degrees Celsius. Their humidity range is 0 to 100%, which is enough for this system. The plants are extremely sensitive to temperature and humidity fluctuations; if both of these factors are high, the plants lose their capacity to transpire. As a result, it has a negative impact on their growth. After their roots have developed, they may adapt to a larger humidity range. An RTC (Timer circuit) may be used to keep track of the time, allowing the system to determine whether it is day or night.

(c) Real-time clock (RTC): The DS3234 RTC may be utilised over the SPI interface. It has an in-built power sensor that detects power outages and automatically sets the battery. The clock, which serves as the controller's focal point, is set to power on at regular intervals. The timer's accuracy is 2ppm between 0 and 40 degrees per C. It can support alarms, allowing it versatility for future applications.

(d) pH level and circuit: Crops have different preferences for pH levels. Controlling the pH is critical to preventing nutrition loss. If we were to pick one pH range, most crops would demand an acidic atmosphere (between 5.5 and 6.0). Nonetheless, most of them adjust to survive in the 7.5 range. The pH level is regularly monitored. Litmus tests are one approach for monitoring the hydrogen ion concentration levels. But, in gardening, these levels must be constantly monitored, which is accomplished by utilising pH sensors. These gadgets can connect to an Arduino.

PLANT	pH	GF	EG	PPM
Bean	6.0	20-40	2-4	1400-2800
Beetroot	6.0-6.5	8-50	0.8-5	1260-2500
Broccoli	6.0-6.5	28-35	2.8-3.65	1960-2450
Brussels Sprout	6.5-7.5	25-30	2.5-3.0	1750-2100
Cabbage	6.5-7.0	25-30	2.5-3.0	1750-2100
Capsicum	6.0-6.5	18-22	1.8-2.2	1260-1540
Cauliflower	6.0-7.0	5-20	0.5-2.0	1050-1400
Cucumber	5.8-6.0	17-25	1.7-2.5	1190-1750
Garlic	6.0	14-18	1.4-1.8	980-1260
Lettuce	5.5-6.5	8-12	0.8-1.2	560-840
Onions	6.0-6.7	14-18	1.4-1.8	980-1260
Bell Peppers	6.0-6.5	20-25	0.8-1.2	1400-1750
Potato	5.0-6.0	20-25	1.4-1.8	1400-1750
Pumpkin	5.5-7.5	18-24	2.0-2.5	1260-1610
Radish	6.0-7.0	16-22	1.6-2.2	840-1680
Spinach	5.5-6.6	18-25	1.8-2.5	1260-1610
Sweet Corn	6.0	16-24	1.6-2.4	840-1680
Sweet Potato	5.5-6.0	20-25	2.0-2.5	1400-1750
Tomato	5.5-6.5	20-50	2.0-5.0	1400-5500

Figure 3. pH, GF, EG and PPM values for various plants.

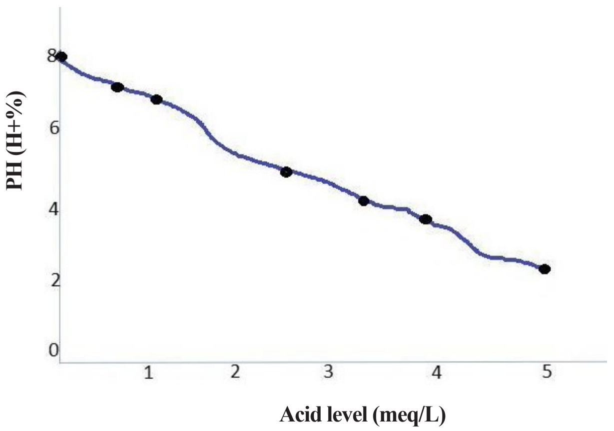

Figure 4. pH level vs acid level.

(e) EC level and circuit: Nutrients are mineral salts that are dissolved in water. An electrical conductivity meter can measure the strength of the nutritional solution. As each nutrient has a variable salt content, it may lack some nutrients or have plenty of one nutrient, etc. This results in EC measurements at a constant pH.

(f) Air temperature: The controller displays the air temperature on the screen in real time. A red light indicates when the level is outside the optimum range. Nevertheless, the temperature of the air may be adjusted, and a fan may be employed for extensions.

(g) Light levels: Light levels might be an issue for plant development in hydroponics. For the nourishment of vertical hydroponic plants, LEDs may be regulated and modified to any desired colour temperature. A LED grow light system may be used to simulate the environmental conditions.

4. Working of automated hydroponics

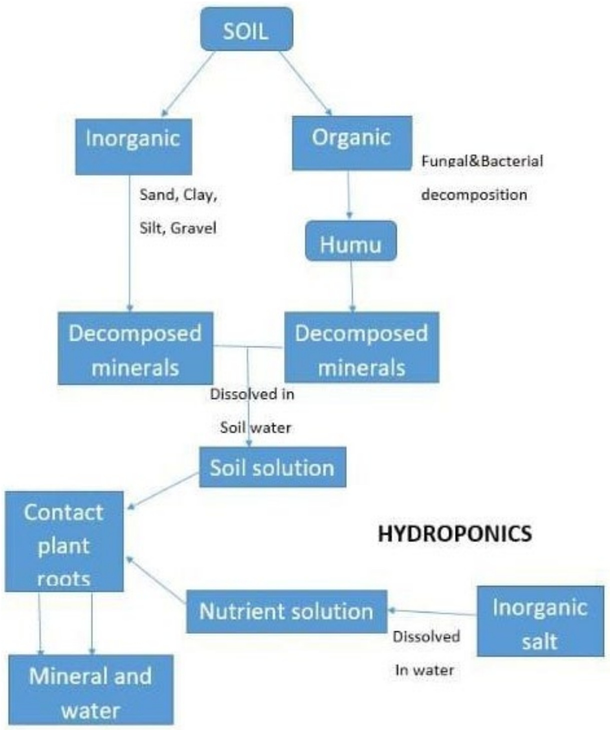

Figure 5. Workflow of hydroponics.

Here is a full description of how hydroponics works:

Selecting a hydroponic system: There are several hydroponic systems available, including deep water culture, nutrient film technology, aeroponics, and drip irrigation. Each system has advantages and disadvantages, and the system chosen is determined by the type of plant being produced, the available area, and the budget.

Setting up the system: Once the hydroponic system has been selected, it must be correctly set up. Preparing the containers or growth beds, installing the pumps, and configuring the nutrient solution are all part of this process.

Preparing the nutrition solution: A nutrient solution is a solution made up of water and vital nutrients for plant development. The nutrients in the solution may differ based on the plant being cultivated. The solution is typically mixed in a big tank, and the pH and nutrient levels are routinely checked.

Planting the seeds or seedlings: The plants are either cultivated from seeds or put into the hydroponic system as seedlings. To support the plant and offer oxygenation to the roots, the plants are placed in net pots or growth trays and coated with a growing material such as rockwool, perlite, or coconut coir.

When the plants are placed in the hydroponic system, it must be checked on a regular basis. This involves keeping track of the pH, nutritional level, water temperature, and oxygen level. The plants must also be checked for symptoms of disease or pests.

Harvesting: When the plants are fully ripe, they are harvested. Because the plants are produced in a controlled environment and are easily accessible, the hydroponic system makes harvesting them simple.

Regular maintenance is required for the hydroponic system. Maintenance involves cleaning the containers, repairing any broken pieces of the system, and changing the nutritional solution.

The plants are grown in net pots or growth trays with a growing medium. The system is periodically checked, and the plants are harvested as they reach maturity. To guarantee maximum plant development, the hydroponic system must be maintained on a regular basis.

5. The IoT in automated hydroponics

The Internet of Things (IoT) can be useful in hydroponics, which is a way of growing plants without soil in a nutrient-rich water solution. IoT devices and sensors can aid in the automation and optimisation of different parts of hydroponic farming, resulting in higher crop yields, lower resource use, and greater control overgrowth conditions.

IoT systems produce a great deal of data, which can be researched in order to understand vital information. Real-time anomalies or deviations from the ideal conditions can be found using sensors. This makes it possible to identify potential problems like nutrient deficits, pests, or diseases early on. Early action may minimise losses and aid to avoid crop damage.

Figure 6. Growth of plants in a hydroponic system.

5.1. Data storage and connectivity dependability

The database collects and organises the data. The data, which include temperature, humidity, pH value, and daylight exposure, is sorted by plant or greenhouse area and mapped to its Crop Virtual Entity before being prepared for analytics. Also, the server will monitor the link or localhost to ensure the connection's stability. If the server does not receive data, it will request that it be retransmitted. If there is still no response, the server will infer that there is a problem with the connection or host and will notify the user.

5.2. Livestream monitoring

The user can access and monitor livestream surveillance from any location. The owner of the greenhouse can utilise this feature to check on the progress of the greenhouse from a distance. The RPi camera constantly captures images at the set frame rate and delivers the live stream to the local address's designated port (Jaiswal et al., 2019).

5.3. Remote monitoring using smartphones

The digital divide that existed between IoT technology and agricultural farmers has been bridged. Productivity will be increased through the use of IoT technology in the sustainable cultivation of food crops. Smart agriculture (IoT-based greenhouse) includes operations such as automatic watering, an automated environment management mechanism, remote monitoring, fertilising, and frost protection (Farooq et al., 2022). Sensor data from the greenhouse is collected and sent to a cloud-based platform for analysis and visualisation using a real-time data acquisition and management system. The Internet of Things (IoT) refers to implementable Machine-to-Machine (M2M) interactions, which are a critical component of the recent growth in automated hydroponic systems monitored by IoT devices (Ray, 2017). The GSM module in the smartphone is specifically created for the Internet. This software operates because the Arduino UNO will bind itself. Without manual control, one may continuously monitor the environment and the farm from a smartphone. The application can be remotely configured on all remote devices (Elsokah and Sakah, 2019). The platform has an easy-to-use interface for remote monitoring and the management of the greenhouse environment.

Figure 7. Remote monitoring using a smartphone system.

5.4. Examples of how IoT may be utilised in hydroponics

Environmental Monitoring: IoT sensors may be used to monitor several environmental elements in the hydroponic system, including temperature, humidity, light levels, and pH levels. This can assist farmers to optimise the growth conditions and ensure that plants receive the nutrients which they require to flourish.

Monitoring Water Quality: IoT sensors may also be used to check the quality of water in a hydroponic system. Farmers may use this to confirm that the fertilizer solution has the proper pH and that there are no dangerous chemicals or pathogens in the water.

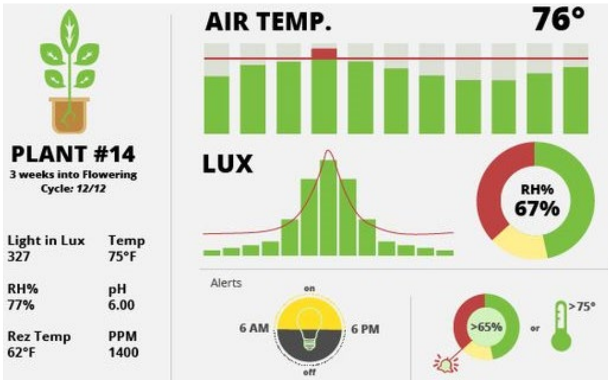

Figure 8. Automation monitoring of temperature, pH, light, and humidity.

Nutrient delivery: IoT devices may also be utilised to automate the fertiliser supply to plants. This can assist to guarantee that the plants receive the appropriate nutrients at the appropriate time, resulting in healthier plants and larger agricultural yields.

Lighting automation: IoT devices may be utilised to automate the lights in a hydroponic system. This can assist to ensure that plants receive the proper quantity and kind of light for maximum development.

Pest control: IoT devices may also be used to identify and control pests in a hydroponic system. Sensors, for example, can detect the presence of pests and initiate an automatic response to destroy them.

Overall, the IoT may bring useful data and insights into hydroponic farmers' growing operations, helping them to optimise the growth conditions and increase crop yields.

6. Components for IoT application

Automated hydroponic greenhouse and nutrient monitoring system using IoT involves several components and steps, including hardware and software components. Here is a general outline of the process.

Hardware components

- Raspberry Pi 3 or 4
- Sensors: pH Sensor, TDS Sensor, Temperature and Humidity Sensor
- Water Pump
- Solenoid Valve
- LED Grow Lights
- Power Supply
- Breadboard or PCB
- Jumper Wires
- Relay Board

Software components

Python Programming language
MQTT Broker
Node-Red
Mosquitto MQTT Client

Step 1: Connecting the sensors

Connect the sensors to the Raspberry Pi via the breadboard or PCB, using the jumper wires. The sensors should be placed in the hydroponic system to monitor the pH, TDS, temperature, and humidity levels.

Step 2: Setting up the water pump and solenoid valve

Connect the water pump and solenoid valve to the Raspberry Pi, which will control the flow of water and nutrients to the hydroponic system.

Step 3: Connecting the LED grow lights

Connect the LED grow lights to the Raspberry Pi, which will control the timing and intensity of the lights for optimal plant growth.

Step 4: Writing the code

Write a Python program to read the data from the sensors, control the water pump and solenoid valve, and control the LED grow lights. Use the MQTT protocol to publish data to an MQTT broker, which can be accessed remotely. Use Node-Red to create a dashboard to display the data.

Step 5: Testing the system

Test the system to make sure that it is working correctly. Monitor the data on the dashboard to ensure that the pH, TDS, temperature, and humidity levels are within the desired range. Adjust the system as needed.

7. Various applications of the IoT in automated hydroponics

IoT (Internet of Things) automated hydroponics is a contemporary approach that incorporates the use of sensors, controllers, and internet connectivity to automate many parts of hydroponic systems. The Internet of Things (IoT) is the most productive and necessary approach for developing problem-solving solutions. Sensors, apps, network elements, and other electronic devices serve as the foundation for the IoT. It also increases the efficacy of knowledge. The Internet of Things enables data to be shared over a network without the need for human interaction (Priya and Sudha, 2021). There are numerous types of IoT-enabled automated hydroponic systems

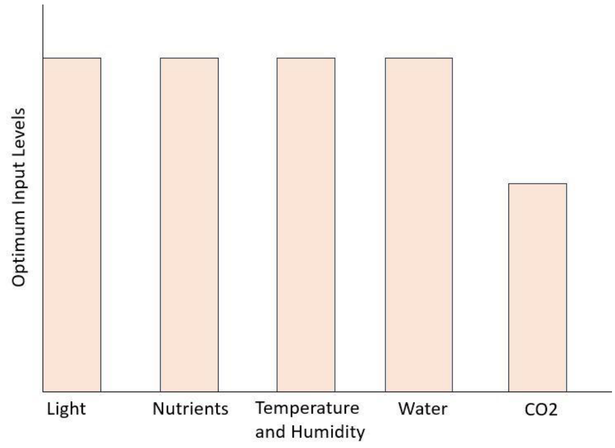

Figure 9. Limiting factors of plant growth.

7.1. Automatic nutrient delivery systems

These systems employ sensors to monitor the pH and nutrient levels of the hydroponic solution and modify the nutrient supply as needed. This ensures that the plants receive the appropriate amount of nutrients at the appropriate time, resulting in increased plant growth and productivity.

7.2. Automatic lighting controls

These controls employ sensors to gauge the hydroponic system's light output and modify the artificial lighting as necessary. This guarantees that plants receive the right quantity of light for photosynthesis, resulting in better plant development and output.

7.3. Automatic humidity and temperature regulation systems

These systems employ sensors to monitor the humidity and temperature in the hydroponic system and change the climate control as necessary. This guarantees that the plants develop in the best possible environment, resulting in increased plant growth and productivity.

7.4. Automatic irrigation systems

These systems utilise sensors to gauge the humidity levels in the hydroponic system and modify the watering as necessary. This guarantees that plants receive the appropriate amount of water at the appropriate time, resulting in better plant growth and yield.

8. Types of automated hydroponics

The systems for automated hydroponic greenhouses are created to offer fine control over the environmental elements including temperature, humidity, lighting, and fertiliser delivery to maximise plant development and raise yields. The following are some examples of popular automated hydroponic greenhouse systems:

8.1. Nutrient film technique

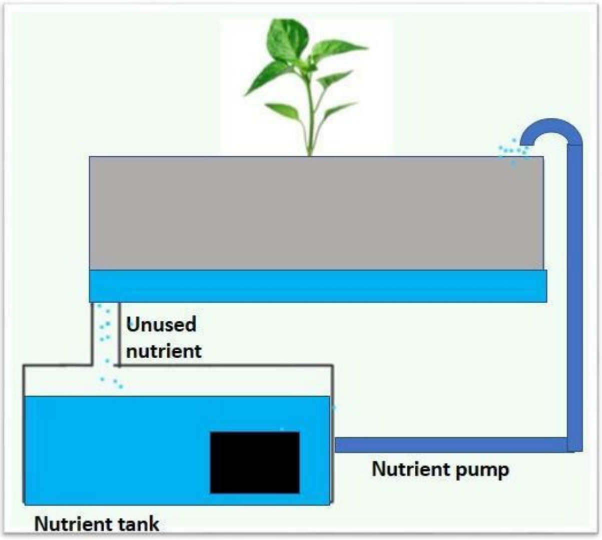

Figure 10. Nutrient film technique system.

Cooper developed the nutrient film method (NFT) in 1976 (Saraswathi et al., 2018), which comprises growing plants in a nutrient-rich stream of water. In this system, a thin film of nutritional solution runs constantly down a channel or gutter, with plant roots floating in the solution.

A growth tray, a nutrient reservoir, and a pump that circulates the nutrient solution throughout the system comprise the basic setup of an NFT system. The growth tray is usually constructed of PVC, plastic, or other non-porous material, and it includes multiple small holes or slits through which the plant roots may develop. With an NFT system, plant roots are continually exposed to oxygen and nutrients, allowing them to absorb the components essential for growth and development. The danger of disease and insect infestation is decreased since the roots are suspended in the air and do not come into contact with the growth media.

The system is highly flexible for a wide range of crop production and is ideal for short-term crops such as lettuces, leafy greens, herbs, and crops. Larger NFT systems are ideally placed for long-term crop production like cucumbers and tomatoes (Burrage, 2006; Sheikh, 2006). NFT systems, on the other hand, require constant monitoring and maintenance to ensure that the nutrient solution is maintained at the right pH and nutrient level.

Graves (1983) provided an outstanding assessment of the following benefits of the nutrient film approach over traditional hydroponics:

The chemical environment of all the roots is more closely controlled; the nutrient supply is uniform and can be matched to the plants' needs as they grow (Richardson, 1982; Winsor, 1980); rather than heating the entire greenhouse, good results can be obtained by simply heating the nutrient solution (Orchard, 1980; Moorby, 1982); it is simple to disperse the chemicals required at low concentrations for crop protection throughout the entire system (Price & Dickinson) (Terence and Purushothaman, 2020).

8.2. Drip irrigation technique

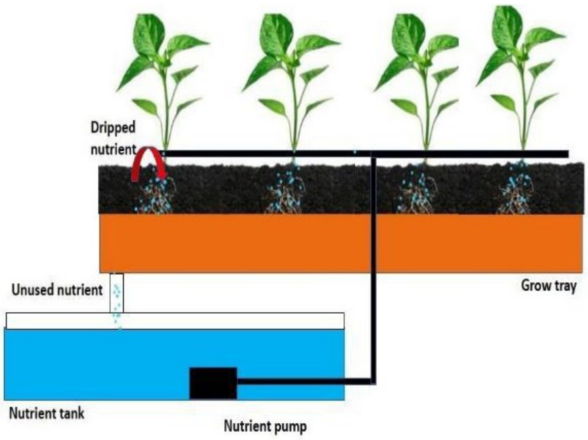

Figure 11. Drip system.

A hydroponic drip system is a type of hydroponic system that uses a drip irrigation system to supply nutrient-rich water straight to the plant's roots. Plants are cultivated on a soilless media, such as perlite or rockwool, and the fertiliser solution is dripped over the medium, where the plant roots absorb it. The former is referred to as recovery drain hydroponics, while the latter is known as a non-recovery drain hydroponic system (Modu et al., 2020). A hydroponic drip system provides exact control over the amount of fertilisers and water delivered to each plant. This can assist to boost plant development and productivity while lowering the chances of overwatering or underfeeding. Additionally, due to the closed-loop architecture, the system can be more water-efficient than traditional soil-based farming, making it a more sustainable agricultural choice. The drip system consists of a reservoir that houses the nutritional solution, a pump that circulates the solution, and a series of tubes or pipes with drip emitters that supply the solution to the plants. The emitters may be adjusted to manage the flow rate of the nutrient solution to each plant, ensuring that the right quantity of water and nutrients is delivered. In order to make the nutrient solution drip slowly, plants are typically placed on growth medium that is only moderately absorbent (Gaikwad and Maitra, 2020).

Aeroponics technique

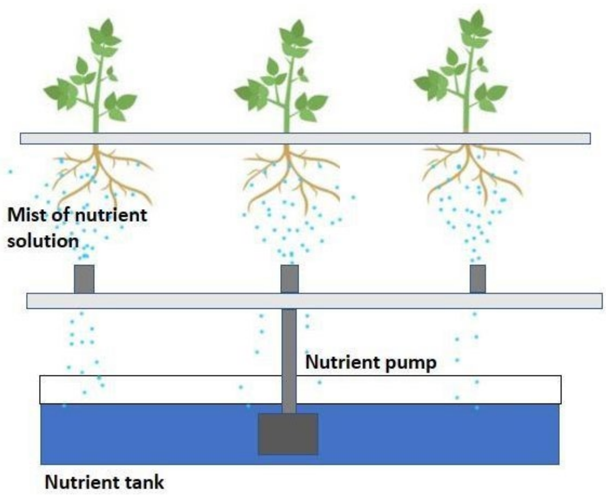

Figure 12. Aeroponic system.

Aeroponics is a sort of hydroponics in which plants are cultivated in a mist or fog environment. In this method, plants are grown while having their roots suspended in the air exposed to constant nutritional solution spraying (Gaikwad and Maitra, 2020).

In aeroponics, plant roots are hung in a dark, humid atmosphere, and the nutritional solution is supplied to them via a mist or fog. This improves oxygenation, which is vital for healthy root development and enables more effective nutrient uptake since the nutrient solution can reach all areas of the roots. Aeroponics is a newer hydroponic system approach; however, it has been shown to be quite successful in generating healthy plants with large yields. Aeroponics provides a number of advantages, including quicker growth rates, larger yields, less moisture usage, and a reduced dependency on pesticides and other chemicals.

9. Advantages

(a) Precision control: The hydroponic system's environment, which includes temperature, humidity, pH levels, and nutrient levels, is monitored and managed by IoT sensors to provide the best conditions for plant growth.
(b) Real-time info: The IoT sensors offer real-time information on the plant's progress, water use, fertiliser uptake, and other critical characteristics, enabling farmers to make knowledgeable judgements regarding the management of the system.
(c) Reduced labour expenses: Automated hydroponics employing IoT systems may automate many of the manual labour tasks involved in conventional farming, such as watering, fertilising, and monitoring, resulting in lower labour costs and more efficiency.
(d) Increased yields: Plants may grow more quickly and produce higher yields using a hydroponic system because the environment can be precisely regulated.
(e) Space-efficiency: Hydroponic systems are more space-efficient than conventional farming methods, making them perfect for urban settings or places with a shortage of available land.
(f) Water-saving: Since hydroponic systems recycle and reuse water, they consume less water than conventional agricultural techniques.
(g) Less negative environmental effect: Automatic hydroponics utilising IoT systems may drastically cut the consumption of pesticides and fertilisers, resulting in a decreased negative environmental impact.

In general, automated hydroponics employing IoT systems can provide important benefits over conventional agricultural techniques in terms of precision, efficiency, production, and sustainability.

10. Disadvantages

(a) High setup costs: The cost of sensors, pumps, controllers, and other equipment might be expensive when setting up an automated hydroponic system utilising IoT technology.
(b) Complexity: Hydroponic systems may be complicated, and leveraging IoT technology to set up an automated system calls for certain knowledge and skills.
(c) Dependency on technology: Automated hydroponics using IoT systems is very reliant on technology, and any system malfunctions or equipment failures can have a major impact on plant growth and output.
(d) Energy usage: Automatic hydroponic systems powered by IoT technology consume more energy since the sensors, pumps, and controllers need a consistent flow of electricity to function.
(e) Crop variety: crop diversity is lacking since hydroponic systems are only good for cultivating a few different kinds of plants.
(f) Concerns about water quality: Hydroponic systems need a steady supply of clean, nutrient-rich water, which can be difficult in places with low water quality or limited access to clean water.
(g) Disease outbreak risk: Disease outbreaks have the potential to spread swiftly throughout hydroponic systems, harming plant development.

Thus, even though automated hydroponics employing IoT systems provides many benefits, it is crucial to carefully consider the hazards and difficulties posed by this technology before making a financial commitment to one.

11. Hydroponics worldwide

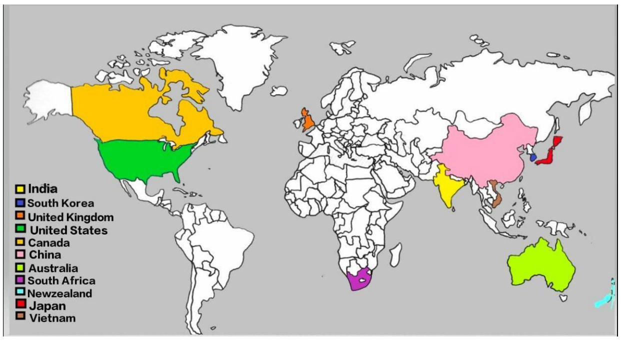

Figure 13. Worldwide countries that use hydroponics.

One of the most demanding and involved agricultural endeavours is the cultivation of vegetables in greenhouses. In particular, in the United States, Canada, Western Europe, and Japan, hydroponics is rising in popularity when combined with greenhouses.

High technology and financial investment are required. It is extremely prolific, responsible with regard to water and land use, and environmentally friendly. Deep flow hydroponics is frequently used for the cultivation of leafy vegetables and plants. The two most common artificial growing media for producing row crops including tomato, cucumber, and pepper are rockwool and perlite.

12. Future work

A brand-new smart hydroponics monitoring and control system has been unveiled. The system is made up in particular of a sophisticated wireless sensor network for controlling the pump and monitoring the vital hydroponics parameters. It offers a user-friendly web-based application for greenhouse keepers to keep an eye on their crops, as well as alarms and warnings, making it possible to monitor several greenhouses with little effort and without the need for involvement.

Our ongoing work will be divided into two areas. Data analytics is the second step after conducting additional reliability analysis by introducing mistakes and stress testing the system. We are notably interested in making predictions about nutrient values based on the initial concentrations and the findings from the water quality sensors. Despite the existence of numerous methods, the monitoring of certain nutrients is generally a difficult task for both terrestrial and space applications (Bamsey et al., 2012). For small-scale farmers who frequently apply nutrients empirically, most of these devices have cost demands that may be prohibitive. This might cause either nutritional starvation in plants or hazardous nutrient absorption levels (Gaikwad and Maitra, 2020).

13. Summary

Agriculture provides a living for 70% of the people in rural India. Hydroponics is a technology that can provide a better nutritional output while using less water. According to research, the amount of water utilised is just 10% of that used by the traditional approach. The IoT is a recent innovation in the realm of automation technology. It operates on the principle of linking numerous devices over the Internet and making items available at the appropriate moment (Harikrishna et al., 2021).

The total number of ions in the plant nutrition solution make up the Electrical Conductivity (EC) in most cases. On day 1, the nutrients are introduced to the water, raising the EC, and gradually absorbed over the course of 24 hours. The utilized ion-specific electrode needs frequent (daily) calibration, which restricts its suitability for distant application. Only using the SCU data to accurately forecast the nutritional amounts would spare the expense of such expensive equipment and the necessity for recalibration while guarding against potential empirical errors. Even though it increases the likelihood of inaccurate observations, it can also be used to decrease the SCU sample rate to save energy. We are investigating a simple regression model due to the low data rate since nutrient levels do not vary quickly and because the EC reflects the sum of all nutrients and is predicted to be very linear.

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