FIELD OF INVENTION

[01] The field of invention pertains to **smart agriculture and precision farming**, specifically focusing on the development of an **IoT-based Remote Hydroponics Health Monitoring System**.The invention addresses the challenges of human error, labor intensity, and inefficiencies in traditional hydroponics, providing an automated and user-friendly approach to precision farming. This field of invention aims to modernize hydroponic farming practices, reduce manual intervention, and support scalable, efficient, and resource-optimized cultivation for both home and commercial growers.

BACKGROUND OF THE INVENTION

[02] Traditional soil-based farming has long been the cornerstone of agriculture, providing plants with a medium for growth and essential nutrients. However, soil's inability to retain water and nutrients for extended periods, coupled with space constraints due to rapid urbanization, has led to the search for more efficient farming methods.

[03] Hydroponic farming, a method of growing plants without soil, relies on a nutrient-rich solution to nourish plants directly through their roots. This technique has gained popularity due to its efficient resource utilization, faster growth rates, and the ability to grow crops in controlled environments. However, traditional hydroponic systems face several challenges, including nutrient management, pH balance, system scalability, and labor demands.

[04] Nutrient management is a critical issue in hydroponics, as the nutrient solution must be adjusted to meet the specific requirements of each crop at different stages of growth. Manual adjustments often result in human error, leading to nutrient imbalances that can negatively impact crop yield and health.

[05] The problem of pH imbalance is another major challenge. Fluctuations in pH levels affect the availability of nutrients to plants, potentially leading to nutrient deficiencies or toxicities. Conventional hydroponic systems often require manual pH adjustments, which are labor-intensive and error-prone. Additionally, the accuracy of pH sensors may drift over time, compounding the issue.

[06] Another key issue is the scalability of hydroponic systems. While small-scale systems can be managed manually, large-scale commercial operations require automation and modular designs to ensure efficient nutrient delivery, pH control, and water level management. Existing systems often lack flexibility and adaptability for both small-scale and large-scale operations.

[07] Labor demands also pose a significant challenge. Conventional hydroponic systems require frequent manual monitoring and adjustments, which increase operational costs and limit scalability. Automation is essential to minimize human intervention, reduce labor costs, and improve overall system efficiency.

[08] To address these challenges, this invention introduces a Hydroponics Health Monitoring System that employs advanced sensor-driven automation, IoT integration, and microcontroller-based control logic. This system ensures precise delivery of nutrients at various growth stages, automated pH regulation, real-time monitoring, and adaptability for small- and large-scale farming setups.This approach ensures a controlled and efficient growing environment, supporting scalable, multi-crop cultivation for home gardeners and commercial farmers alike.

OBJECTIVES OF PRESENT INVENTION

[09] Precise Delivery of Nutrients at Different Growth Stages : The primary objective is to deliver nutrients tailored to the specific needs of plants at various growth stages. Instead of altering the genetic composition of seeds, the system supplies appropriate nutrients at each growth phase. For example, crops like tomatoes require different nutrient balances at each growth stage. By referencing a comprehensive database of nutrient profiles for various crops, the system enables data-driven decision-making and enhances plant health, resulting in maximum growth potential.

[10] Reduce Potential Errors in Nutrient Management : Automation of nutrient delivery and pH adjustments minimizes human error, leading to consistent nutrient delivery and a stable growth environment. The system integrates sensor-driven automation, significantly reducing sensor drift and ensuring more accurate pH measurements. This approach not only enhances system reliability but also reduces manual labor, enabling consistent crop health.

[11] Design a Setup Suitable for Small- and Large-Scale Agriculture : The system employs a modular design that supports scalability, allowing it to be deployed in both small-scale hobby farms and large-scale commercial operations. By supporting scalability, the system broadens its utility and applicability, enabling farmers with varying operational needs to implement automated hydroponic farming efficiently.

[12] Enhance Plant Growth and Yield : The system provides early detection of imbalances or deficiencies in the nutrient solution. By continuously monitoring critical parameters like pH, Total Dissolved Solids (TDS), and temperature, the system generates alerts when values deviate from the optimal range. Early detection allows users to intervene before deficiencies impact crop yield, thereby improving crop quality and overall management efficiency.

SUMMARY OF PRESENT INVENTION

[13] This project develops a Hydroponics Health Monitoring System to enhance nutrient delivery, automate processes, and scale across diverse hydroponic setups. Addressing common challenges in traditional hydroponics, such as nutrient management and labor demands, this project integrates microcontrollers, sensors, and IoT capabilities to monitor and control essential parameters like pH, TDS, and water levels in real-time.

[14] The key objectives include delivering precise nutrients according to plant growth stages, minimizing nutrient management errors, designing for scalability, and ensuring early detection of imbalances to improve crop yield and efficiency.

[15] Sensor-driven automation, managed by the ESP32 microcontroller, utilizes a series of pumps for pH and nutrient adjustments, and transmits data to the Blynk app for remote monitoring and alerts.

[16] With a modular, scalable design, the system is adaptable to both small and large hydroponic operations, and it supports multiple crops by allowing tailored nutrient management for different plant types.

[17] Components such as temperature, pH, TDS, and ultrasonic sensors are carefully placed and calibrated, while control logic optimizes sensor performance and conserves energy. Future enhancements may incorporate machine learning to optimize growth patterns and enable multi-crop flexibility.

[18] A maintenance schedule, routine updates, and real-time data insights ensure the system remains reliable and sustainable, catering to a broad range of users in hydroponic farming.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[19] These and other features, aspect, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings are explained in more detail with reference to the following drawings:

[20] Figure 1 illustrates the workflow of the remote hydroponics health monitoring system

[21] Figure 2 illustrates the blocks in remote hydroponics health monitoring system

[22] Figure 3 illustrates the circuit of the system.

[23] Figure 4 illustrates the data display in the blynk app.

DETAILED DESCRIPTION OF THE INVENTION

[24] System Initialization : This step involves setting up all the necessary parameters for the hydroponics system to function. It includes setting initial values for sensors, configuring internal settings, and preparing the system for operation.

[25] Connect to WiFi : The system establishes a WiFi connection, which is crucial for enabling remote monitoring and control via the Blynk app. Without this connection, the system cannot transmit real-time data to the app or receive commands remotely.

[26] Sensors Initialization : All sensors (Temperature, TDS, pH,Ultrasonic) are powered on and calibrated if needed. This ensures accurate readings when the system starts monitoring conditions. Initializing sensors might include steps like stabilizing readings or setting reference points.

[27] Temperature Sensing : The temperature sensor measures the ambient temperature of the hydroponic solution environment. After temperature sensing, this data is factored for the TDS sensor, since TDS readings can vary with temperature.

[28] Nutrient Solution Management : Proper nutrient management is essential in hydroponics to ensure that plants receive a consistent supply of nutrients in solution. Over time, the nutrient solution level may decrease due to plant uptake and evaporation, which can impact the nutrient balance and affect plant health. To effectively manage the nutrient levels, a low-solution detection system is implemented using an ultrasonic sensor.

[29] When the solution level drops below this threshold, it indicates that the solution is low and requires replenishment. The ultrasonic sensor constantly monitors the solution level in real-time.

[30] If the solution level is within the acceptable range, no action is needed. If the ultrasonic sensor detects that the solution level has dropped below the set threshold,a notification is sent to the user in the form of an alert.This immediate notification ensures that the user can promptly refill the nutrient tank, preventing nutrient deficiencies and promoting optimal plant growth.

[31] TDS (Total Dissolved Solids) Sensing: The TDS sensor measures the nutrient concentration in the solution, expressed in parts per million (ppm). The system checks if the TDS value is within a specified safe range (1400 ppm to 3500 ppm).If the TDS value is outside the acceptable range, an alert is triggered to notify the user of an imbalance in nutrient concentration.If the TDS is within the safe range, the system considers the nutrient concentration adequate and moves on to check the pH level.

[32] pH Adjustment Block : The pH sensor measures the acidity or alkalinity of the nutrient solution, with an ideal pH range for hydroponic systems usually around 5.5 to 6.5.Maintaining an optimal pH range is essential in hydroponics to support nutrient uptake and promote healthy plant growth.

[33] If the pH is between 5.5 and 6.5, the pH is considered optimal, so no adjustments are made, and the pH control systems (pumps) remain off.If the pH is below 5.5, the system activates the "pH up" dosing pump, which adds a pH-raising agent to increase the pH level.If the pH is above 6.5, the system activates the "pH down" dosing pump, which adds a pH-lowering agent to decrease the pH level.

[34] In this project, a pH adjustment module has been developed with 2n222 to regulate the solution's pH level, specifically tailored to the ideal range of 5.8 to 6.3 for tomato plants. This module includes two types of pH solutions—pH Up and pH Down—each prepared in separate reservoirs for automatic adjustment as needed.

[35] The pH Up solution consists of a diluted base mixed at a 1:4 ratio, with one part concentrated solution and four parts distilled water. Similarly, the pH Down solution is a diluted acid mixture using the same ratio. This dilution ensures gradual adjustments to prevent sudden fluctuations in the nutrient reservoir. This automated regulation allows for precise and consistent pH control, avoiding potential nutrient imbalances or plant stress.

[36] Sensor Control Logic Block : This technique leverages the microcontroller's General-Purpose Input/Output pins to control the power state of each sensor allowing continuous activation of TDS sensor and periodic activation of pH sensors .

[37] The implementation logic involves : Set up GPIO pins to control power to the pH and TDS sensors. A timer variable is initialized to track the time since the last pH reading. In a continuous loop TDS values are monitored while checking if 4 hours have passed since the last pH reading.

[38] If the timer reaches 4 hours, a sequence is initiated to power off the TDS sensor to prevent interference.Powering on of the pH sensor. A time is set for the pH sensor to stabilize.pH values are taken and if the readings are not within the required range then pH adjustment is taken place.This process repeats until the pH values falls under the required range.pH sensor is powered off and TDS sensor is powered back on.The timer is reset for the next 4 hour interval.This loop is repeated continuously.

[39] The periodic deactivation of the TDS sensor during pH measurement ensures accuracy by eliminating cross-sensor interference. This approach maintains real-time nutrient concentration monitoring, crucial for system stability. By using only GPIO pins for power control, this solution is both cost-effective and efficient, as it avoids additional hardware components.

[40] Throughout the entire process, data from all sensors (temperature, water level, TDS, pH) is continuously sent to the Blynk app.

[41] This allows users to monitor the system in real time, receive alerts, and see the status of various parameters remotely.The Blynk app serves as a user interface for viewing current conditions, receiving alerts, and potentially adjusting system settings.

Advantages of the Hydroponics Health Monitoring System

[42] Automated Nutrient Management: The system ensures precise delivery of nutrients by continuously monitoring TDS, pH, and nutrient solution levels. It automatically adjusts pH using pH Up and pH Down solutions, reducing manual intervention and promoting consistent plant growth.

[43] Real-Time Monitoring and Alerts: Data from the temperature, TDS, pH, and water level sensors are continuously transmitted to the Blynk app, allowing users to remotely monitor system health. Instant alerts are triggered for low nutrient levels, pH imbalances, or abnormal TDS readings, enabling quick corrective action.

[44] Energy Efficiency: The use of GPIO-controlled sensor activation logic reduces power consumption by deactivating sensors like the TDS sensor during pH measurement. This approach avoids the need for additional hardware components, optimizing system efficiency.

[45] Resource Optimization: By using affordable components like the 2N2222 transistor for motor control, the system minimizes hardware usage and reduces overall production costs, making it accessible for small-scale growers and large hydroponic farms alike.

[46] Remote Control and User Convenience: Farmers can monitor and control the system remotely via the Blynk app. This remote access reduces on-site labor, allowing farmers to manage multiple hydroponic systems from a single interface, enhancing operational efficiency.

We claim:

1 . The remote hydroponic health monitoring system, comprises of a nutrient level monitoring block , pH adjustment block , Tds monitoring module , web dashboard , sensor control block , The hardware optimization block , The automated alert system .

2. The nutrient level monitoring block as per Claim 1 , comprises an HC-SR04 ultrasonic sensor connected to an ESP32 microcontroller, wherein the sensor detects low nutrient solution levels and triggers a replenishment pump.

3. The pH adjustment block as per Claim 1, comprises of a pH management module, which includes a pH sensor, ESP32 microcontroller, and pH Up and pH Down pumps, wherein the microcontroller automatically adjusts pH levels to maintain an ideal range of 5.8 to 6.5 in the nutrient reservoir.

4. The TDS monitoring module of Claim 1 integrates a TDS sensor and DS18B20 temperature sensor connected to an ESP32 microcontroller, with temperature-compensated TDS readings ensuring accurate nutrient concentration measurement, and alerts triggered when TDS levels fall below a predefined threshold.

5. The web dashboard as per Claim 1, comprises a user interface accessible via the Blynk application, wherein real-time data from pH, TDS, temperature, and nutrient level sensors is displayed. The dashboard enables users to view historical data, receive alerts on abnormal parameter fluctuations, and control system operations remotely, including pH and nutrient adjustments.

6. The sensor control block as per Claim 1, comprises an ESP32 microcontroller utilizing GPIO pins to selectively power on and off the TDS and pH sensors. The logic ensures that only one sensor operates at a time to prevent cross-sensor interference, with a 4-hour periodic interval for pH measurement, during which the TDS sensor is deactivated to avoid signal distortion, and automatic reactivation of the TDS sensor thereafter.

7. The hardware optimization block as per Claim 1, employs a 2N222 transistor for motor and pump control, reducing the need for additional relay modules or motor drivers. This hardware reduction minimizes system complexity, lowers power consumption, and enhances cost-efficiency while maintaining reliable control of peristaltic pumps for nutrient and pH adjustments.

8. The automated alert system as per Claim 1, is configured to notify users of required maintenance and low reservoir levels. Using data from the HC-SR04 ultrasonic sensor and TDS sensor, the system triggers refill alerts via the Blynk app when nutrient solution levels fall below a critical threshold. This ensures timely intervention, reduces manual monitoring, and maintains system efficiency and plant health.

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ABSTRACT

Hydroponics is a method of growing plants without soil, using mineral nutrient solutions in an aqueous solvent. The hydroponics health monitoring system is designed to enhance the management of nutrient solutions in soilless plant cultivation.The existing method needs human help to add the pH up or down solution and it might cause some problems when the solution is added more or less than the required amount. In our project, we have automated it and the pH level of the solution will be displayed to the user in the cloud.

To automate the flow of pH up or down solution into the nutrient solution based on the sensor data.To make a complete setup for a smart hydroponics system which is suitable for indoor gardening and to show the plant's data as well as other data such as level of the nutrient solution and water to the user through a cloud platform.By integrating real-time data collection, automated pH management, sensor switching logic, and efficient alert mechanisms, the proposed hydroponics health monitoring system effectively streamlines nutrient management.This approach minimizes manual intervention and human error, which leads to better nutrient delivery to the plant, reduced maintenance, and enhanced plant growth as well as good yield.The system's scalability and advanced design make it suitable for various users, from home gardeners to commercial farmers, offering a reliable and comprehensive solution for modern hydroponic practices.

KEYWORDS :

Hydroponic method of plant growing - data sets and threshold values - Sensor calibration - Automation - Complete setup - Increased yield and user friendly

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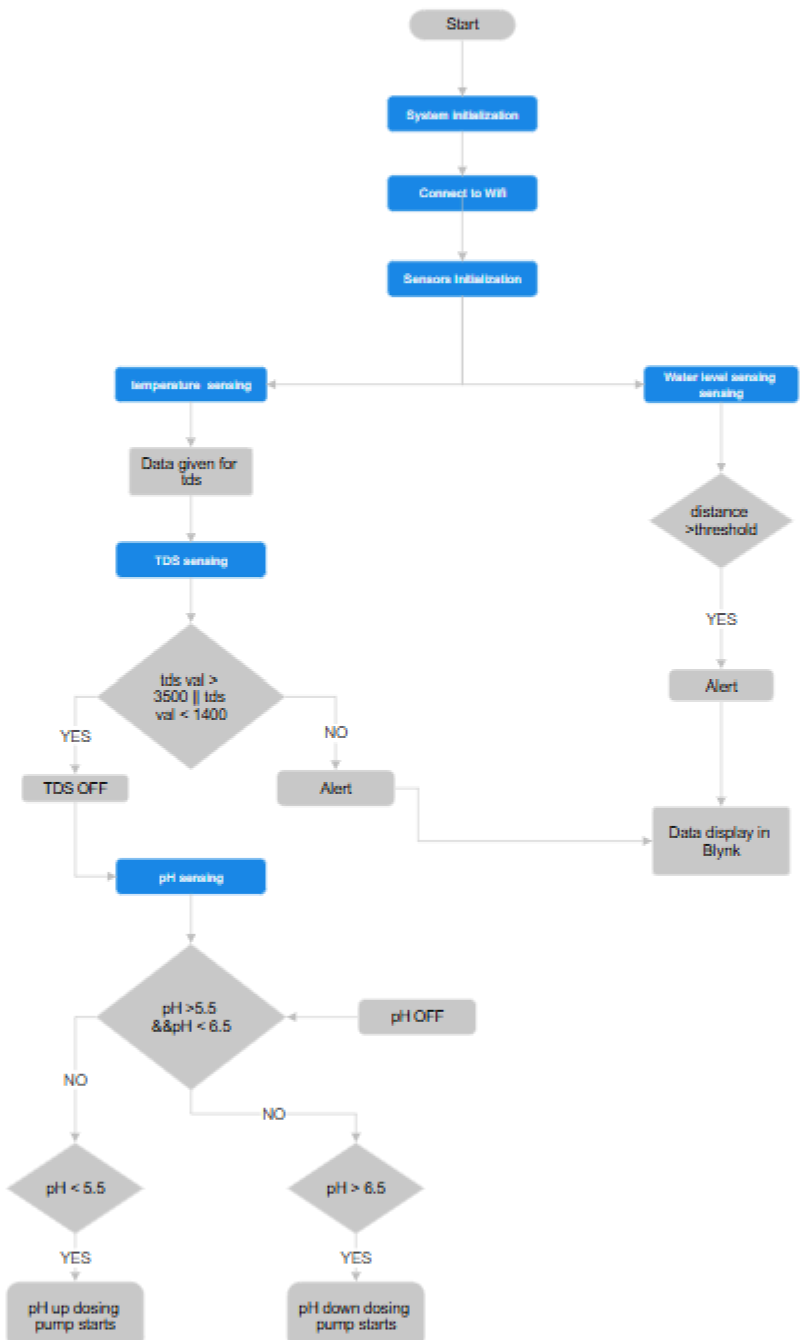

Figure 1

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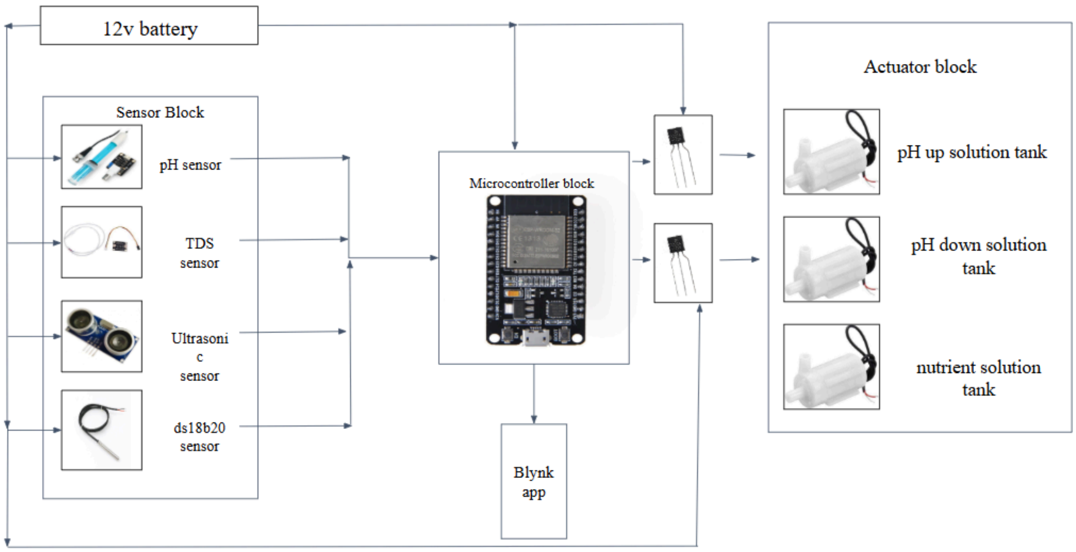

Figure 2

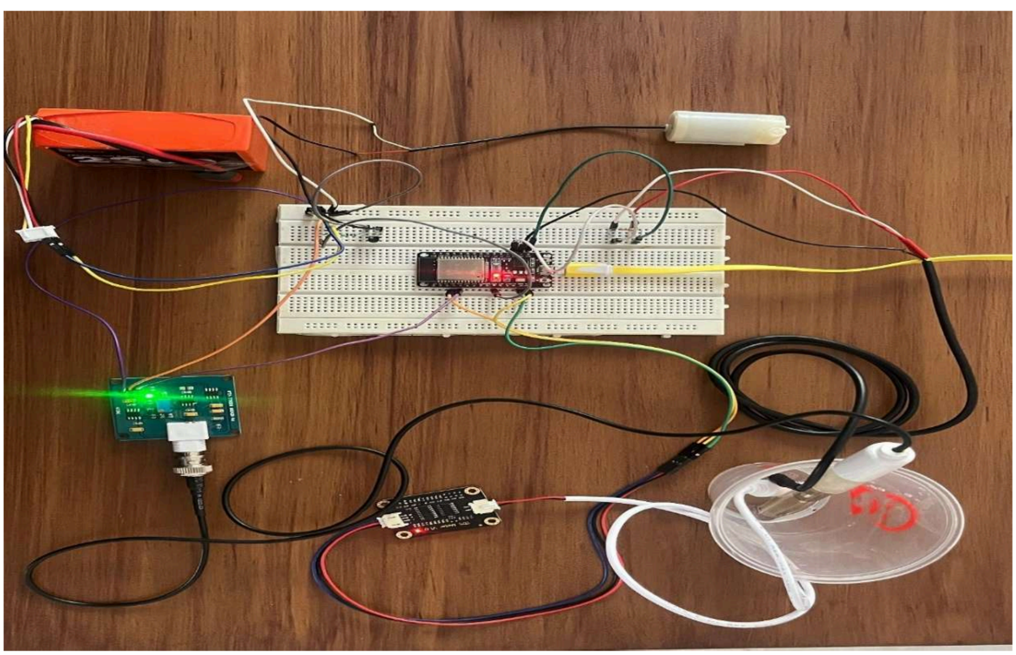

Figure 3

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Figure 4

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