

# Android-based Nutrition Requirement Control Application for Hydroponic Plants

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## ABSTRACT

Hydroponics is a planting method that doesn't use soil but instead relies on water and nutrient solutions to emphasize the fulfillment of plant nutritional needs. In hydroponic cultivation techniques, it is crucial to pay attention to water quality and nutrient content that will be provided. Inadequate nutrient levels, over a certain period, can affect the growth and quality of the plants. This research implements a system or application that can assist hydroponic farmers in controlling nutrient pH and monitoring. This nutrient requirement control application utilizes *Internet of Things* (IoT) technology with the NodeMCU ESP8266 microcontroller and sensors to collect data, and it uses Firebase for real-time data storage. This application system is designed to provide ease of access, control, and monitoring of the nutrients required by hydroponic farmers without the need to be on-site. Farmers can easily monitor the real-time pH conditions of hydroponic plant nutrients, especially the vital water conditions for plant growth. The conclusion of this research is that farmers can now control and monitor plants using the application.

## General Terms

Android, Firebase, Nutrition

## Keywords

Application, NodeMcuEsp8266, Hydroponics, *Internet Of Things* (IoT)

## 1. INTRODUCTION

Hydroponics is a cultivation method that does not use soil but instead utilizes water and nutrient solutions to emphasize the fulfillment of plant nutritional needs. The nutrient condition in hydroponic plants is of paramount importance and must be periodically checked manually to assess nutrient availability. Insufficient nutrient levels over a specific period can adversely affect the growth and quality of the plants. In today's era, available agricultural land in large cities is becoming increasingly scarce, especially in densely populated urban areas [1]. The problem lies in the scarcity of land for farmers. One common issue faced by farmers is that during measurements, the nutrient solution reservoir is often placed lower than the planting medium and shielded from sunlight, making it difficult for farmers to take measurements [2], [3]. The problem addressed in this research is how to automate hydroponic plant maintenance and develop a system that can remotely monitor hydroponic plants for greater effectiveness. Hydroponics is one of the suitable urban farming methods that does not involve the use of soil (soilless); instead, it utilizes other materials such as mineral fibers, sand, crushed bricks, wood powder, and more as substitutes for soil [4]. The challenge addressed in this research requires a nutrient distribution system that combines agriculture with mechatronics. The *Internet of Things* (IoT) in hydroponics can result in a hydroponic nutrient system capable of monitoring

and providing fertilizers according to the needs of hydroponic plants based on their type and age [5]. One of the factors influencing the success of hydroponic techniques is the electrical conductivity value in the nutrient solution, which decreases with each nutrient absorption and evaporation [6]. An automated hydroponic system can control the nutrient content in the water, a crucial element in hydroponic cultivation [7], [8]. This system requires a controlled environment to prevent a decrease in plant quality and ensure plant health [9]. The challenge addressed in this research is that the use of manual nutrient measurement and control tools is still less effective in hydroponic plant cultivation methods.

This research identifies how to design and implement a new system and application to facilitate hydroponic farmers in checking nutrient levels and controlling nutrients in hydroponic plants. It utilizes microcontrollers (*Internet of Things*) as tools for measuring nutrient levels and control. The data is then sent to a Firebase database in real-time and can be accessed and monitored remotely via smartphones (Android), eliminating the need for physical presence at the hydroponic cultivation site. With this application, hydroponic farmers can easily control and monitor their plants without the need to visit the cultivation site regularly to ensure nutrient levels in the plants.

## 2. RESEARCH METHOD

This section introduces the system implemented in an application. Farmers can access and use the Android application for nutrient control and monitoring. The Android application is integrated with *Internet of Things* (NodeMcu) devices for data collection and control systems, as well as a real-time Firebase database that can be used to retrieve and manage data in hydroponic plants. IoT devices integrated with Firebase, connected to the internet, are used for real-time plant condition monitoring, nutrient control in water, and user account data storage. The system's operation can be visualized in the architecture depicted below in Figure 1.

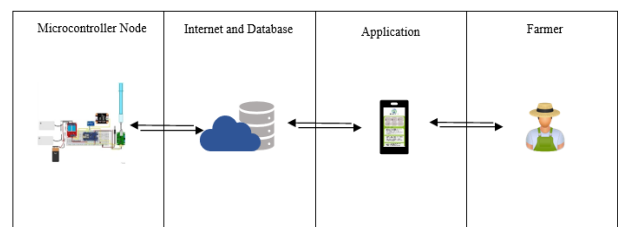


Fig 1 Architecture Diagram

This system combines data collected from microcontrollers, which are sourced from sensors measuring temperature, pH levels, TDS (Total Dissolved Solids), and water pumps. In this scenario, incoming data is first received and then transmitted to farmers through the NodeMcu ESP8266 microcontroller. The data received by the microcontroller is subsequently stored in a real-time Firebase database for data processing. Afterwards, the data is sent to the Android application, allowing farmers to

control and monitor their hydroponic plants. The system design encompasses *Internet of Things* (IoT) devices, Wi-Fi connectivity, Firebase database, and the mobile application. Farmers can access and monitor the condition of their hydroponic plants through the Android application interface..

### 2.1 Interface Design

The interface design for the nutrient requirement control application is created using Figma. The application for hydroponic plants includes several screens, including the login screen, registration screen, menu or monitoring screen for hydroponic plants, nutrient level control screen, and a screen displaying the history of nutrient data for the plants.



Fig 2 Wireframes for the HDR Application

Hardware design using Fritzing with the microcontroller NodeMCU ESP8266, and two water pumps for nutrient control, relay, TDS sensor, water temperature sensor, pH sensor, and a 9V battery.

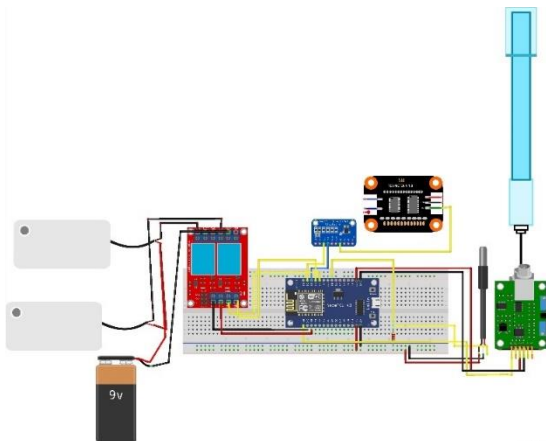


Fig 3 Wireframes for Internet of Things Hardware

## 3. RESULT AND DISCUSSION

### 3.1 Assumption

The application is intended for hydroponic farmers who can operate it using an Android smartphone. This application needs to be connected to the *Internet of Things*, requiring an internet connection to access the interface for plant control and monitoring.

### 3.2 Hypothesis

This hypothesis is based on assumptions gathered and formulated during the research phase. This research hypothesizes that “*The Android-Based Nutrient Control Application for Hydroponic Plants*”

### 3.3 Feature

There are several features within this nutrient requirement control application, which are designed based on the needs of hydroponic farmers. Here are some of the application's components.

Table 1 List Of Feature

No.	Actor	Description
1.	Farmer	Login Page, Register Page, Menu/Monitoring Page, Nutrient Control Page, Nutrient Data History List Page, About Page, Hydroponic News Page

### 3.4 Run an Experiment

After the wireframe has been successfully created, the next step is programming. This hydroponic plant nutrient control application uses Java for programming, as well as the programming language Python for the microcontroller (*Internet of Things*).

### 3.5 Result Of Sensor Testing

Direct sensor testing affects both the system's transmission performance and the stability of the application. To ensure the validation of pH, water temperature, and TDS parameter readings in hydroponic plants, it goes through a process of sensor parameter testing using the serial monitor available in the Arduino IDE.

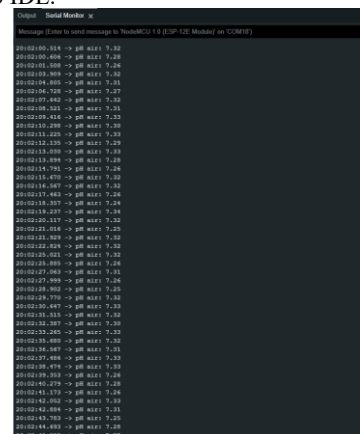


Fig 4 The testing conducted for the pH sensor is performed using the serial monitor

The pH sensor testing is conducted by the researcher through the testing of readings from the sensor to assess its performance and capabilities. The pH sensor is used to measure the pH levels in the hydroponic plant's water, as depicted in Figure 4 above.

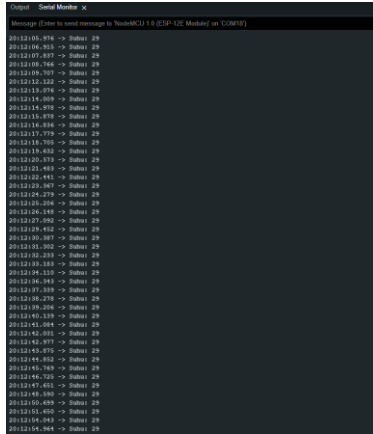


Fig 5 The testing for the water temperature sensor is carried out using the serial monitor

The water temperature sensor testing is conducted by the researcher through the testing of readings from the sensor to assess its performance and capabilities. This sensor is used to measure the water temperature for plants, as depicted in Figure 5 above.

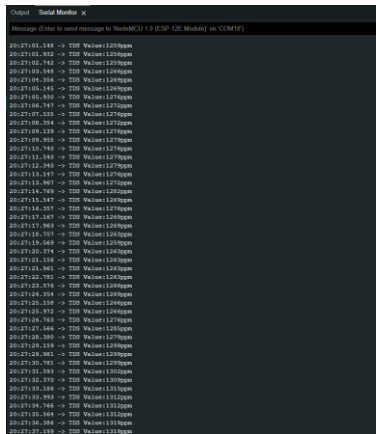


Fig. 6 The testing for the TDS sensor is performed using the serial monitor

The researcher conducts TDS sensor testing to assess the sensor's performance and capabilities by testing the readings from the TDS sensor. The results of the testing are obtained using the serial monitor, as shown in Figure 6 above.

The results of the sensor readings, after calibration, show a slight difference in the pH sensor readings after one minute, ranging from 8.45 to 8.70. Meanwhile, the TDS sensor exhibits a difference of 1 ppm after one minute.

Table 2 The results of the water temperature, pH, and TDS sensor testing

No	The pH Sensor Readings	Water Temperature Sensor Readings	The TDS Sensor Readings
1	7.14	29	1259
2	7.02	29	1276
3	7.01	29	1282
4	7.32	29	1263
5	7.32	29	1266
6	8.45	29	1309
7	8.70	29	1312

8	8.70	29	1302
9	8.70	29	1319
10	8.70	29	1340

Table 3 The results of the nutrient controller testing

No	Nutrient Levels	Output Relay	Acculator
1	Acid	0	On
2	Base	0	On

The nutrient control used involves controlling the water's pH level, which includes both acid and base control. This control system operates when adjusting or reducing the pH nutrient levels in hydroponic plants. The results of the testing can be seen in the table mentioned above (Table 3).

### 3.6 Implementation

Implementation is the system that has been designed and programmed into the HDR (hydroponic) application, as well as the *Internet of Things* devices. Here are the results of the application created by the researcher

#### 3.6.1 Login page user

The Login Page is the screen that appears when opening the hydroponic application. On this page, users are prompted to enter their Username and Password if they already have an account. Email: Users are required to input their email, and Password: Users must enter their password



Fig 7 Login Page View HDR Application

#### 3.6.2 Register page user

The Registration Page is the screen that appears if the user doesn't have an account yet. Users are allowed to fill in their details as indicated on the page. In the registration menu, users should enter their email, password, and confirm the password.



Fig 8 Register Page User View HDR Application

### 3.6.3 Home page user and monitoring

The Menu Page is the screen that appears after the user logs in. On the Menu Page, there are several displays and tools. On the initial screen, there are displays for hydroponic plant cultivation news, temperature and pH monitoring, nutrient monitoring, nutrient control, and information about the application.



Fig 9 Home Page User View HDR Application

### 3.6.4 The Nutrient Control Page

This page is for controlling the pH nutrient levels in hydroponic plants. To input nutrients, you can use buttons for base or acid and send the data to Firebase. Then, it instructs the IoT device to process and pump nutrients to the hydroponic plants.



Fig 10 The Nutrient Control Page of the HDR Application

### 3.6.5 The Nutrient Data History Page

The Nutrient Data History Page is used to view all nutrient history stored in the database, enabling users to monitor the progress of hydroponic plants through this page.

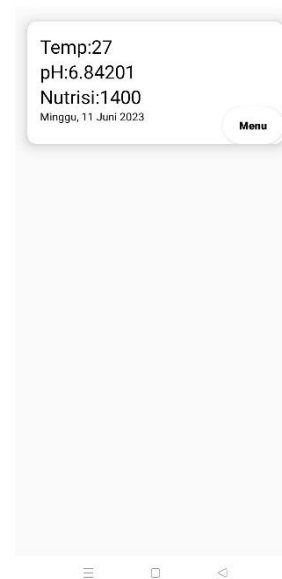


Fig 11 The Nutrient Data History Page of the HDR Application

### 3.6.6 The About Page

The About Page displays the name of the application creator, their student ID (NIM), and the year of creation.

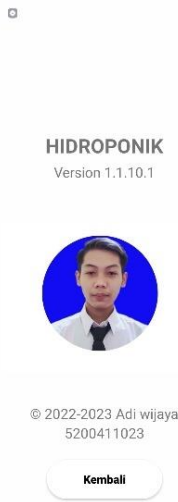


Fig 12 The About Page of the HDR Application

### 3.6.7 Internet of Things Hardware

The hardware design used for controlling and managing plants consists of a system that includes an IoT device management container. This container serves as a storage space for IoT components such as microcontrollers and various supporting sensors. Additionally, plant pumps are utilized to deliver nutrients to the plant.

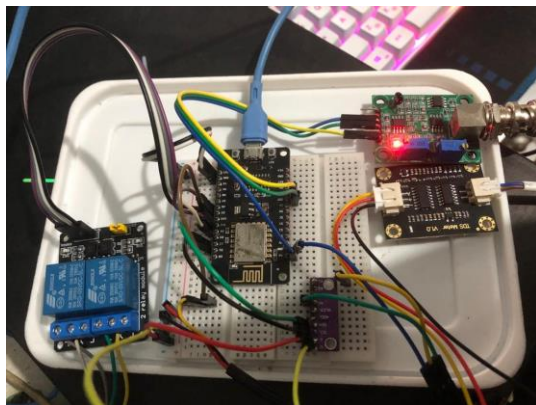


Fig 13 Hardware (NodeMcu ESP8266)

### 3.7 Discussion of Result

The next stage is application testing. During this stage, the testing aims to ensure that every function of the application operates as intended. Black box testing is used for testing at this stage. Black box testing conducts tests without detailed knowledge of the internal structure of the system or component being tested, focusing on input/output testing or functional testing [10]. Errors that are checked include software interface errors, performance errors, data structure errors, and initialization or termination errors. With the presence of black box testing, it is expected that any errors or deficiencies in the application can be promptly identified by the researcher.

Table 4 Black Box Testing Application Android

Testing Activities	Expected Realization	Testing Results	Conclusion
Account Register	Farmers can create a new account	They can create a new account, and it will be saved	Accepted
Account Login	Farmers can log in after registering	They can log in using the email and password they provided during registration tersimpan	Accepted
Home Page	Farmers can access the menu and monitoring	The application allows access after login and displays the menu or monitoring	Accepted
The Nutrient Control Page	Farmers can control the nutrients	The application can control the pH nutrients in the plants	Accepted
The Nutrient Data History Page	Farmers can view nutrient history	The application can display nutrient data history	Accepted
The About Page	Farmers can view information about the application (The About Page)	The application can display an About page	Accepted

In this research, hydroponic farmers are needed as users. After being tested in using the application, based on the Black Box testing conducted, the “Android-Based Nutrient Control Application for Hydroponic Plants” was successfully accepted

## 4. CONCLUSION & FUTUR WORKS

The conclusion of this research is that, during the testing phase, the system was able to control and monitor plants in providing pH nutrient solutions according to the plant's needs. Farmers were able to control various conditions required by the plants, such as controlling the acidity and alkalinity of pH nutrients. Farmers could also monitor water temperature, pH levels, and nutrient levels in real-time and view nutrient data history. The results obtained in the hydroponic plant testing were that the plants could grow well, and there was a successful harvest using the IoT device created by the author.

In this research, the focus has not yet been on push notifications to send information related to plant nutrient levels, so further research is needed to develop push notification features. By expanding the application's connectivity, such as using short messages or SMS to provide information regarding nutrient sufficiency and notifications if the plant nutrient concentration is too low or too high, which is highly useful for hydroponic farmers in monitoring their plants.

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