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HydroTech: Water Quality Monitoring System on Smart Agriculture

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Abstract:- Agriculture is at the center of all economic activity since it is the link between agricultural expansion and economic riches. New and developing technology has the potential to constantly increase the productivity, profitability, and quality of our key agricultural systems. Hydroponics is a method of planting or producing plants that do not require soil and instead relies on water, nutrients, and oxygen. It requires accuracy, patience, and constant monitoring, all of which are difficult to do. The objective of this research is to create a monitoring tool for the automated flow of nutrients in hydroponic plants using an Arduino microcontroller and a smartphone. The HydroTech can detect sensor data from four parameters: temperature, pH, turbidity, and electrical conductivity, and simultaneously display its reading in an application. The device has an ESP32, which can transport data over WIFI and Bluetooth. Two weeks of lettuce testing revealed that the sensors and application worked well. The equipment was practical and useful since it met the specifications. The researcher suggests utilizing digital sensors because the device employs analog sensors and reading depends totally on the type of sensor used.

Keywords:- *Arduino Microcontroller, Water Quality Monitoring, Developmental Design, Smart Agriculture, Internet-Of-Things.*

I. INTRODUCTION

Agriculture is regarded as the foundation of human life since it is the primary source of food grains and other basic resources. It is critical to the country's economic prosperity.

According to the United Nations, the need for localized food systems will be a component of how people produce food in the future, and hydroponics is one of the present agricultural methods that has the ability to tackle this sort of problem.

Hydroponics relies on high water quality requirements that must be monitored and maintained. Hydroponic systems have the capacity to increase plant development and potential. The plant does not need to invest energy extending its roots or extracting nutrients from soil because the nutrient-rich fluid supplies all of its sustenance. Instead, it accelerates its upward growth.

A hydroponics system is a plant-growing method that does not require soil but instead utilizes water and nutrients to conserve space and avoid contamination from chemicals in soil. Hydroponics contains a variety of novel techniques that are not restricted to plant growth in water, such as nutrient film technique, deep flow technique, dynamic root floating technique, and so on. Furthermore, soilless cultivation is separated into two basic categories: water culture and substrate culture. It is more productive and faster to plant than dirt, and the plant has a high nutritional value. It also regulates the quality of production.

Water and nutrients are required for plant growth. When water and nutrients are supplied in sufficient quantities, it is feasible to attain large yields and good quality in hydroponics. Plants' nutrient and water requirements may be determined. However, the water quality given is as crucial, but the quality (the salt and nutrient content) is generally predetermined. As a result, it is critical to understand the water quality being utilized and, as a result, what fertilization modifications are necessary (Os et al., 2016).

Plant care tasks include characteristics such as watering, revitalizing, fertilizing, and others that are performed to maintain plants healthy and well-groomed. Water remains the main source of life for all plants to support the photosynthesis process, notably in hydroponic plants that live on nutrients from water (Sihombing et al., 2018).

Water quality is a critical determinant in hydroponics production. Water is the primary nutrient carrier in hydroponics since it dissolves and distributes nutrients to plants. Water, on the other hand, removes many pollutants that might be damaging to plants. These pollutants are difficult to detect visually, and it is all too easy to be mislead into making incorrect judgments about the cleanliness of water based on sample clarity. Poor water quality can cause a variety of plant development issues such as stunted growth, mineral toxicity or deficiency symptoms, undesirable element buildup in plant tissue, bacterial contamination, and others (Water for hydroponics, n.d.).

Sensorex (2022) states that the water in a hydroponic system must be nutrientenriched in order for hydroponically grown plants to receive the nutrients they require. Nutrient-enriched water should be constantly monitored to ensure that nutrient levels are not too low (which inhibits growth) or too high (which promotes growth) (potentially toxic). As a result, electrical conductivity is an important water quality metric in hydroponics applications.

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Current automated hydroponics systems on the market are either prohibitively costly or fail to handle all of the factors required for good plant development. Some systems offer autonomous parameter control but are costly in the high 2000s. Other systems are less expensive, but they lack environmental parameter automation, monitoring, and control. This research gives total automation with monitoring of all the factors required for plant growth..

II. OBJECTIVES OF THE STUDY

The study aimed to design, develop and test the Garbage Bin Monitoring System.

- To design HydroTech: an Arduino-based water quality monitoring system compatible for smart agriculture.
- To develop HydroTech: an Arduino-based water quality monitoring device, which will allow farmers to monitor the quality of water supply using four sensors in one device using smartphones.
- To test HydroTech: an Arduino-based water quality monitoring device in terms of functionality and general usability.

III. METHODOLOGY

The design and development of this project are divided into two main parts: hardware architecture and software details. In the hardware architecture, the creation of the circuit was constructed, and the prototype of the project was built. While in the software development, the whole complete prototype was operated via programming codes.

A. Hardware Architecture

The project's block diagram is broken down into three main subsystems as presented in Figure 1. An application that can access the device environment and display the same data to the user is necessary for the Data Management Module. The wireless communication interface with built-in security measures makes up the data transmission subsystem, which transports data from the controller to the data storage server. Multi-parameter sensors attached in the Hydroponics System make up the data-collecting subsystem, which also has a wireless communication device for relaying sensor data to the controller. The controller compiles the data and uses it in the same way.

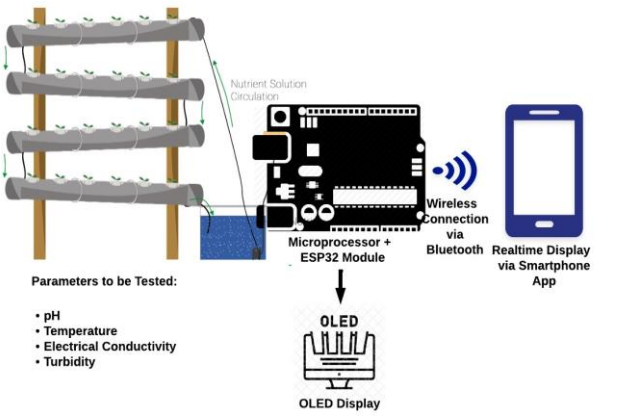

Fig 1. Data Flow Diagram of the Water Quality Monitoring System

B. Schematic Diagram

Turbidity (TU), Electrical Conductivity (EC), Dissolved Oxygen (EC), temperature, and pH are the main parameters controlled in the system. The overall project schematic diagram is shown in Figure 2.

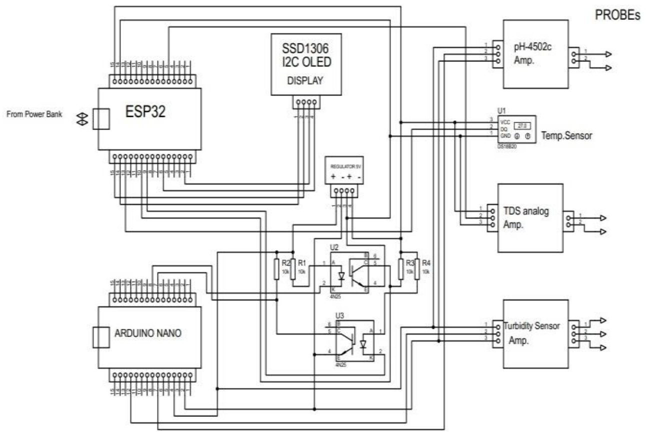

Fig 2. Project Schematic Diagram

An Arduino NANO microcontroller is the central component of the water quality monitoring system enabled by IoT. Most IoT-based device models use an external WiFi interface. This design is economical, they are powerful, and they often lead to complex circuits.

Since the device function is to track water quality, sensors are immediately interfaced with the controller. The sensors like *Turbidity (TU)* and *Electrical Conductivity (EC)*, *Dissolved Oxygen (DO)*, *temperature* and *pH* are measured by inserting the sensor into the water. It can display the calculated parameters to the LCD. The sensor data are transmitted through the controller to the application. An application is built that displays the values obtained by each sensor.

C. Software Development

The project's software is based on a flowchart in Figure 3. The developed device needs to be connected in 5 volts of power to start its operation. Once connected, the device will automatically initial its connections between the controller and microprocessor. Initialization is complete once the OLED display will continuously display the sensor readings. A separate application was developed to check the device's functionality.

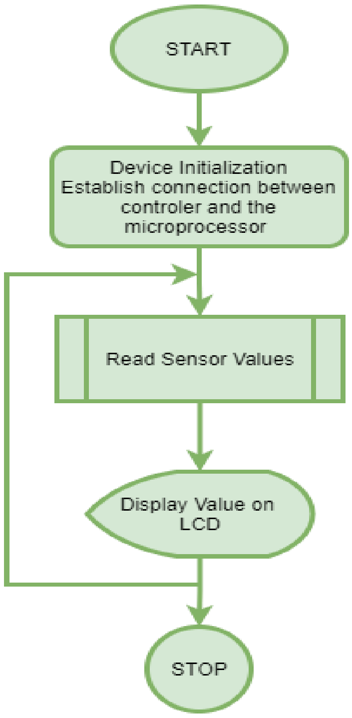

Fig 3. Flow Chart for Water Quality Monitoring System

IV. RESULTS AND DISCUSSION

A. Acceptance Testing

Acceptance testing is a type of software testing in which a system is evaluated for usability. The goal of this test is to determine whether the system meets the user requirements and whether it is suitable for delivery (Software Testing Fundamentals, 2022). The following five aspects of satisfaction are used to evaluate the performance of the HydroTech System using ISO 9126 quality standard:

- The *functionality* characteristic enables judgments to be drawn about how well software performs intended functions.
- The *reliability* property enables inferences to be drawn about how effectively software maintains the level of system performance when employed under specific situations.
- The *usability* characteristic allows the developer to form judgments about how effectively software may be understood, learnt, used, and loved.
- The *efficiency* property allows us to draw inferences about how effectively software performs in relation to the quantity of resources consumed
- The *portability* property enables inferences to be drawn about how effectively software may be moved from one environment to another.

TABLE I. FUNCTIONALITY TEST RESULT

Criteria	Mean	Interpretation
• The capability of the product to provide an appropriate set of functions for specific tasks and user objectives.	4.8	Very Good
• The capability of the software product to provide the right and agreed results of effect with the needed degree of precision.	4.5	Very Good
• The capability of the software product to interact with one or more specified systems.	5.0	Excellent
Overall Mean	**4.8**	**Very Good**

TABLE II. RELIABILITY TEST RESULT

Criteria	Mean	Interpretation
• The capability of the software product to avoid failure as a result of faults in the software	4.6	Very Good
• The capability of the software product to re-establish a specified level or performance and recover the data directly affected in the case of failure.	4.4	Very Good
Overall Mean	**4.5**	**Very Good**

TABLE III. USABILITY TEST RESULT

Criteria	Mean	Interpretation
• The capability of the software product to be attractive to the user.	4.8	Very Good
• The capability of the software product to enable the user to learn its application.	5.0	Excellent
• The capability of the software product to enable the user to operate and control it.	5.0	Excellent
Overall Mean	**4.9**	**Very Good**

TABLE IV. EFFICIENCY TEST RESULT

Criteria	Mean	Interpretation
• The capability of the software product to provide appropriate response and processing times and throughput rates when performing its functions, under stated condition..	4.8	Very Good
Overall Mean	**4.8**	**Very Good**

TABLE V. PORTABILITY TEST RESULT

Criteria	Mean	Interpretation
The capability of the software product to be installed in a specified environment.	5.0	Excellent
Overall Mean	**5.0**	**Excellent**

Figure 4 presents the summary result of functionality, reliability, usability, efficiency, and portability quality attribute during the acceptance test of the HydroTech System on Smart Agriculture. In the criterion of "Functionality", the system obtained a mean value of 4.8 and was interpreted as Very Good. In terms of "Reliability", the system obtained a mean value of 4.5 and was interpreted as Very Good. The criterion of "Usability", obtained a mean value of 4.9 and was interpreted as Very Good while "Efficiency", obtained the value of 4.8 and was interpreted as Very Good and lastly, the criterion of "Portability", obtained the value of 5.0 and was interpreted as Very Good. Results shows that the developed system is functional, reliable, usable, efficient, and portable which can be installed in any environment, and is now ready for implementation. This also means that parameters are already calibrated to its standards and will surely display correct result.

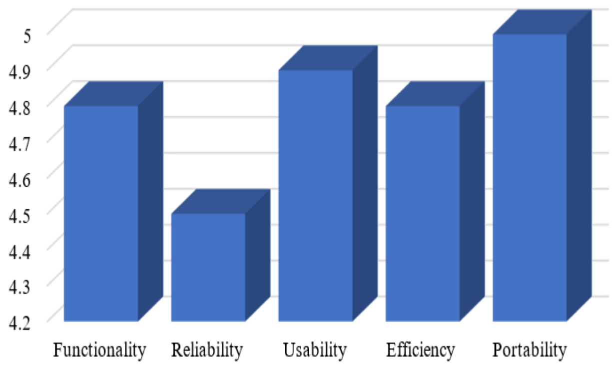

Fig 4. Summary Result of Acceptance Test

B. System Usability Test

After the experimental testing, the usability test followed to guarantee that the developed device meets the requirements and is ready for implementation. The respondent used the System Usability Scale (SUS) by the (Digital Equipment Corporation, 1986), which measures how well a product allows users to accomplish their goals. The SUS Scale is generally used after the respondents had an opportunity to use the system being evaluated before any debriefing or discussions take place.

To calculate the SUS score, first sum the score contributions from each item. Each item's score contributions will range from 0 to 4. For items 1,3,5,7 and 9, the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the score contribution is the scale position minus 5. Multiply the sum of the scores by 2.5 to obtain the overall value of the SUS. A SUS score of 68 is considered above average, and anything below it is below average.

The evaluators of the system usability tests were three faculty members from Eastern Samar State University and three farm operators in the Municipality of Salcedo. During the testing, the respondent uses the Water Quality Monitoring System Mobile Application (Chica et al., 2021) to furtherly check its usability in terms of its ease in interconnecting with other technology.

Table 2 displays the summary for system usability on the quality of the Arduinobased Water Quality Monitoring System that was done on the second week of September 2022. It represents the overall score of the 10 item statements. It obtained an overall SUS score of 81.75. It implies that the developed device is usable and now ready for implementation.

TABLE VI. SYSTEM USABILITY TEST RESULT

Criteria	Mean	SUS Score
1. I think that I would like to use the system frequently	**4.0**	**3.0**
2. I found the system unnecessarily complex	**1.0**	**4.0**
3. I thought the system is easy to use	**3.8**	**2.8**
4. I think that I would need the support of a technical person to be able to use the system	**1.5**	**3.5**
5. I found the various functions in this application were all integrated	**3.5**	**2.5**
6. I thought there was too much inconsistency in this system	**1.3**	**3.7**
7. I would imagine that most people would learn to use this system very quickly	**3.8**	**2.8**
8. I found the system very cumbersome to use	**1.3**	**3.7**
9. I felt very confident using the application	**4.0**	**3.0**
10. I needed to learn a lot of things before I could get going with this system	**1.3**	**3.7**
SUS Score x 2.5		**32.7**
Overall SUS Score		**81.75**

V. CONCLUSION

The researchers arrived at the following conclusions based on the study's findings and evaluation. The HydroTech system for Smart Agriculture was created and tested successfully. Some hydroponics growers and the business owner backed the gadget and the application. The HydroTech System was effective and functioning since it matched the criteria established during the design and development of the system. The sensors determine the outcomes of the HydroTech System

RECOMMENDATION

The following recommendations were made by the researchers based on the study's findings. Farmers or owners of hydroponic systems should be targeted with the HydroTech System on Smart Agriculture. Branded sensors should be purchased since they influence the application outcomes. The HydroTech System could potentially be applied to other types of water quality study.

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