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Advance Hydroponic System

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Abstract*: Currently hydroponic cultivation is gaining popularity all over the world because of efficient resources management and quality food production. Soil based agriculture is now facing various challenges such as urbanization, natural disaster, climate change, indiscriminate use of chemicals and pesticides which is depleting the land fertility. In this article various hydroponic structures viz. wick, ebb and flow, drip, deep water culture and Nutrient Film Technique (NFT) system; their operations; benefits and limitations; performance of different crops like tomato, cucumber, pepper and leafy greens and water conservation by this technique have been discussed. Several benefits of this technique are less growing time of crops than conventional growing; round the year production; minimal disease and pest incidence and weeding, spraying, watering etc can be eliminated. Commercially NFT technique has been used throughout the world for successful production of leafy as well as other vegetables with 70 to 90% savings of water. Leading countries in hydroponic technology are Netherland, Australia, France, England, Israel, Canada and USA. For successful implementation of commercial hydroponic technology, it is important to develop low cost techniques which are easy to operate and maintain; requires less labour and lower overall setup and operational cost.*

Keywords: Internet of things, NFT ,Fertility , Watering

I. INTRODUCTION

Hydroponics is a technique of growing plants in nutrient solutions with or without the use of an inert medium such as gravel, vermiculite, rockwool, peat moss, saw dust, coir dust, coconut fibre, etc. to provide mechanical support. The term Hydroponics was derived from the Greek words hydro' means water and ponos' means labour and literally means water work. The word hydroponics was coined by Professor William Gericke in the early 1930s; describe the growing of plants with their roots suspended in water containing mineral nutrients. Researchers at Purdue University developed the nutriculture system in 1940. During 1960s and 70s, commercial hydroponics farms were developed in Arizona, Abu Dhabi, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries. Most hydroponic systems operate automatically to control the amount of water, nutrients and photoperiod based on the requirements of different plants (Resh, 2013). Due to rapid urbanization and industrialization not only the cultivable land is decreasing but also conventional agricultural practices causing a wide range of negative impacts on the environment. To sustainably feed the world's growing population, methods for growing sufficient food have to evolve. Modification in growth medium is an alternative for sustainable production and to conserve fast depleting land and available water resources. In the present scenario, soil less cultivation might be commenced successfully and considered as alternative option for growing healthy food plants, crops or vegetables (Butler and Oebker, 2006). Agriculture without soil includes hydro agriculture (Hydroponics), aqua agriculture (Aquaponics) and aerobic agriculture (Aeroponics) as well as substrate culture. Among these hydroponics techniques is gaining popularity because of its efficient management of resources and food production. Various commercial and specialty crops can be grown using hydroponics including leafy vegetables, tomatoes, cucumbers, peppers, strawberries, and many more. This article covers different aspect of hydroponics, vegetables grown in hydroponics system and global hydroponic market.

II. PROPOSED BLOCK DIAGRAM

In our proposed idea of hydroponic project, several key components work together to monitor and control the growing environment for optimal plant growth. The project utilizes various sensors including a Total Dissolved Solids (TDS) sensor, Electrical Conductivity (EC) sensor, water temperature sensor, soil moisture sensor, and a NodeMCU controller for data acquisition and system management.

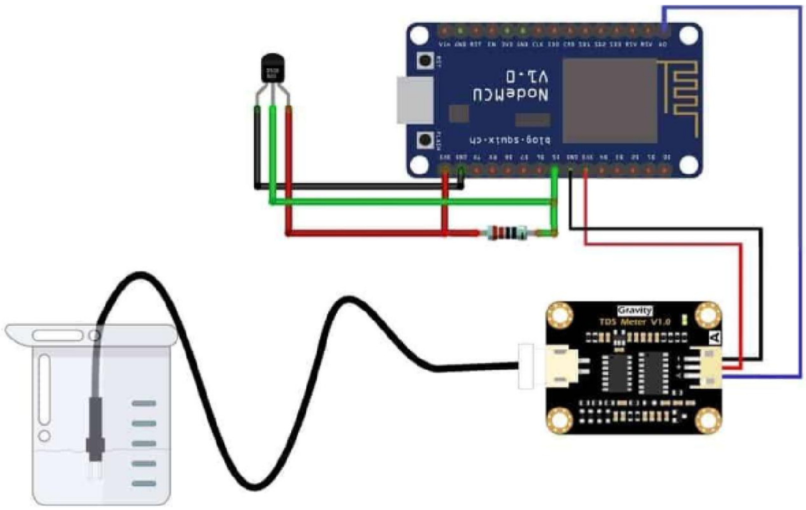

Fig. 1. Proposed block diagram of Advance Hydroponic System

Starting with the TDS sensor, this component measures the concentration of dissolved solids in the nutrient solution. The TDS value indicates the nutrient levels available to the plants, helping to ensure the correct balance of nutrients for healthy growth. The EC sensor complements this by measuring the electrical conductivity of the solution, which correlates with the nutrient concentration. Together, these sensors provide crucial data on the nutrient status of the hydroponic system. Additionally, the water temperature sensor monitors the temperature of the nutrient solution. Temperature plays a vital role in plant health, affecting nutrient uptake and overall growth. By monitoring this parameter, the system can adjust environmental conditions to optimize plant performance. Incorporating a soil moisture sensor adds versatility to the project, enabling the monitoring of moisture levels in the growing medium (such as coco coir or perlite). This sensor helps prevent overwatering or underwatering, ensuring the roots receive the appropriate amount of moisture for healthy plant development. Central to this hydroponic setup is the NodeMCU controller, which serves as the brain of the system. The NodeMCU collects data from all the sensors and processes it to make informed decisions. It can be programmed to automatically adjust parameters like nutrient dosing, water temperature, and irrigation based on predefined thresholds or user-defined settings. Additionally, the NodeMCU can facilitate data logging and remote monitoring, allowing users to track the hydroponic system's performance and make real-time adjustments as needed. In summary, this hydroponic project integrates multiple sensors and a NodeMCU controller to create a smart, data-driven system for efficient plant cultivation. By continuously monitoring key parameters like TDS, EC, water temperature, and soil moisture, the system optimizes growing conditions, ultimately promoting healthier and more productive plants.

III. METHODOLOGY USED

Our methodology outlines a structured approach to develop &emphasize the integration of various automation components with water quality analysis and functionalities. Each step is essential for ensuring a successful implementation that meets the project objectives effectively.

The hydroponic project incorporates a range of sensors and a NodeMCU controller to optimize the growing conditions for plants. The methodology involves several key steps to monitor and maintain crucial environmental parameters.

To begin with, the project utilizes a TDS (Total Dissolved Solids) sensor to measure the concentration of dissolved salts in the nutrient solution. This sensor helps ensure that the nutrient levels remain within optimal ranges for plant growth. The TDS readings are recorded periodically by the NodeMCU controller.

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In addition, an EC (Electrical Conductivity) sensor is employed to assess the overall nutrient content in the water. This sensor measures the ability of the solution to conduct electricity, providing a valuable indicator of nutrient strength. The NodeMCU logs the EC values alongside the TDS data for comprehensive nutrient management.

To monitor water temperature, a dedicated sensor is integrated into the system. This component continuously measures the temperature of the nutrient solution, which is critical for maintaining ideal conditions for plant root health and nutrient uptake. The NodeMCU captures and processes this temperature data in real-time.

Furthermore, a soil moisture sensor is utilized to assess the moisture levels within the growing medium. This sensor helps prevent overwatering or underwatering of the plants by providing accurate moisture readings. The NodeMCU controller interprets these values to automate watering cycles based on plant needs.

The NodeMCU controller serves as the central hub, collecting data from all sensors and executing control algorithms. Through a programmed interface, the NodeMCU processes sensor inputs and adjusts parameters such as nutrient concentration, water temperature, and watering schedules to optimize plant growth.

Overall, the methodology involves continuous monitoring of TDS, EC, water temperature, and soil moisture using respective sensors interfaced with a NodeMCU controller. This integrated approach enables precise control over hydroponic conditions, enhancing plant health and growth efficiency.

IV. SYSTEM OVERVIEW

The proposed system i.e. "ADVANCE HYDROPONIC SYSTEM" consists of several sensors and controller which are listed below with the overview of their specification –

- NodeMCU (Microcontroller)
- TDS V1.0 (Turbidity and EC sensor)
- DS18B20 (Waterproof temperature sensor)
- Resistive Soil Moisture Sensor

NODEMCU V1.0

The NodeMCU ESP8266 is a versatile and widely-used development board renowned for its compact size and powerful features. It serves as an essential tool in the, IoT (Internet of Things) and embedded systems development.

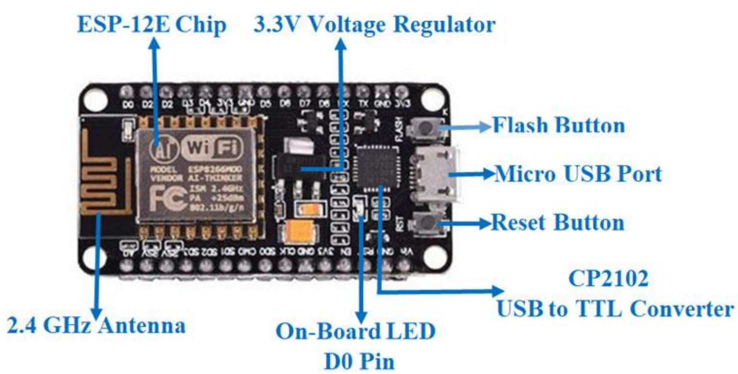

Fig.2. System component – NODEMCU ESP8266

The NodeMCU ESP8266 is an integrated development board built around the ESP8266 microcontroller module, designed to facilitate the rapid prototyping of IoT projects and embedded systems. At its core, the ESP8266 microcontroller boasts a 32-bit Tensilica Xtensa LX106 processor, clocked at speeds of up to 80MHz (with the possibility of overclocking to 160MHz), rendering it capable of handling a wide range of tasks with remarkable efficiency.

One of the most notable features of the NodeMCU ESP8266 is its built-in Wi-Fi connectivity, which enables seamless communication with local networks and the internet. This functionality allows devices built with the NodeMCU ESP8266 to interact with online services, exchange data with remote servers, and participate in IoT

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ecosystems. The board supports the 802.11 b/g/n Wi-Fi standards, ensuring compatibility with most modern wireless networks.

In terms of connectivity, the NodeMCU ESP8266 provides a plethora of GPIO (General Purpose Input/Output) pins, offering flexibility for interfacing with various sensors, actuators, and peripheral

devices. These GPIO pins support digital input/output operations, analog input measurements, and PWM (Pulse Width Modulation) output control, enabling a widerange of applications.

The NodeMCU ESP8266 board also features a USB-to-Serial interface chip, typically the CH340 or CP2102, which facilitates easy programming and debugging via a standard USB connection. This interface allows developers to upload firmware, monitor serial output, and interact with the microcontroller directly from their computer, streamlining the development process.

TDS SENSOR

The TDS (Total Dissolved Solids) sensor V1.0 is an analog sensor designed to measure the concentration of dissolvedsolids in a liquid solution. It operates on the principle of conductivity, where the electrical conductivity of the solution is directly proportional to the concentration of dissolved ions, including salts, minerals, and other organic and inorganic substances.

The TDS sensor V1.0 is calibrated to provide accurate measurements of TDS levels in parts per million (ppm) or milligrams per liter (mg/L). It converts the conductivity readings obtained from the solution into TDS measurements using pre-determined calibration factors specific to the sensor model.

The TDS sensor V1.0 typically consists of two electrodes, immersed in the liquid solution being tested. When voltage isapplied across these electrodes, an electric current flows through the solution. The magnitude of this current is influenced by the number and type of dissolved ions present in the solution, which in turn affects its conductivity.

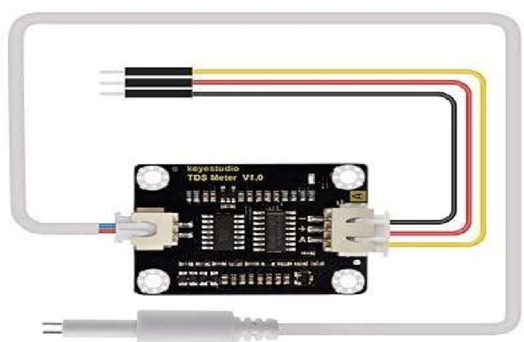

Fig.3. System component – TDS V1.0 SENSOR

DS18B20 Temperature Sensor

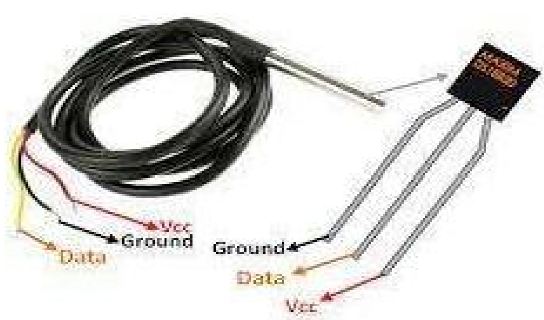

Fig.4. System component – DS18B20 SENSOR

The DS18B20 sensor is a digital temperature sensor manufactured by Maxim Integrated. It operates on the one-wire communication protocol, allowing multiple sensors to be connected to a single microcontroller pin. This feature simplifieswiring and makes it suitable for applications where space and complexity are concerns.

One of the standout features of the DS18B20 sensor is its high level of accuracy, with temperature readings typically accurate to within ±0.5°C in the range of -10°C to +85°C. This level of precision makes it ideal for applications where precise temperature measurement is critical.

The DS18B20 sensor is also known for its wide temperature range, spanning from -55°C to +125°C. This wide range of operation makes it suitable for use in a variety of environments, from extreme cold to high temperatures.

RESISTIVE SOIL MOISTURE SENSOR

A resistive soil moisture sensor is a fundamental component used in agriculture and gardening applications to measure the moisture content of the soil. This type of sensor operates on the principle of electrical conductivity, where the moisture level affects the resistance between two conductive probes inserted into the soil.

The construction of a resistive soil moisture sensor typically involves two metal probes or electrodes that are inserted into the soil. These probes are connected to a circuit that applies a small electrical current between them. The resistance measured across these probes changes based on how much moisture is present in the soil.

When the soil is dry, it has higher resistance, meaning less electrical current flows between the probes. Conversely, when the soil is moist or wet, it becomes more conductive, allowing more current to pass through and resulting in lower resistance readings. This relationship between soil moisture and electrical resistance forms the basis for the sensor's functionality.

The output from a resistive soil moisture sensor is usually analog, providing a voltage or resistance value proportional to the moisture level in the soil. This output can be interfaced with microcontrollers like Arduino or NodeMCU for data processing and analysis. By continuously monitoring the sensor's readings, it's possible to determine when and how much to water plants based on their specific moisture requirements.

One advantage of resistive soil moisture sensors is their simplicity and cost-effectiveness. They are relatively easy to use and integrate into automated irrigation systems or environmental monitoring setups. However, they may require calibration for accurate readings, as factors like soil composition and temperature can influence the sensor's output.

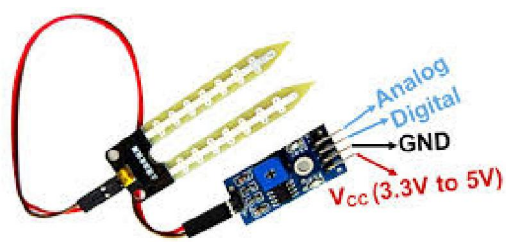

Fig.5. System component – Resisitve Soil Moisture Sensor

V. CONCLUSION

In conclusion the hydroponics is extending worldwide and such systems offer many new opportunities for growers and consumers to have productions with high quality, including vegetables enhanced with bioactive compounds. As it is possible to cultivate soil- less culturein very low spaces with low labour and short time, so hydroponics can play a great contribution for the poorer and landless people. Besides, it can improve the lifestyle of people and enhance the economic growth of a country. In India, the hydroponic industry is expected to grow exponentially in near future. To encourage commercial hydroponic farm, it is important to develop low cost hydroponic technologies that reduce dependence on humanlabour and lower overall start up and operational costs. Also in recent years te hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow short duration crop like vegetables round the year in very limited spaces with low labour, so hydroponics can play a great contribution in areas with limitation of soil and water and for the poorer and landless people. In India, the hydroponic industry is expected to grow exponentially in near future. To encourage commercial hydroponic farm, it is important to develop low cost hydroponic technologies that reduce dependence on human labour and lower overall startup and operational cost.

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