Vertical Farming using Smart Farming

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***Abstract*— Nutrient content (Nitrogen, Phosphorous, Potassium) monitoring in soils is essential for the proper use of fertilizers to minimize the environmental impact of wrong pattern fertilization practice. Collecting samples from different locations and laboratory testing takes longer and costs a lot. New-generation digital sensors are smart enough to replace chemical lab testing in real-time with minimum effort and with almost precise results. The Proposed system tends to implement various suggestions that would also help improve the quality of the work being done by the soil testing laboratories. By this, we can able to test our soil parameter in that condition quickly in our field for further processes and we will get the soil parameter report without any delay. And we can get information about the fertilizer and crop matches for that result and the number of fertilizers to be used. And to demonstrate soil humidity sensors and pH sensors to measure the NPK values which determine the fertility of the soil, which helps to improve cultivating system. The results obtained from our developed sensing system are almost accurate and very close to the laboratory test readings. Arduino plays a key role in processing data received from the sensor as input, the counters used here produce the respected output values for the parameters. There the values received by the Arduino are compared with the database and provide related information which is matched to the current calculated values. The output values provided by the Arduino and sensors will be displayed on the LCD. Here the output not only provides formation on fertility present in the soil but also suggests crops to be grown on that soil.**

Keywords—Vertical farming, smart farming, nutrient monitoring, digital sensors, soil fertility, crop suggestions.

I. INTRODUCTION

Soil testing started in India in the year 1955 with 16 laboratories by the Department of Agriculture. And as the day begins the number of centers increased all over India. But also, all farmers are facing many problems with this. That is all soil analysis centers are dependent on primitive method that is on chemical base testing method only and these soil testing centers are not accessible to all farmers in all areas. In every state around 9 to 10 lakhs soil samples have been received in laboratories and it is very difficult to test all the soil samples in time by the laboratories.

Monitoring in soils is essential for the proper use of fertilizers to minimize the environmental impact of wrong pattern fertilization practices. Collecting samples from different locations and laboratory testing takes longer and costs a lot. New-generation digital sensors are smart enough to replace chemical lab testing in real-time with minimum effort and with almost precise results.

Indian economy is mainly based on agriculture still we are not able to make the most favorable, commercial, and sustainable use of our land resources. The main reason is the lack of knowledge regarding soil analysis for the growth of crops. Soil analysis is a valuable tool for farmers as it determines the inputs required for efficient and economic production. A proper soil test will support the presentation of plenty of fertilizer to come across the desires of the crop while taking advantage of the nutrients already present in the soil.

This paper will be useful for the technical staff of the soil testing laboratories in doing their day-to-day analytical work and framing fertilizer use recommendations. Implementing various suggestions would also help improve the quality of the work being done by the soil testing laboratories. By this, we can able to test our soil parameter in that condition quickly in our field for further processes and we will get the soil parameter report without any delay. And we can get information about the fertilizer and crop matches for that result and the amount of fertilizers used.

II. PROPOSED SYSTEM AND METHODOLOGY

This paper is based on the concept of turning soil analysis into an automated soil testing device. This system requires the Arduino, which acts as a key to control and monitor various aspects of the soil testing process. 1. We have different wireless sensor networks to measure different parameters in agriculture. We use a Ph and based on the Ph value; we will suggest suitable crops to the farmer. 2. We use a soil moisture sensor to monitor the dryness and wetness of the soil. If the soil is dry, it will turn on the pump. It will help to maintain sufficient wetness in the soil. 3. We have a DHT-11 sensor to measure the humidity and temperature. This measure data will be uploaded to the cloud using IoT technology for future analysis. 4. A GSM modem is used to send the information to the farmer. 5. All measured parameters are uploaded to the cloud using Wi-Fi(IoT) module.

Whenever a farmer wants to analyze the soil fertility, he needs to take the soil sample, and water should be added to the soil sample and allow the sample to settle down. The pH sensor will be placed in the sample. Here pH sensor which measures the Nitrogen, Phosphorous, and Potassium. We use a pH sensor to monitor the soil pH, and based on the pH value we will suggest suitable crops to farmers.

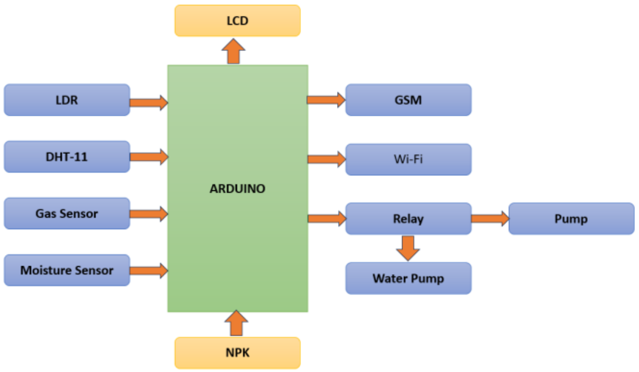

Fig 1. Block diagram of the proposed system

Here we have different wireless sensor networks to measure different parameters in the agriculture field. And soil moisture sensor is used to monitor dryness and wetness of the soil. If the soil is dry it will turn on the pump. It will help to maintain sufficient wetness in the soil.

DHT-11 sensor will measure the humidity and temperature. This measured data will be uploaded to the cloud using IoT technology for future analysis. We use a GSM modem to send the information to the farmer. And also upload all measured parameters to the cloud using Wi-Fi (IoT) module. This data will be useful for future analysis.

The Arduino plays a key role in processing data received from the sensor, where it compares the data already pre-stored with the sensor output signal. The Arduino after comparison gives the output and the values are displayed on the LCD. The output not only provides information on fertility present in the soil but also suggests crops to be grown on that soil. The complete technology is made like a kit that is easy to implement and low cost which is helpful for modern farmers.

Sl.No.	Soil Type	N-P-K and per values as Lab	N-P-K and pH values as per Experimental results	Suitable Crops
1	Red soil (College Campus)	N=77	N=69	Rice, groundnut, Brinjal, Wheat, Sugarcane
		P=63	P=65	
		K=59	K=51	
		pH=8.3	pH=7.9	
2	Red Soil (Anjaneya Nagar)	N=73	N=65	Rice, groundnut, Brinjal, Wheat, Sugarcane
		P=58	P=48	
		K=55	K=57	
		pH=7.8	pH=7.3	
3	Black Soil (Bijapur)	N=46	N=49	Cotton, Jawar, Wheat, Sunflower.
		P=38	P=34	
		K=54	K=50	
		pH=6.6	pH=6.2	
4	Sandy soil (Khanapur)	N=49	N=40	Rice, Jawar, sugarcane, peas, cotton
		P=38	P=42	
		K=26	K=33	
		pH=6.4	pH=7.0	

Fig 2. Various parameters & crops obtained from the results of soil testing from the lab

III. HARDWARE ANALYSIS

A. Power supply

The power supply is a major concern for every electronic device. Since the controller and other devices used are low-power devices there is a need to step down the voltage and as well as rectify the output to convert the output to a constant DC. The major blocks of power supply are the transformer, rectifier, voltage regulator, and filter.

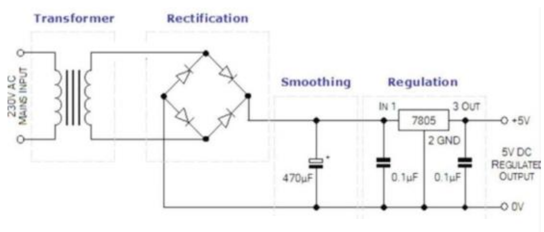

Fig 3. Power supply circuit

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B. *Arduino UNO*

The Arduino Uno is an open-source microcontroller board based on the Microchip AT mega 328P microcontroller and developed by Arduino. cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced with various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), and 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Common Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.

Fig 4. Image of Arduino UNO

While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Arduino Uno is a microcontroller board based on 8-bit ATmega328P microcontroller. Along with ATmega328P, it consists of other components such as a crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller.

Arduino Uno has 14 digital input/output, 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header, and a reset button.

C. *pH sensor*

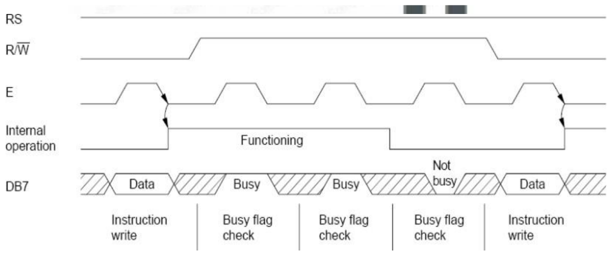
pH Sensor is specially designed for Arduino controllers and has built-in simple, convenient, and practical connections and features. It has an LED that works as the Power Indicator, a BNC connector, and a PH2.0 sensor interface. You can just connect the pH sensor with the BNC connector, and plug the PH2.0 interface into any analog input on the Arduino

controller to read the pH value easily.

D. *Soil moisture sensor*

Soil Moisture Sensors measure the volumetric water content in soil Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighing of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content.

Fig 9. Internal circuit of relay



E. *DHT-11 sensor*

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital signal acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability, and cost-effectiveness.

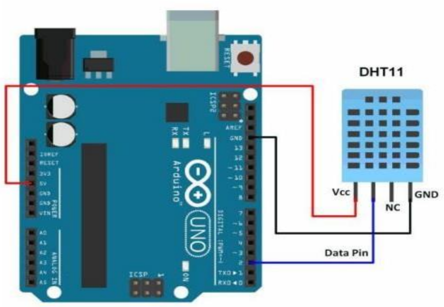


Fig 7. DHT-11 sensor with Arduino

F. *LCD Display*

LCD (Liquid Crystal Display) is a type of flat panel display that uses liquid crystals in its primary form of operation. Normally to interface LCD with the microcontroller requires 3 control signals and 8 data lines. This is known as an 8-bit interfacing mode which requires a total of 11 I/O lines. To save a number of I/Os required for LCD interfacing we can use 3 control signals with 4 data lines. This is known as 4-bit interfacing mode and it requires 7 I/O lines. We are using a 4-bit interfacing mode to reduce the number of I/O lines. In this mode, the higher nibble and lower nibble of commands/data sets need to be sent separately. The figure shows LCD interfacing in 4-bit mode. The three control lines are referred to as EN, RS, and RW.

The EN line is called "Enable" and it is connected to PORT 2's 5th pin (P2.4). This control line is used to tell the LCD that the microcontroller has sent data to it or microcontroller is ready to receive data from LCD. This is indicated by a high-to-low transition on this line. To send data to the LCD, the program should make sure that this line is low (0) and then set the other two control lines as required and put data on the data bus. When this is done, make EN high (1) and wait for the minimum amount of time as specified by the LCD datasheet, and end by bringing it to low (0) again.

The RS line is the "Register Select" line and it is connected to PORT 2's 7th pin (P2.6). When RS is low (0), the data is treated as a command or special instruction by the LCD (such as a clear screen, position cursor, etc.). When RS is high (1), the data being sent is treated as text data which should be displayed on the screen.

The RW line is the "Read/Write" control line and it is connected to PORT 2's 6th pin (P2.5). When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading from) the LCD.

The data bus is bidirectional, 4-bit wide, and is connected to the PORT2 (P2^0 to P2^3) of the microcontroller. The MSB bit (DB7) of the data bus is also used as a busy flag. When the Busy flag is 1, the LCD is in internal operation mode, and the next instruction will not be accepted. When RS = 0 and R/W = 1, the Busy flag is output on DB7. The next instruction must be written after ensuring that the busy flag is 0.

G. Relay

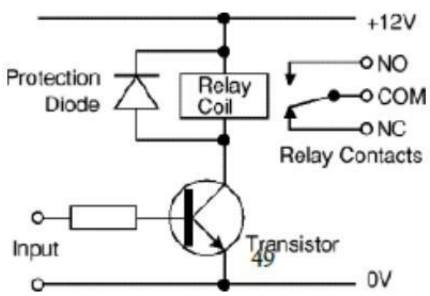


Fig 8. LCD timing diagram

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field that attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions. Relays allow one circuit to switch to a second circuit which can be completely separate from the first. For example, a low-voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits. The link is magnetic and mechanical.

IV. SOFTWARE ANLAYSIS

This chapter describes the analysis of software that are used namely the Arduino IDE and Embedded C in this project.

A. Arduino IDE Software

The Arduino IDE is a cross-platform application written in Java and is derived from the IDE for the Processing programming language and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development.

B. Embedded C

Having decided to use an 8051 processor as the basis of your embedded system, the next key decision that needs to be made is the choice of programming language. To identify a suitable language for embedded systems, we might begin by making the following observations:

1. Computers such as microcontrollers, microprocessors, and DSP chips only accept instructions in machine code. Machine code is, by definition, in the language of the computer, rather than that of the programmer.

2. All software, whether in the assembly, C, C++, or Java must ultimately be translated into machine code to be executed by the computer.

There is no point in creating 'perfect' source code if we then make use of a poor translator program (such as an assembler or compiler) and thereby generate executable code that does not operate as we intended.

1. Embedded processors – like the 8051 – have limited processor power and very limited memory available: the language used must be efficient.

2. To program embedded systems, we need low-level access to the hardware: this means, at least, being

able to read from and write to particular memory locations.

3. No software company remains in business for very long if it generates new code, from scratch, for every project. The language used must support the creation of flexible libraries, making it easy to reuse (well-tested) code components in a range of projects.

The language chosen should be in common use. This will ensure that you can continue to recruit experienced developers who know the language. It will also mean that your existing developers will have access to sources of information that give examples of good design and programming practice. Even this short list immediately raises the paradox of programming language selection. From one point of view, only machine code is safe, since every other language involves a translator, and any code you create is only as safe as the code written by the manufacturers of the translator.

V. RESULTS

Fig 10. The soil moisture content using the forked moisture sensor was found to be 1% & the light intensity of the environment was found to be 51 %.

Fig 11. The environment's air quality is collected as 100 % (as there was no smoke introduced) & displaying that all the required data has been collected.

PLACE	N,P,K & pH values (Lab result)		N,P,K & pH values (Experimental result)		CROPS
SHIMOGA	N(kg/hector)	219.52	N(kg/hector)	220	Paddy Coconut Arecanut Mango Banana Vegetables Oil seeds
	P(kg/hector)	142.51	P(kg/hector)	145	
	K(kg/hector)	165.76	K(kg/hector)	170	
	pH	6.90	pH	7	

Fig 12. The were recor

Fig 15. Comparison of lab values with the results obtained.

Fig 13. Once all the data was collected it was sent to the Thingspeak cloud for further analysis.

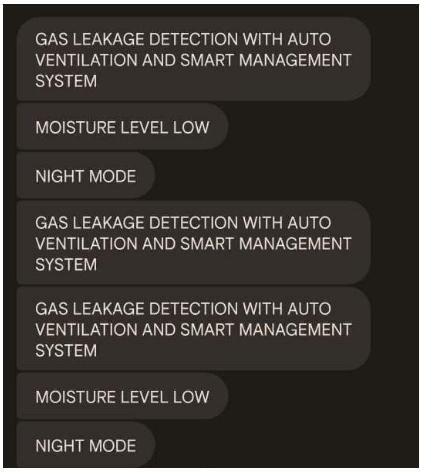


Fig 14. Messages sent from the GSM module to the SIM number used.

CONCLUSION AND FUTURE SCOPE

Automated Soil Testing Device and Crop Advisory System, has been developed for soil testing of agricultural farms. The N P K & pH values vary from one type of soil to others. N P K & pH values of soil samples are measured in real-time and compared with the pre-stored values received from the agricultural department. The system also provides information about the crops that can be grown in respective soils. A wireless communication system has been incorporated for interacting with the experts.

IoT can be used for further enhancement purposes, the data which is available from the soil testing device can be centralized where it gets uploaded to a website.

By this data, a farmer who doesn't have this device also can refer to the previous data sheets to grow the crops followed by their place and type of nutrient values present in that soil.

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