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Development of an IOT Based Smart Soil Monitoring System

Gulja S Nair*Assistant Professor(SG), Department of Agricultural Engineering,
Dr T Jayaprakash, Professor, Department of Physics
Nehru Institute of Technology, Coimbatore
Kaviya S, III Year Student, BE Agricultural Engineering, Nehru Institute of Technology
Email: guljasnair@gmail.com

ABSTRACT

Meeting the fasting growing populations demand for food demands a new agricultural era which can provide food security to the future world. To bring about a new era for agricultural production, smart monitoring of soil parameters and micro climate of the farm field is necessary. Present study was conducted to develop a smart soil monitoring kit, which monitors soil moisture, soil pH level, soil temperature, humidity and also gives alerts on animal or bird intrusion to the farmer field. The soil parameters sensed are displayed in LCD display and also the data are sent to user mobile via GSM module. The developed soil monitoring kit was successfully tested in nearby fields and found out to be satisfactorily working.

INTRODUCTION

More than 50% of the total work force in India depends on agriculture and also agriculture contributed to 17-18% of the country's GDP[1]. The fast growing population demands food and to supply adequate food the only solution is agriculture. For a country like India, who is having the second largest arable land resources in the world, 20 agro-climatic regions and 46 types of soils, it is a responsibility to contribute for future food security. Although, India stands first in the production of spices, pulses, cashew, tea, jute, second in the production of rice, fruits, vegetables, wheat, sugar cane, cotton and legumes, we are lagging in the yield, ie, the production per unit of land. Compared to China, Brazil and United States, the agricultural yield is less [2].

The key factors affecting the yield are dependence on monsoon, small land holdings, inadequate irrigation, unbalanced use of soil nutrients, lack of access to modern technology etc. Currently 51% of the food grain cultivation is depending on irrigation[3] and the remaining area being completely rain-fed agriculture. Currently 84% of the total water availability of the country is used for irrigation[4] Irrigation sources include surface water and ground water. Over use of ground water has been reported in states growing water intensive crops. In states like Punjab, Haryana and Rajasthan the ground water unites were reported as over exploited [5]. The water use efficiency of irrigation need to modified and for this sensor based automatic micro irrigation system can be adopted, thus helping in water conservation and better yield. India uses 2-3 times the quantity of water used by China, Brazil and United states to produce 1 tonne of grain [6].

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Soil conditions are yet another important factor affecting the yield. Indian soil contains primary, secondary nutrients as well as micro nutrients, but the over utilization during past decades has resulted in the deterioration of Indian soil [7,8]. Soil erosion of about 5.3 billion tonnes annually has been reported. Surplus or inadequate use of fertilizers is resulting in fertility loss and variability of soil pH. The acidity or alkalinity of soil need to be identified and proper reclamation measures are to be taken. For this soil analysis is required which is a tedious and expensive process.

Crop damages due to animal and bird intrusions is yet another reason for reduction of crop yield, notices in about 10 states in India, with Andhra Pradesh and TamilNadu on the leading positions. There have been many human animal conflicts reported frequently and the manual monitoring process is very hectic and dangerous one. A continuous smart monitoring with alert or warning system is can very well help to reduce the loss in yield.

Timely monitoring of weather parameters like climate and temperature can help to plan better crop management methods and there by modifying the micro climate of the crop land, which can add to the optimum productivity.

Based on the above observations, an IoT based smart soil monitoring system was developed which can monitor the micro climate, soil pH level, moisture content as well as give alert for animal or bird intrusion.

METHODOLOGY

The present study was an attempt to develop a smart soil monitoring system. The developed soil analysis kit consists of different sensors connected in series and then connected to the arduino board micro controller. The sensor readings are displayed in LCD monitor as well as user's mobile.

The main components of the proposed system are Moisture sensors, Temperature and humidity sensors, pH sensors, PIR sensors, buzzer system, Arduino UNO, USB cables, battery recharge, jumper wires, GSM Modules kit, IR resistor and led lights.

Soil Moisture Sensor: Soil moisture sensor uses capacitance to measure dielectric permittivity, which is a function of the moisture content. A voltage proportional to the dielectric permittivity or we can say the moisture content is created . The sensor is inserted to the soil and the moisture content is obtained as percentage. The required voltage is 5V ad current is less than 20mA. It works in a temperature range of 10-30 degree Celsius.

Temperature and Humidity sensor: DHT 11 sensor was chosen to monitor temperature and humidity. It consists of a capacitive humidity sensing element and a thermister element to sense temperature. It provides reliable and stable output which can be interfaced directly to Arduino port pin. The sensor is of small size, works in low power and is reliable. It measures temperature

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with an accuracy of 2 degree Celsius and humidity at 5 % accuracy. Maximum current usage is 2.5 mA and operating voltage is 3 to 5 volts.

PIR Sensor: Pyroelectric Infrared Sensors are excellent sensors to detect human or animals. All living things emit infrared rays. PIR sensors detect the infrared rays emitted and identify the human or animal presence. They are widely used in surveillance.

pH Sensor: pH refers to the acidity or alkalinity. It measures the free hydrogen ion concentration in soil. pH value varies from 0 to 14, 7 being neutral, less than 7 acidic and greater than 7 alkaline. pH sensor measures the free hydrogen ion concentration of soil solution. Voltage signals are generated based on the pH level of the soil. This will help the farmer to determine the soil amendments required to neutralize the soil.

Arduino Uno microcontroller: The Arduino uno microcontroller board with the 14 digital pins for input and output is connected through USB cables for power supply. It is main source of connecting all the devices in a single unit. The Arduino uno based on ATmega328 with a limited voltage of 6-20 V used in the setup.

GSM Module: GSM module uses GSM mobile telephone technology to provide a wireless data link to a network. The arduino GSM shield is a GSM modem. In addition to GSM shield and an arduino, a SIM is needed. SIM cards are fixed in the GSM shield and connected to arduino pin which is used to display the values in the phone.

Blynk : It is an application designed to remotely control hardware and display sensor data. It can store as well as visualize data. The blynk consists mainly of three platforms, blynk app which helps to create interfaces, blynk server helps to communicate between smart phone and hardware and blynk libraries to enable communications with server and process incoming and outgoing commands.

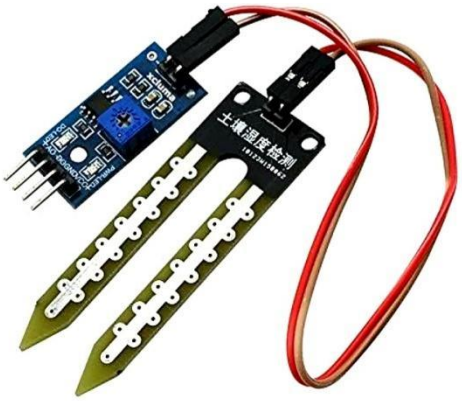

Fig. 1 Soil Moisture Sensor

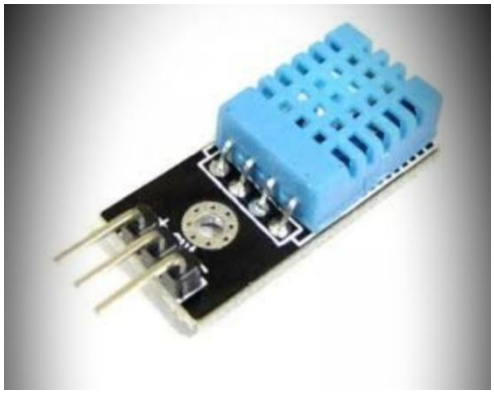

Fig 2. Temperature and humidity sensor

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Fig. 3 PIR Sensor

Fig. 4 pH Sensor

Fig. 5 Arduino micro controller

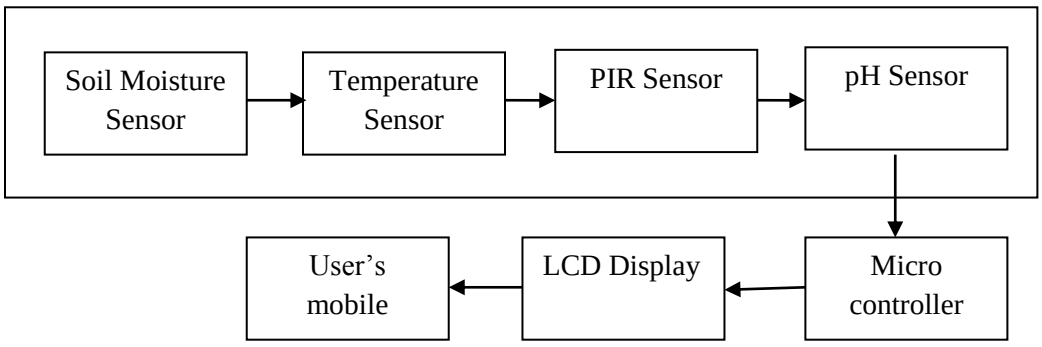

Fig 6. Block diagram of soil analysis kit setup

Fig. 6 describes the outlook connection of the experimental setup. Program coding is done to give the reading of the soil in LCD Display as well as in the user's mobile. With the help

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of the blynk app monitoring of the climate changes, temperature differences, water content in the soil and also monitoring the animal/ bird attack to the farm field is done. Using simple methodology and simple platforms we can monitor our field in smart way.

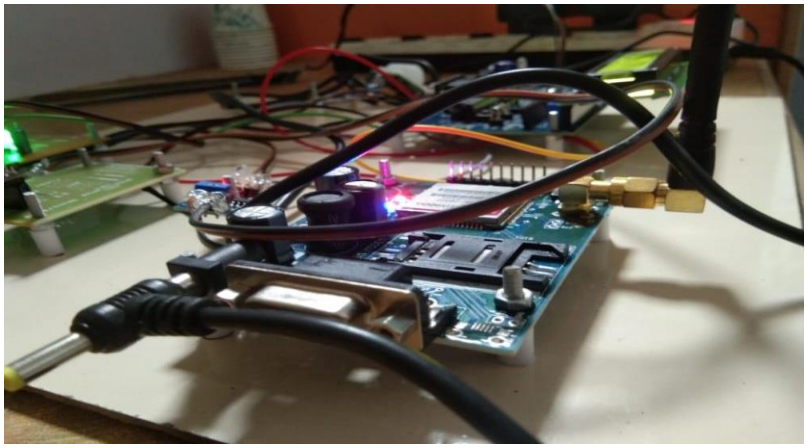

Fig 7 GSM Module and its connections

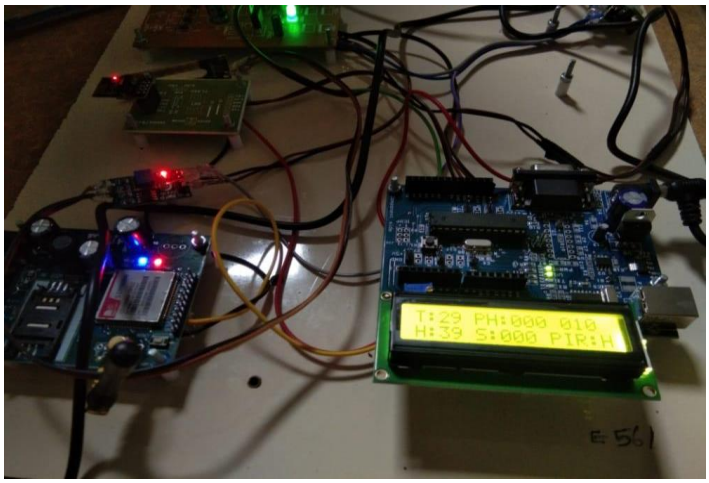

Fig 8 Overall setup of the product

S.NO	CONTENT	READING
1.	Soil moisture content	80%
2.	Temperature	29
3.	Humidity	39
4.	PIR	H (Human/animal intrusion)
5.	pH level	10

Table 1 Sample readings obtained using the soil analysis kit

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RESULTS AND DISCUSSION

All the sensors were connected in a series with the arduino microcontroller board and also external power supply given to the unit. All the soil sensors are directly connected in the field for continuous monitoring of the soil. The soil is tested in 5 to 8 check points in the same field for accurate reading of the soil contents. The number of sensors can be increased according to the field size and usage of the kit. A limited voltage supply 220V is used for the whole setup.

SAMPLES	READINGS
Sample 1	Difference in temperature range
Sample 2	Difference in the moisture range
Sample 3	Changes in the pH level
Sample 4	Changes in the moisture content
Sample 5	Difference in the animal/bird intrusion

Table 2 Variations observed in soil parameters for different samples

Fig 9 LCD display results of the soil analysis kit

The results are obtained in the user's mobile also through blynk app. This will help to monitor the field continuously and frequently with the help to IoT sensors. The continuously monitoring of the soil parameters can add to increase the yield as well as reduce the water scarcity in the field.

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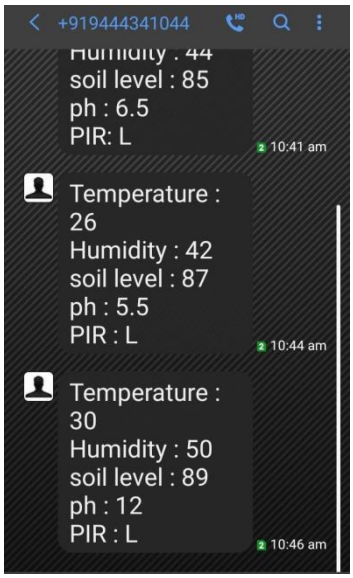

Fig 10 User' mobile updates on a real time basis

CONCLUSION AND FUTURE WORK

Proper analysis of soil parameters will help to plan cultivation practices which can help in increased yield from unit area of land. A smart soil monitoring system was developed which gives real time monitoring of temperature and humidity, soil moisture, pH level and animal/bird intrusion to the field. The developed system was used to test soil at different locations and found to be satisfactory. The measured soil parameters are displayed in LCD display screen and also in user mobile.

The future research prospects include adding sensors to analyze macro (NPK) and micro nutrients of soil and thus recommending the amount of manures/fertilizers to be applied to the soil. Also, finding all the soil parameters and micro climate, app can be developed which can suggest crops suitable for the soil conditions along with the cultivation practices, irrigation scheduling, fertilizer applications etc. The application can be programmed to assess the marketing and income prospects of each crop suggested. Development of such an application will be a great help to the farming community.

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