EFFECTIVE CROP PRODUCTIVITY AND NUTRIENT LEVEL MONITORING IN AGRICULTURE SOIL USING IOT

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ABSTRACT:

In today's world, there is an increase in population growth. Hence there is a need in increase in food production. Fertilizers are being used to increase crop productivity but what is ideal to produce more crop, nutrient level of soil and crop monitoring is more important. Hence we introduce Internet of Things for monitoring the soil parameters including pH level, soil moisture, temperature and humidity. Soil moisture and pH value are the important parameters for crop growth. The soil parameters are detected and monitored using various sensors. Infrared sensors are also used in order to detect disease in plants. The values detected are stored and updated in cloud server for future use. Also an application is developed for farmers in order to know the pH level of nutrients in soil, soil moisture and temperature for efficient productivity of crops.

Keywords – pH sensor, soil moisture sensor, infrared sensor, raspberry pi, cloud server

INTRODUCTION:

During the year 80's and 90's there were no scarcity of food and water. Now a day's scarcity of food and water increases as the population increases. To provide more crops fertilizers are being used. Fertilizers are mainly used to provide more crops and it must be used up to a certain limit. But now a day's there is no limit for the use of fertilizers which alters the fertility of soil. For an acre 50 kilograms of fertilizer are being used which is hazardous to human health. For efficient plant growth, nutrients [1, 3, 4] are more important. In soil the nutrients are classified into micro nutrients and macro nutrients. Micro nutrients consist of copper (Cu), manganese (Mn), zinc (Zn), chlorine (Cl), boron (B) etc . . . Macro nutrients consist of potassium (K), phosphorus (P), nitrogen (N) which in short is identified as NPK nutrients. Macro

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nutrients are more essential for plant growth. Plants consume 20% of micro nutrients and 80% of macro nutrients [2]. Plants do not consume the essential nutrients due to alteration in level of fertilizers. Excess use of fertilizers affects the living organisms and leads to abnormal life of human beings. Use of excess amount of fertilizers is considered to be a slow poison for living organisms. To avoid this, pH level of nutrients must be known. By determining the pH level of nutrients in soil, amount of fertilizers to be used can be reduced. When the level of soil nutrient is 75%, then 25% of fertilizer can be used. Medium amount of fertilizer can be used if the soil nutrient level is of 50%. 75% of fertilizer can be used only if soil nutrient level is of 25%. Along with that temperature level of land, humidity and moisture of soil is determined. By determining the soil moisture, wastage of water can be reduced. Using these farmers can decide what type of crop to be planted. The values determined are updated in database for further improvement in agriculture.

PROPERTIES OF SOIL:

Soil is a mixture of gases, liquids, organic matter and organisms that support human life. It is considered to be one of the major of earth's ecosystem. There are various types of soils. Each type of soil consists of mineral particles, organic matter, air and water. These entire particles combine and provide soil properties such as its texture, structure, porosity, colour, resistivity and consistency.

Texture:

Sand, silt and clay particles combine to form various types of soil. The proportion of these particles along with organic matter forms the soil texture. Sandy soils are rough when rubbed between fingers whereas silts are smooth like flour and clay is sticky and mouldable. Sand and are the inactive part of soil as it does not have the ability to absorb water or nutrients. Clay is the active portion of soil and absorbs water as it has large amount of surface area per unit mass.

Structure:

Soil structure is termed as the arrangement of soil particles. It is referred to as aggregates of primary soil particles such as sand, silt and clay into compounds or clusters of primary particles. It is expressed in terms of grade, class and aggregates and is rated from 0 to 3. Grade is defined as the degree of aggregation and the four major grades rated are 0 as structure less, 1 as weak, 2 as moderate and 3 as strong. It modifies the effect of

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texture along with moisture, air, availability of nutrients and root growth.

Porosity:

Pores within the soil are referred to as soil porosity. This influences the movement of air and water. Healthy soils have many pores within and between aggregates whereas poor quality of soils has few visible pores and cracks. The size of pores varies considerably and is classified into micro pores and macro pores. Pore size also affects the ability of plants and other organisms to access water and oxygen. A large pore allows transmission of air, water and dissolved nutrients through soil whereas small pores store water.

Colour:

Soil colour can be viewed and is determined by its organic content and degree of oxidation. Based on the soil colour, characteristics of soil can be determined. Soil colour is due to various iron minerals. Soils that have more iron minerals are orange-brown to yellowish-brown and soils that are high in organic matter are dark brown or black in colour.

Resistivity:

Soil resistivity is termed as the measure of how much the soil resists the flow of electricity. The electrical resistivity of soil also affects the rate of corrosion of metallic structures in contact with the soil. The corrosion rate can be increased by lowering the resistivity and by increasing the conductivity. Soil resistivity range from 2 to 1000 Ω-m. Also the soil resistivity depends on moisture content, salt content and temperature.

Consistency:

Consistency of soil is referred to the aggregates that can be crushed using fingers. It depends on soil moisture content and is classified into wet soil, moist soil and dry soil. Dry soils are extremely hard, moist soils are extremely firm and wet soils are sticky. In construction, soil consistency estimates the ability of soil to support buildings and roads.

PARAMETERS OF SOIL:

The soil parameters that are to be considered for efficient crop production are temperature, humidity, soil moisture and pH of soil.

Temperature:

Soil temperature plays one of the major roles in plant growth and is found by the measurement of warm air in soil. Temperature not only affects the climate [12] , leaf fall but also affects the decomposition rate of organic material,

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chemical process, biological process and physical process of soil. For most plant growth, the ideal soil temperature is 65 to 75F (18 to 24□).

Humidity:

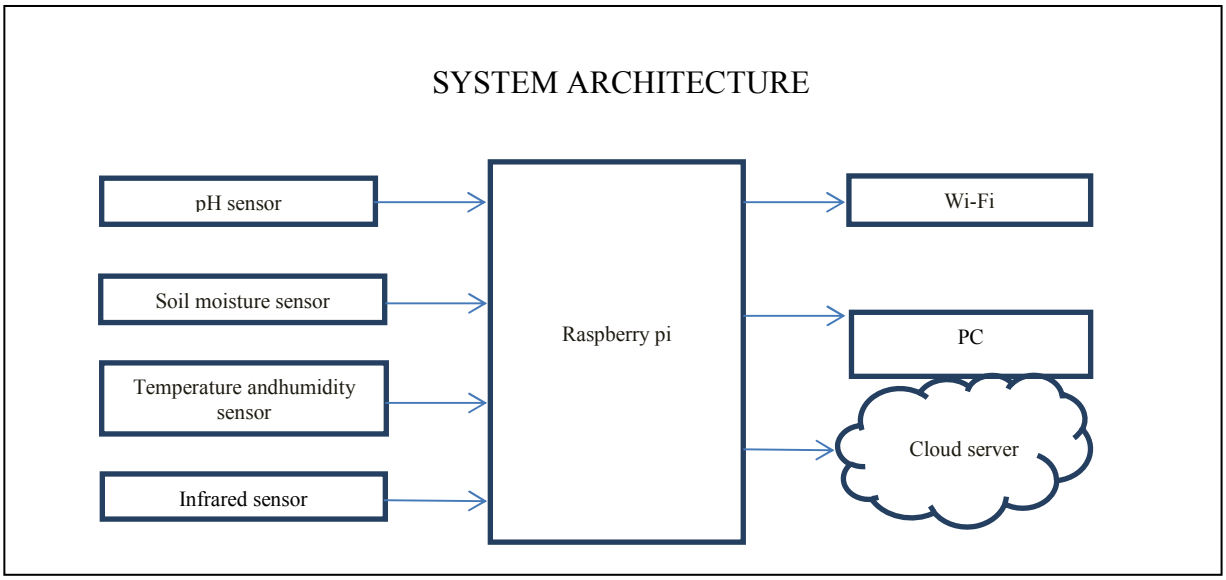
The amount of water vapour present in air is determined as humidity. Humidity is classified into three ways such as absolute humidity, relative humidity and specific humidity. Plants grow best if the relative humidity is above 50%. An effect of humidity is seen in plants, animals, human comfort, construction [15] and humidity. Humidity depends on temperature, water vaporization and condensation. Also effectiveness of sweating is reduced when there is high humidity.

Soil moisture:

Soil moisture is determined as the amount of water contained in soil. Water is the major component of soil for plant growth. If the water (moisture) content in soil is optimum, plant can absorb the water and serves as the carrier of food nutrients for efficient plant growth. The information about soil moisture can be used for irrigation scheduling, crop yield forecasting, early warning of droughts and reservoir management.

pH level:

pH measures the acidity and alkalinity levels of soil for proper plant growth. Based on the level of pH, crops are cultivated. The pH range for most plants is between 5.5 to 7.5. The soil is acidic, if the pH range is below 6 and is alkaline, if the pH range is above 7. Factors that affect the soil pH are the temperature and rainfall [5], which in turn controls the soil mineral weathering.



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The system is implemented based on Internet of Things (IoT) which in other words known as system of connected devices. Connected devices are that sensor, actuators and other embedded devices. Internet of Things is applied in agriculture, industries, home appliances etc. . . . . In agriculture, Internet of Things is applied in order to monitor the soil nutrient level for efficient crop growth. To monitor the nutrient level of soil, the system is designed using various sensors such as pH sensor for determining pH range of soil, soil moisture sensor for determining the water content in soil, temperature and humidity sensor for determining the temperature and humidity. Along with these sensors, infrared sensor is used in order to determine heat objects such as human beings, animals etc. . . . . These sensors are then connected to a Raspberry pi microcontroller where the values detected are stored and uploaded to the server.

PRINCIPLE OF OPERATION:

As explained earlier, the system is designed using sensors connected with microcontroller. Here the Raspberry pi 3 Model B microcontroller is used which acts as a control unit for the whole process. Jumper wires are used to connect the sensors to Raspberry pi microcontroller. Raspberry pi is then connected to the personal computer for displaying the details about the soil parameters. Raspberry pi is in turn a central processing unit and can be connected to the computer easily through USB cable. The sensors and microcontroller used has various operations and several features.

Raspberry pi:

Raspberry pi microcontroller has various versions. The latest version of this microcontroller is the Raspberry pi 3 model B. The initial version of this microcontroller is Raspberry pi 1 model B (First generation). All versions of microcontroller consists of a Broadcom system on a chip (SoC) along with ARMcompatible central processing unit (CPU) and on-chip graphics processing unit (GPU). Raspberry pi 3 Model B is the third generation of Raspberry pi. Its features also include Bluetooth, Wi-Fi and USB boot capabilities. The latest version is 10x times faster and has powerful processor than the previous generations of Raspberry pi.Also it consists of four USB ports for connecting keyboard, mouse and sensors. Another feature is that there are 40 general purpose input output (GPIO) pins. Using these GPIO pins, sensors can be connected easily through jumper wires. For loading

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operating system and storing the data SD card is inserted to the microcontroller.

Temperature sensor:

Temperature sensors are of different levels. But here temperature sensor (DS18B20) is used. This sensor has three pins which can be connected to the microcontroller. The power supply range for this sensor is from 3.0V to 5.5V and measures the temperature from -55□ to +125□. Here the first pin is ground (GND), second pin is used for data in/out (DQ) and the last pin is for power supply voltage (V_{DD}). The functionality of this sensor is direct digital temperature sensor and is configurable with 12bits. Temperature conversion can be performed and the value is stored in memory of 16bits. The temperature sensor has a register containing sign (S) bit which denotes whether the temperature is positive or negative.

Humidity sensor:

Humidity also depends on the temperature. To measure humidity DHT11 sensor is used which provides a digital signal output. The sensor has high reliability and long term stability. It offers fast response, excellent quality and is very much cost effective. It is easier to connect to the microcontroller and has 4 pin configurations. The measurement range of this sensor is 20-90% RH and 0-50□. The maximum response time of humidity sensor is 15s and needs a power supply of 3-5.5V DC [11]. Here the first pin is connected to the power supply V_{DD}, second pin for data and third pin for ground GND. Instruction must not be sent within one second. For power filtering, a capacitor (100nF) can be added between V_{DD} and GND.

Soil moisture sensor:

Soil moisture sensor is used for measuring the water content in soil. The moisture sensor has two probes to pass current through the soil. It then determines the resistance (conductance) in the soil. If the soil has less water content, then there is high resistivity (dry soil). If there is more water content in soil, lesser resistance occurs. The power supply needed for this sensor is of 3.3V to 5V [8, 9, 10] and can provide output as digital and analog signals. Sensor has three pins which can be connected to microcontroller through jumper wires. The first pin for signal (S), second pin for power supply V_{DD} and third pin for ground (GND).

pH sensor:

The level of pH in soil is determined using pH sensor. By measuring the pH, the soil

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can be determined whether it is alkaline or acidic. The values range from 0-14. The optimum range for plant growth is 5.5 to 7.5. The soil is acidic when the value is below 6 and alkaline when the value is above 7. pH sensor additionally measures the light intensity, water level [18] and temperature. Sensor is convenient to use and can be directly connected to the microcontroller. Has two probes and is of length 21cm. Provides high quality and electrodes must be cleaned every time when taken out after used.

Infrared sensor:

IR sensor identifies the objects that emit heat (objects can be of animals, human beings etc.). IR devices also include IR emitters, IR receivers (sensors), photo reflectors and photo interrupters, communication modules and remote control module receivers. Consumes low power, provides high security and communication speed

EXPERIMENTAL SETUP:

The system designed can be implemented for any type of soil. The values of various parameters of soil are sensed by using various sensors. In this, the architecture is designed for particular agricultural area (one acre). Previously monitoring of crops is done by using ZigBee technology but the disadvantage is that data loss occurs [6, 7]. To overcome this, the setup can be done by placing temperature sensor, infrared sensor, humidity sensor, pH sensor but more than one soil moisture sensor has to be placed in order to determine the soil moisture. Soil moisture sensor can be placed at the corners and middle of the agricultural field since the moisture soil varies from one end to the other. The values for temperature, humidity and pH does not vary and hence more than one temperature sensor, humidity sensor and pH sensor need not be used. The values are detected and stored in the memory of microcontroller. The values stored are then updated to cloud thingspeak server for further enhancement. The system monitors the whole parameters of soil. pH sensor must be cleaned when taken out from soil for providing the correct pH range of soil. Based on the pH value detected, crops can be cultivated as each crop has various pH ranges for proper growth.

RESULT:

The values detected are shown in graph. The resulting graph denotes the day to day change in agriculture soil. Variations occur specially in pH range and soil moisture [17, 16] for cultivating different crops in agriculture soil. Resulted graph for

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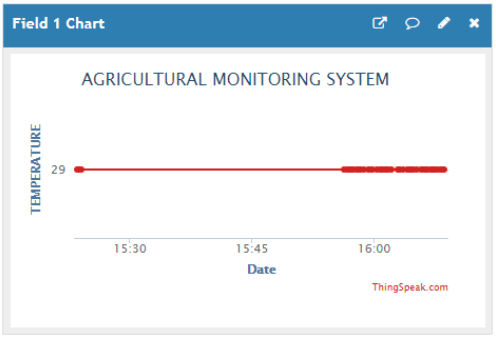
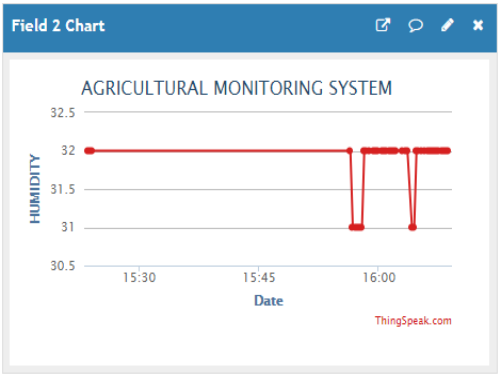
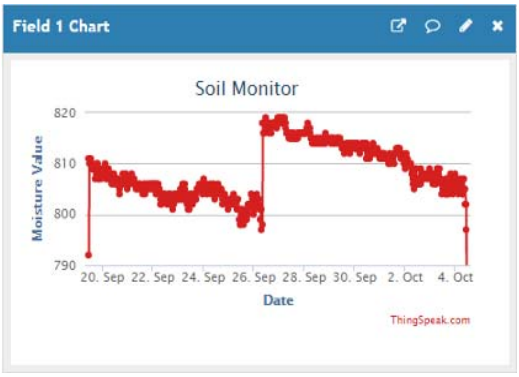
temperature, humidity, soil moisture are shown below:







CONCLUSION:

Hence the soil is monitored for cultivation and providing more efficient crops by frequently monitoring the temperature, humidity, soil moisture and pH range [13] of soil. pH range not only determines the type of crop for cultivation but also reduces the usage of fertilizers. For further enhancement electrochemical sensor can be used which determines the pH range of each nutrients separately and also has minimum lifetime of three years. The system can be implemented in distributed system to gather information all around for further agricultural improvement.

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