CHAPTER 1

INTRODUCTION

To fulfill the increasing demand of growing population over the years there is a need of increase in food production. Improper use of fertilizers in turn results into poor quality in fruits, vegetable lagging in color, size, test and even quantity. In China over-application of fertilizers has caused low fertilizer usage efficiency (~35% in average) resulting in low agricultural product quality, serious environmental pollution, etc. Quantity of nutrients is dependent on crop type and on plant growth status. Then how much quantity of fertilizer to be used is further dependent on present contents of nutrients in the soil.

Researchers in agriculture are looking for ways to optimize plant yield while minimizing the consumption of fertilizer. Since these macro-nutrients vary even on a small scale throughout a cultivated field, numerous researchers have attempted to develop the sensors to map these nutrient contents. Integrated crop management systems have been designed to study spatial and temporal behavior of nutrients. Continuous monitoring of these along with moisture, Temperature, humidity and pH of soil is leading to automation in agricultural areas to improve crop productivity.

There are plenty of sensors available for Moisture, Temperature, Humidity, pH and numerous nutrient sensors. For automation we need to integrate this sensor to a Single device. This helps in detecting the deficient component of the soil. Thus undesired dispensing of the fertilizers can be controlled which in turn reduces deterioration of soil.

In this system we demonstrate a NPK sensor device for continuous nutrient determination and pH, Soil moisture, Temperature and Humidity which are also some essential parameters for fertilizing. The primary aim of this system to develop a sensitive and reliable agricultural device using sensors for monitoring the nutrients in soil sample for long-term applications

CHAPTER 2

LITERATURE REVIEW

[2.1] **Diya, Siva Sunder, "SMART SENSOR BASED SOIL MONITORING SYSTEM" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 5, Issue 4, April 2016.**

Monitoring of various soil parameters using sensor networks. To overcome the problems caused by these expensive soil monitoring robots, a smart wireless sensor based soil monitoring android application have been proposed. The various sensors used sense the soil and acquire data.

The temperature sensor, analog moisture sensor and LDR should be kept in the soil which has to be tested. Each sensor is separately connected to the PIC microcontroller. This PIC microcontroller transmits the information about the parameters to the Bluetooth module. This Bluetooth module sends the information to the Android mobile phone when the device is paired and the user views it.

This approach for measuring the soil parameters is used for the efficient plant growth. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. The important parameters of the soil such as temperature, moisture and light sensitivity are checked by the respective sensors.

[2.2] **Deepak V. Raman, Sup Riya S. Patel, "DETECTION OF NPK NUTRIENTS OF SOIL USING FIBER OPTIC SENSOR" International**

Colorimetric measurement of aqueous solution of soil has been carried out. The color sensor is based on the principle of absorption of color by solution. It helps in determining the N, P, K amounts as high, medium, low, or none. The sensor probe along with proper signal conditioning circuits is built to detect the deficient component of the soil. It is useful in dispensing only required amount of fertilizers in the soil.

During the work NPK sensor is built using multimode, plastic optical fibers. The designing of fiber optic NPK sensor probe is a critical job. Various sensing configurations have been reported for chemical sensing. A sensor probe consists of seven fibers arranged in concentric configuration with central fiber acting as receiving fiber and surrounding six fibers acting as transmitting fibers.

Each fiber is a multimode plastic fiber of 488μm core diameter with numerical aperture of 0.47. The length of each fiber is 90 mm. The fiber tips are polished with zero emery paper. These fibers are enclosed in a brass cylinder. To the sensing tip end of fiber bundle a round cut glass plate is press fitted in order to avoid damage of polished tip due to interaction with chemical under test. At one end of fiber a circular brass disc is attached which holds six high bright LED's in a circular fashion and one photodiode at center.

The developed sensor works on colorimetric principle. Calorimeter deals with the measurement of colored intensity. The color of a substance is due to the absorbance of light waves of certain wavelengths. The absorption of light by solution results in excitation of electrons in its molecule.

The different colored LEDs emit colored light of same intensity. Through multimode optic fibers light is incident on the liquid. At a optimized distance a reflector is placed. When light travels through the solution from the probe towards the reflector and back, depending on the color of absorption characteristics of the solution, different intensities will be received for different reflected intensities can be plotted against the wavelength of the source to obtain a fairly simple absorption spectrum at discrete wavelengths. From the obtained spectrum for the different soil sample aqueous solutions a simplified detection mechanism is developed.

[2.3] **Mohammad Jun aid Khan, Rashid Mustafa, "SOIL TESTING AND ANALYZING USING AVR MICROCONTROLLER", ISSN : 2230-7109, Vol. 3, Issue 1, Jan. - March 2012.**

Soil pH is the pH of soil solution. Soils are both acidic and alkaline. Measurement of soil pH gives information about the availability and deficiency of nutrients which in turn determine the application of fertilizers, treatment to be given to soil in order to alter the soil pH in order to favor the crop growth and activity of microorganism in soil i.e. soil life. Here the pH electrode is connected to microcontroller pin with BNC socket. The signals generated by the sensors. The signals are send to ADC of inbuilt AVR microcontroller. AVR microcontroller accepts the signals from computes the soil ph. AVR Microcontroller displays the three parameters of the soil on

LCD. These parameters are used to interpret the properties or quality of soil, treatment to be given to soil to make it suitable for plant growth.

Conductivity cell consists of two rectangular electrodes of well-defined dimensions placed 1 cm distance apart. The parameter cell constant of conductivity cell is the used to convert the conductance measured by conductivity cell. Conductivity of solutions cannot be measured by applying a D.C. signal to conductivity cell. Only sinusoidal ac or pulse signal is to be used be used. Because if the D.C signal is passed through the conductivity cell and dipped in the aqueous solution, it will rip the ions apart and a constant changing reading will be obtained. In the product conductivity sensor is interfaced to the microcontroller through the standard interfacing card with provides the ac excitation to the cell and generate a signal proportional to the conductivity of the solution.

After calibrating the pH sensor, the sensor is placed in the soil extract of each sample. The results of measurement for ph. The pH of tested soil samples lies between 8.0 and 8.6. The results of the measurement show that the pH of the selected field lies in the strongly alkaline region. PH characteristic of tested soil samples.

Measurement of conductivity does not require any calibration before measurement. The conductivity cell is placed in the soil extract and the obtained reading on the digital readout is noted down. The results of measurement for conductivity. The pH of tested soil samples lies between 0.69 mS/cm and 0.76.mS/cm. The results of the measurement show that the conductivity of the selected field lies in the strongly alkaline region. Conductivity characteristic of tested soil samples.

[2.4] Swanti.A.Jain, M.S.Jagtap, K.P.Patel, "PHYSIC-CHEMICAL CHARACTERIZATION OF FARM LAND SOIL USED IN SOME VILLAGES OF LUNAWADA TALUK. DIST. MAHISGAR (GUJARAT) INDIA", International Journal of Scientific and Research Publications, Volume 4, Issue 3, March 2014, 1 ISSN 2250-3153.

Total 15 villages soil samples of Lunawada Taluk, Dist. Mahisagar were collected in clean polythene bags and brought to the Laboratory it is the permissible standard according to Anand Agricultural University. Air dry the soil samples in shade, crush the soil clods lightly and grind with the help of pestle and mortar, pass the entire quantity through 2mm stainless steel sieve, if the gravel content is substantial record as percent of the sample (w/w) as to pass it through 0.2 to 0.5 mm sieves, processing of the samples for analysis.

Soil temperature is one of the most important soil properties that effect crop growth. The major source of heat is sun and heat generated by the chemical and biological activity of the soil is negligible.

The soil reaction or PH is meant to express the acidity or alkalinity of the soil. The PH is very important property of the soil is it determines the capacity. The PH values fluctuated less than 8.5(table-1) .The limit of PH value for soil Acidic. < 6.5, Normal 6.5-7.8, Alkaline 7.8- 8.5, Alkali > 8.5.

Soil organic carbon is the seat of nitrogen in soil and its determination is often carried out as an index of nitrogen availability. In the colorimeter method (Dutta et al, 1962), Organic matter is oxidized with chromic acid. OC in Lunawada taluk 0.23 to 0.85 (table no.1) .Standard value of OC low < 0.50, medium 0.50- 0.75 and high > 0.75.

Phosphorus was found in the range of low, medium, high (table no.1). Inorganic phosphorus as orthophosphate plays a dynamic role in aquatic ecosystem. Phosphorus, the most important micro nutrient, is utilized by plant in the form of $H_2PO_4^-$ & HPO_4^{2-} species.

This can be concluded from this study that the available EC, PH, OC N, P, K, deficient soil is recommended rich fertilizer. To predict the probable crop response to applied nutrients. To identify the type and degree of soil related problems like salinity, alkalinity and acidity etc. and to suggest appropriate reclamation / amelioration measure.

CHAPTER 3

EXISTING METHODOLOGIES

3.1 LABORATORY TESTING

Soil testing is often performed by commercial labs that offer a variety of tests, targeting groups of compounds and minerals. The advantages associated with local lab are that they are familiar with the chemistry of the soil in the area where the sample was taken. This enables technicians to recommend the tests that are most likely to reveal useful information.

Laboratory tests often check for plant nutrients in three categories:

Major nutrients: Nitrogen (N), Phosphorous (P), Potassium (k).

Secondary nutrients: Sulfur, Calcium, Magnesium.

Micro nutrients: Iron, Copper, Zinc, Boron, Molybdenum, Chlorine.

Do-it-yourself kits usually only test for the three "major nutrients", 3 and for soil acidity or pH level. Do-it-yourself kits are often sold at farming cooperatives, university labs, private labs, and some hardware and gardening stores. Electrical meters that measure pH, water content, and sometimes nutrient content of the soil are also available at many hardware stores. Laboratory tests are more accurate than tests with do-it-yourself kits and electrical meters. Here is an example soil sample report from one laboratory.

Soil testing is used to facilitate fertilizer composition and dosage selection for land employed in both agricultural and horticultural industries.

Fig 3.1 SOIL TESTING IN LABORATORIES

Prepaid mail-in kits for soil and ground water testing are available to facilitate the packaging and delivery of samples to a laboratory. Similarly, in 2004, laboratories began providing fertilizer recommendations along with the soil composition report.

Lab tests are more accurate, though both types are useful. In addition, lab tests frequently include professional interpretation of results and recommendations. Always refer to all proviso statements included in a lab report as they may outline any anomalies, exceptions, and shortcomings in the sampling and/or analytical process/results.

Some laboratories analyze for all 13 mineral nutrients and a dozen non-essential, potentially toxic minerals utilizing the "universal soil extracting" method.

Drawbacks to proposed solution:

This method of soil testing is more accurate but the only major drawback is it took lots of days to get the result, which many farmers feel very difficult.

3.2 USING FIBER OPTIC SENSOR

This existing system deals with the actual detection of NPK values of the soil using multimode plastic fiber optic sensor. Aqueous solution of soil under test is illuminated by different light colors.

The principle of optical NPK fiber is based on the interaction between incident light and the soil surface properties, such that the reflected light vary due to the soil physical and chemical properties. This sensor works on the colorimetric principle, which deals with the measurement of colored intensity. The sensor probe consists of seven fibers arranged in concentric configuration with central fiber acts as receiving fiber and surrounding six fibers acts as transmitting fiber. The driving circuit of LED consists of voltage to current converter, buffer and a subractor.

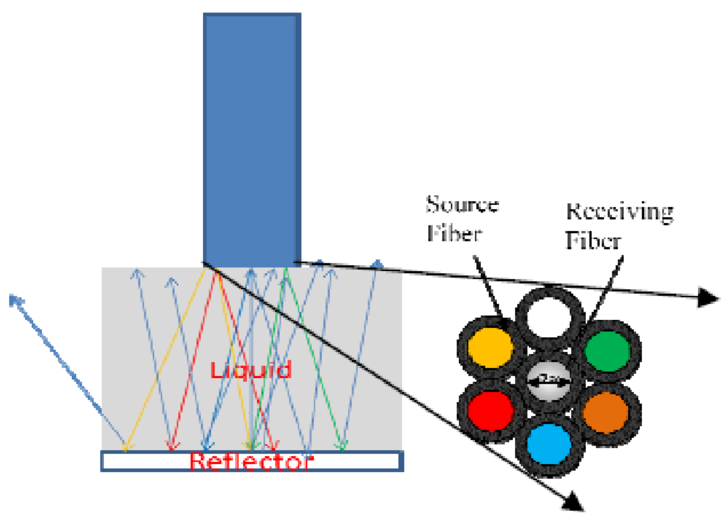

Fig 3.2 WORKING PRINCIPLE OF OPTIC FIBER BASED NPK SENSOR

The colored light passed through the fiber to aqueous solution of soil sample. Depending upon NPK values of the soil light pf particular wavelength and strength gets absorbed by the solution and remaining gets reflected back. Reflected light is get collected by the receiver probe and then converted to electrical signal using phototransistor. The sensor output is calibrated in terms of deficient component values as per the standard color chart.

Drawbacks to proposed solution:

Fiber optic sensors are widely used in various industrial applications as well as in agriculture etc. For their inherent advantages such as light weight, immunity to EMI and RFI, economical etc. but the major drawback is results are not accurate and it requires more number of days.

CHAPTER 4

HARDWARE UTILIZATION

4.1 ESP 8266 (NODE MCU)

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP tack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.

Fig 4.1 ESP 8266

The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.

The successor to these microcontroller chips is the ESP32.

4.1.1 Features:

Processor: L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz

Memory:

- o 32 KiB instruction RAM
- o 32 KiB instruction cache RAM
- o 80 KiB user data RAM
- o 16 KiB ETS system data RAM

External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)

IEEE 802.11 b/g/n Wi-Fi

- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks

16 GPIO pins

SPI

I²C (software implementation)

I²S interfaces with DMA (sharing pins with GPIO)

UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2

10-bit ADC (successive approximation ADC)

Both the CPU and flash clock speeds can be doubled by overclocking on some devices. CPU can be run at 160 MHz and flash can be sped up from 40 MHz to 80 MHz's Success varies chip to chip.

4.1.2 32-bit Tensilica Processor

The ESP8266EX microcontroller integrates a Tensilica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz's The Real-Time Operating System (RTOS) and Wi-Fi stack allow about 80% of the processing power to be available for user application programming and development.

4.1.3 Power-Saving Architecture

Engineered for mobile devices, wearable electronics and IoT applications, ESP8266EX achieves low power consumption with a combination of several proprietary technologies. The power-saving architecture features three modes of operation: active mode, sleep mode and deep sleep mode. This allows battery-powered designs to run longer.

4.1.4 Compactness

ESP8266EX is integrated with a 32-bit Tensilica processor, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules. All of them are included in one small package, our ESP8266EX.

4.1.5 High Durability

ESP8266EX is capable of functioning consistently in industrial environments, due to its wide operating temperature range. With highly-integrated on-chip features and minimal external discrete component count, the chip offers reliability, compactness and robustness.

4.1.6 ESP8266 Pin Diagram

ESP8266EX is among the most integrated Wi-Fi chip in the industry; it integrates the antenna switches, RF blunt, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. ESP8266EX also integrates an enhanced version of ten silica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the Wi-Fi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; sample codes for such applications are provided in the software development kit (SDK).

4.1.7 Features

Integrated low power 32-bit MCU

Integrated TCP/IP protocol stack

Integrated TR switch, balun, LNA, power amplifier and matching network

802.11 b/g/n Wi-Fi 2.4 GHz, support WPA/WPA2

Support STA/AP/STA+AP operation modes

10-bit ADC, SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO

Deep sleep power <10uA, Power down leakage current < 5uA

Wake up and transmit packets in < 2ms

Standby power consumption of < 1.0mW (DTIM3)

+20 dBm output power in 802.11b mode

Operating temperature range -40C ~ 125C

FCC, CE, TELEC, Wi-Fi Alliance, and SRRC certified

4.1.8 ESP8266 ESP-12 Pin Out

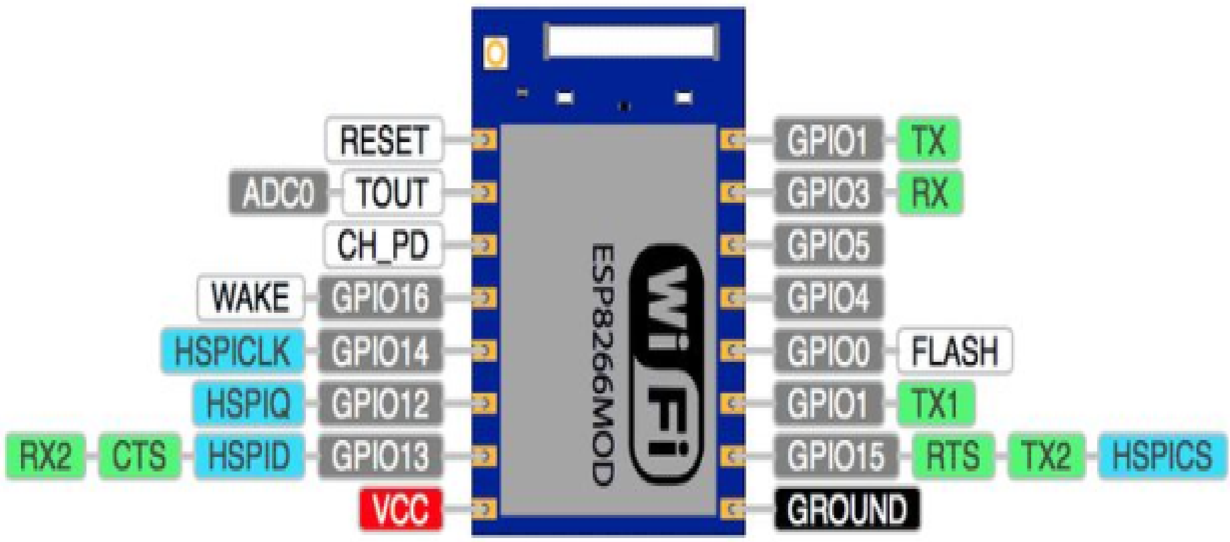

Fig 4.2 ESP8266 ESP-12 Pin Out

4.1.9 ESP8266 ESP-01 Pin Out

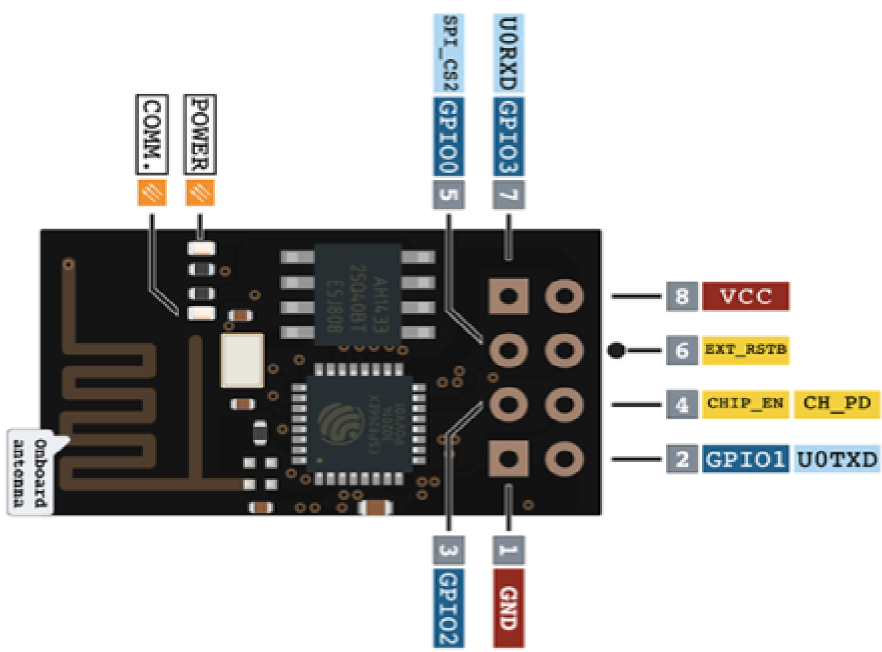

Fig 4.3 ESP8266 ESP-01 Pin Out

4.1.10 Pin Definition

Name	Type	Function
VCC	P	Power 3.0 ~ 3.6V
GND	P	Ground
RESET	I	External reset signal (Low voltage level: Active)
ADC(TOUT)	I	ADC Pin Analog Input 0 ~ 1V
CH_PD	I	Chip Enable. High: On, chip works properly; Low: Off, small current
GPIO0(FLASH)	I/O	General purpose IO, If low while reset/power on takes chip into serial programming mode
GPIO1(TX)	I/O	General purpose IO and Serial TXd

GPIO3(RX)	I/O	General purpose IO and Serial RXd
GPIO4	I/O	General purpose IO
GPIO5	I/O	General purpose IO
GPIO12	I/O	General purpose IO
GPIO13	I/O	General purpose IO
GPIO14	I/O	General purpose IO
GPIO15(HSPI_CS)	I/O	General purpose IO, Connect this pin to ground through 1KOhm resistor to boot from internal flash.

Note: TX1 and TX GPIO1 are internally connected, On board blue LED is also connected to this pin

4.1.11 ESP Witty Cloud Module Pin Connections

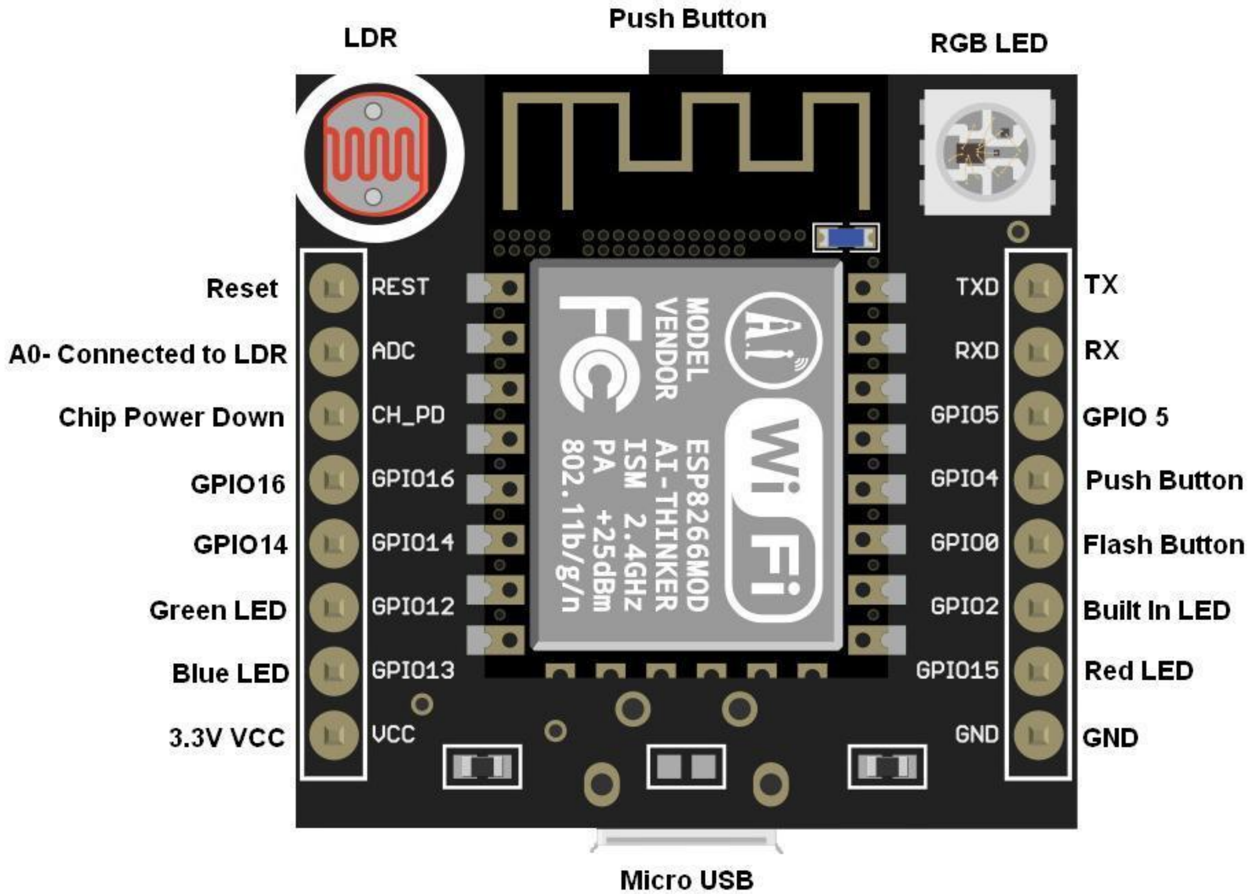

Fig 4.4 ESP Witty Cloud Module Pin Connections

NodeMCU is a very easy to use ESP8266 board that can be bought at eBay for less than 4 euros. It's also very practical since it already has an USB header, so we can program the microcontroller without any additional hardware. Besides that, the pins are easily accessible, allowing us to take full advantage of the capabilities of the ESP8266, as opposed to other simpler boards, such as the ESP-01, which only expose some of the GPIOs of the microcontroller. Nevertheless, as indicated in some previous tutorials, the numbers of the pins in the board don't map to the numbers of the pins on the ESP8266. So, for example, pin D1 of the board doesn't map to GPIO1 of the ESP8266 (it actually maps to GPIO5). Naturally, if this is not taken in consideration, it will lead to a difficult debugging process, since we will be assuming that the board is not working correctly.

4.2 PH SENSOR:

PH meter instrument. PH meter, electric device used to measure hydrogen-ion activity (acidity or alkalinity) in soil. Fundamentally, a pH meter consists of a voltmeter attached to a pH-responsive electrode and a reference (unvarying) electrode. pH probes measure pH by measuring the voltage or potential difference of the soil in which it is dipped. By measuring potential difference, hydrogen ion concentration can be calculated using the Nernst equation which gives the relationship between Hydrogen ion concentration and Voltage or Potential.

Fig 4.5 pH SENSOR

Use the pH Sensor just as you would a traditional pH meter with the additional advantages of automated data collection, graphing, and data analysis. Typical activities using our pH sensor include:

Acid-base titrations

Studies of household acids and bases

Monitoring pH change during chemical reactions or in an aquarium as a result of photosynthesis

Investigations of acid rain and buffering

Analysis of water quality in streams and lakes

4.2.1 Working with pH Sensor

When you think of pH, you probably think of liquid acids and bases. But soil can be acidic or basic, too. Soils with pH above 7 are basic or sweet. Soils with pH below 7 are acidic or sour.

The pH of soil is an important factor in determining which plants will grow because it controls which nutrients are available for the plants to use. Three primary plant nutrients—nitrogen, phosphorus, and potassium—are required for healthy plant growth. They are the main ingredients of most fertilizers that farmers and gardeners add to their soil. Other nutrients, such as iron and manganese, are also needed by plants, but only in very small amounts.

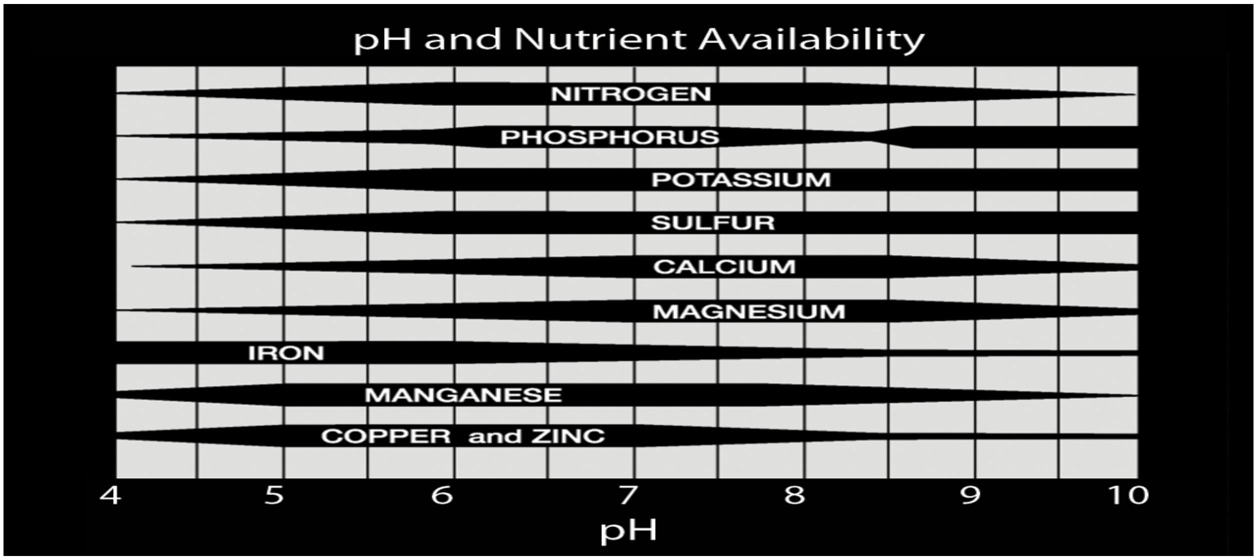

Fig 4.6 pH AND NUTRIENT AVAILABILITY

To measure the pH of soil, the standard method is to mix equal parts of soil and distilled water, let sit, and then measure the pH of the resulting slurry. Our regular pH Sensor has a glass bulb that performs very well in liquids, but is easier to break when used in this type of semi-solid. It can also be difficult to clean the soil out from around the glass bulb at the tip of the electrode. A more appropriate sensor is our new Tris-Compatible Flat pH Sensor. This new specialty pH sensor has two unique features that make if perfect for use in agricultural science courses and some biological applications.

The flat glass sensing surface makes it ideal for measuring the pH of semisolids, such as food or soil slurries. While the glass can still break, it is thicker and the flat shape makes it less vulnerable than a bulb. It is easier to clean than a bulb, and the flat shape allows for smaller sample sizes, as well.

It has a double-junction electrode, making it compatible with Tris buffers and solutions containing proteins or sulfides. Single junction electrodes, like our pH Sensor, will eventually become clogged with precipitates formed from the reaction between these compounds and the AgCl gel.

For all chemistry and most biology experiments, we continue to recommend our pH Sensor. The pH Sensor is custom calibrated, faster responding, and less expensive than the Tris-Compatible Flat pH Sensor.

4.3 TEMPERATURE SENSORS

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

Fig 4.7 TEMPERATURE SENSOR

The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4˚C at room temperature and ±3⁄4˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the water level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package

4.3.1 Features

Calibrated directly in ˚ Celsius (Centigrade)

Linear + 10.0 mV/˚C scale factor n 0.5˚C accuracy guarantee able (at +25˚C)

Rated for full −55˚ to +150˚C range

Suitable for remote applications

Low cost due to wafer-level trimming

Operates from 4 to 30 volts

Less than 60 µA current drain

Low self-heating, 0.08˚C in still air

Nonlinearity only ±1⁄4˚C typical

Low impedance output, 0.1 Ω for 1 mA load

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ºC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 ºC temperature rise in still air.

The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ºC rise/fall in ambient temperature, *i.e.,* its scale factor is 0.01V/ ºC.

4.3.2 Pin Diagram

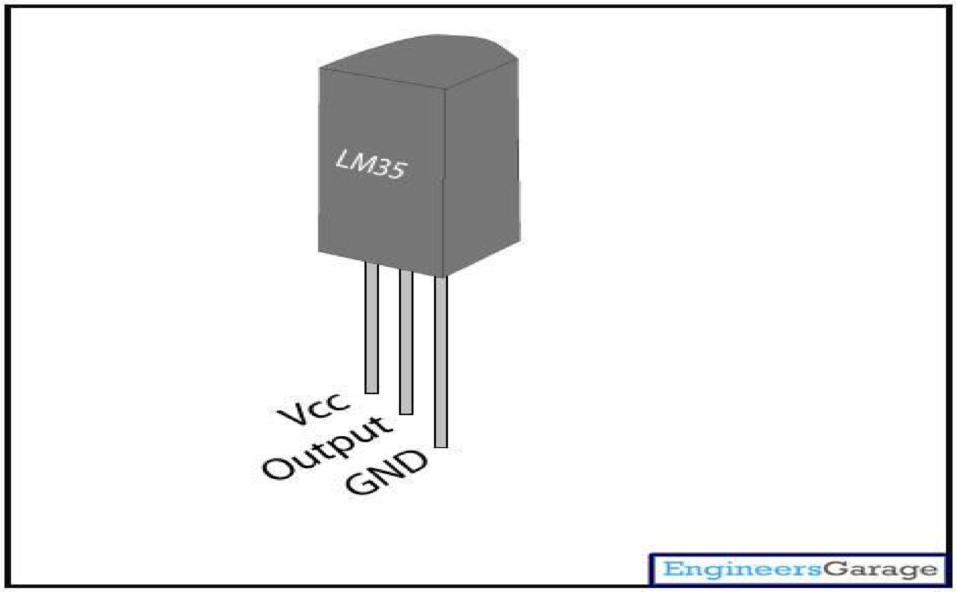

FIG 4.8 PIN DIAGRAM

4.3.3 Pin Configuration:

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications
2	Analog Out	There will be increase in 10mV for raise of every 1°C. Can range from -1V(-55°C) to 6V(150°C)
3	Ground	Connected to ground of circuit

4.3.4 Use OF LM35 Temperature Sensor:

LM35 is a precession Integrated circuit Temperature sensor, whose output voltage varies, based on the temperature around it. It is a small and cheap IC which can be used to measure temperature anywhere between -55°C to 150°C. It can easily be interfaced with any Microcontroller that has ADC function or any development platform like Arduino.

Power the IC by applying a regulated voltage like +5V (V_S) to the input pin and connected the ground pin to the ground of the circuit. Now, you can measure the temperate in form of voltage as shown below.

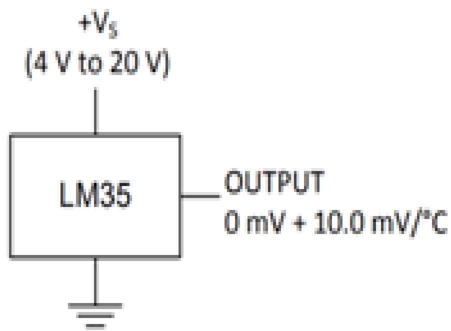

FIG 4.9 CIRCUIT DIAGRAM

If the temperature is 0°C, then the output voltage will also be 0V. There will be rise of 0.01V (10mV) for every degree Celsius rise in temperature. The voltage can converted into temperature using the below formulae.

V_{OUT} = 10 mv/°C × T

where

- V_{OUT} is the LM35 output voltage
- T is the temperature in °C

4.3.5 Applications

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01˚C of the surface temperature. This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature.

This is especially true for the TO-92 plastic package, where the copper leads are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature. To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die's temperature will not be affected by the air temperature. The TO-46 metal package can also be soldered to a metal surface or pipe without damage. Of course, in that case the V− terminal of the circuit will be grounded to that metal.

Alternatively, the LM35 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM35 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as Humiseal and epoxy paints or dips are often used to insure that moisture cannot corrode the LM35 or its connections.

These devices are sometimes soldered to a small light-weight heat fin, to decrease the thermal time constant and speed up the response in slowly-moving air. On the other hand, a small thermal mass may be added to the sensor, to give the steadiest reading despite small deviations in the air temperature.

4.4 MOISTURE SENSORS

Soil moisture sensors measure the volumetric water content in soil.[1] Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting 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. The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for sensing in hydrology and agriculture. Portable probe instruments can be used by farmers or gardeners.

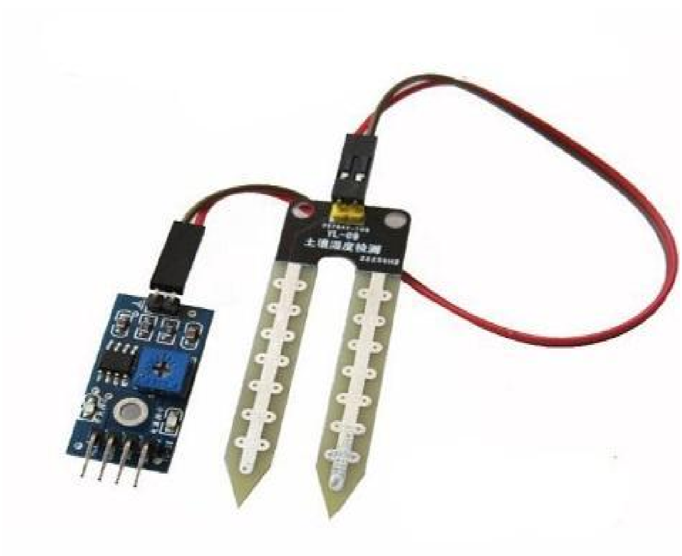

Fig 4.10 Moisture sensors

Soil moisture sensors typically refer to sensors that estimate volumetric water content. Another class of sensors measure another property of moisture in soils called water potential; these sensors are usually referred to as soil water potential sensors and include tensiometers and gypsum blocks.

4.4.1 Working Principle of Moisture Sensor

The Soil Moisture Sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. There is a 2 cm zone of influence with respect to the flat surface of the sensor, but it has little or no sensitivity at the extreme edges. The Soil Moisture Sensor is used to measure the loss of moisture over time due to evaporation and plant uptake, evaluate optimum soil moisture contents for various species of plants, monitor soil moisture content to control irrigation in greenhouses and enhance bottle biology experiments.

4.4.2 Technology

Technologies commonly used to indirectly measure volumetric water content (soil moisture) include)

- Frequency Domain Reflectometry (FDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the operating frequency of an oscillating circuit.

- Time Domain Transmission (TDT) and Time Domain Reflectometry (TDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the speed of propagation along a buried transmission line.[2]
- Neutron moisture gauges: The moderator properties of water for neutrons are utilized to estimate soil moisture content between a source and detector probe.
- Soil resistivity: Measuring how strongly the soil resists the flow of electricity between two electrodes can be used to determine the soil moisture content.
- Galvanic cell: The amount of water present can be determined based on the voltage the soil produces because water acts as an electrolyte and produces electricity. The technology behind this concept is the galvanic cell

4.4.3 Soil Moisture Sensor Probe Features

Extreme low cost with volume pricing.

Not conductivity based.

Insensitive to salinity.

Probe does not corrode over time.

Rugged design for long term use.

Small size.

Consumes less than 7mA for very low power operation.

Precise measurement.

Measures volumetric water content (VWC) or gravimetric water content (GWC).

Output Voltage is proportional to moisture level.

Wide supply voltage range.

Can be buried and is water proof.

Probe is long and slender for wider use, including smaller potted plants.

4.4.4 Applications

1) Agriculture

Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

2) Landscape irrigation

In urban and suburban areas, landscapes and residential lawns are using soil moisture sensors to interface with an irrigation controller. Connecting a soil moisture sensor to a simple irrigation clock will convert it into a "smart" irrigation controller that prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event.

Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground.

3) Research

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

4) Simple sensors for gardeners

Relatively cheap and simple devices that do not require a power source are available for checking whether plants have sufficient moisture to thrive. After inserting a probe into the soil for approximately 60 seconds, a meter indicates if the soil is too dry, moist or wet for plants.

4.5 DTH11 SENSORS:

DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability. The DHT11 Humidity and Temperature Sensor consists of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by any microcontroller or microprocessor for further analysis.

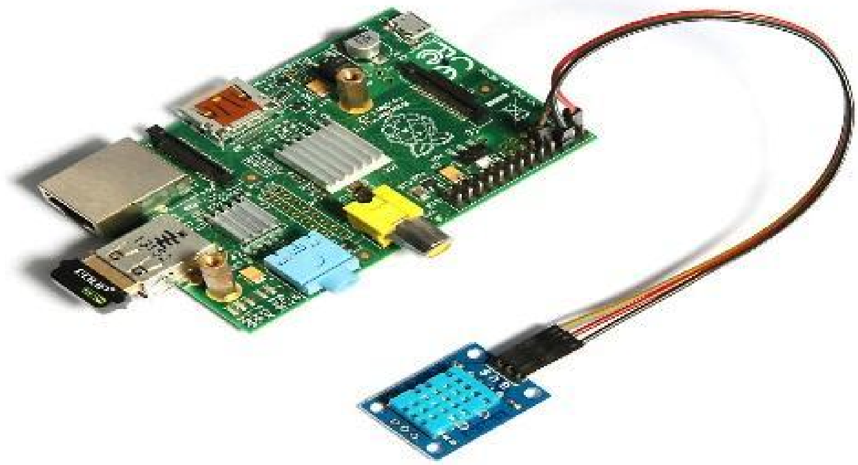

Fig 4.11 DTH11 SENSOR

DHT11 digital temperature and humidity sensor is a composite Sensor contains a calibrated digital signal output of the temperature and humidity. Application of a dedicated digital modules collection technology and the temperature and humidity sensing technology, to ensure that the product has high reliability and excellent long-term stability. The sensor includes a resistive sense of wet components and an NTC temperature measurement devices, and connected with a high-performance 8-bit microcontroller

4.5.1Features

Low cost.

Long-term stability.

Relative humidity and temperature measurement.

Excellent quality.

Fast response.

Strong anti-interference ability.

Long distance signal transmission.

Digital signal output.

Precise calibration.

4.5.2 Dimensions (unit: mm)

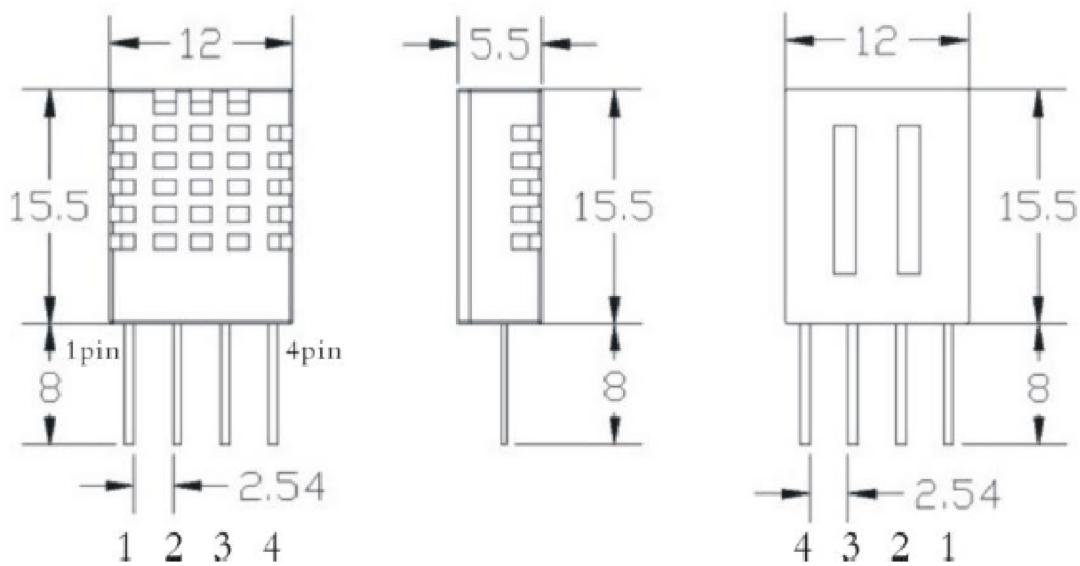

FIG 4.12 DIMENSIONS

4.5.3 Product Parameters

Relative humidity Resolution: 16Bit

Repeatability: ±1% RH

Accuracy: At 25℃ ±5% RH

Interchangeability: fully interchangeable

Response time: 1 / e (63%) of 25℃ 6s 1m / s air 6s

Hysteresis: <± 0.3% RH

Long-term stability: <± 0.5% RH / yr in

Temperature Resolution: 16Bit

Repeatability: ±0.2℃

Range: At 25℃ ±2℃

Response time: 1 / e (63%) 10S

4.5.4 Electrical Characteristics

Power supply: DC 3.5～5.5V

Supply Current: measurement 0.3mA standby 60μA

Sampling period: more than 2 seconds

4.5.5 Pin Description

1, the VDD power supply 3.5～5.5V DC

2, DATA serial data, a single bus

3, NC, empty pin

4, GND ground, the negative power

4.5.6 Applications

HVAC, dehumidifier, testing and inspection equipment, consumer goods, automotive, automatic control, data loggers, weather stations, home appliances, humidity regulator, medical and other humidity measurement and control.

4.5.7 Typical circuit

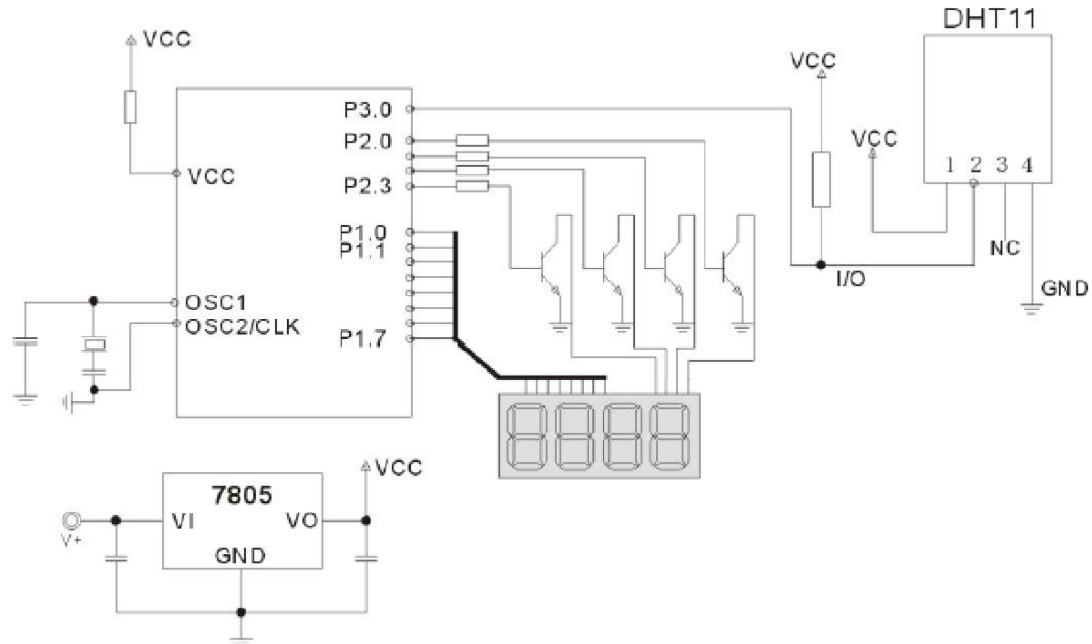

FIG 4.13 CIRCUIT DIAGRAM

Microprocessor and DHT11 of connection typical application circuit as shown above, DATA pull the microprocessor I / O ports are connected.

1. Typical application circuit recommended in the short cable length of 20 meters on the 5.1K pull-up resistor, the resistance of greater than 20 meters under the pull-up resistor on the lower of the actual situation.

2. When using a 3.5V voltage supply cable length shall not be greater than 20cm. Otherwise, the line voltage drop will cause the sensor power supply shortage, caused by measurement error.

3. Each read out the temperature and a humidity value are the results of the last measurement for real-time data, sequential read twice, but is not recommended to repeatedly read the sensors, each read sensor interval is greater than 5 seconds can be obtained accurate data.

4.6 NPK SENSORS

The use of micro-sensors for in-field monitoring of environmental parameters is of great interest, particularly semiconductor-based micro-sensors, due to their many advantages over conventional sensors such as small size, robustness, low output impedance and rapid response. They can further be integrated in circuitry and multiple sensors in the same substrate and accordingly they can be implemented in compact probes for particular applications e.g., in situ monitoring, or on-line or on-the-go measurements.

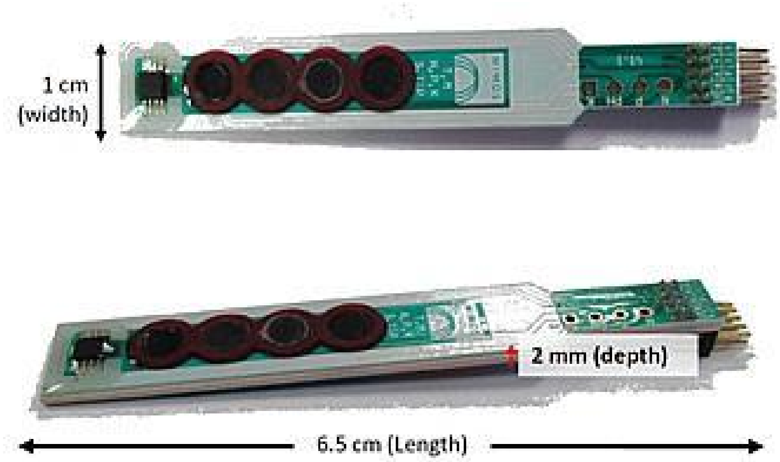

Fig 4.14 NPK SENSORS

The sensors are using Ion Selective Field Effect Transistors (ISFETs) based micro-sensors, for environmental applications and are helpful for measuring primary macronutrients in soil.

Selected target ions include potassium, phosphate and nitrates. Required samples are in small volumes and such sensors can be integrated in compact flow cells for continuous measurements.

NPK micro-sensors are enabling precision agriculture to assist in

Spatial data collection

Precision irrigation

Variable-rate technology (automated fertiliser)

Supplying data to farmers.

4.6.1 Competitive Advantage

At NPK sensors for precision agriculture the cost of each sensor needs to be low and the stability of the sensor membrane needs to be high, especially when such sensor deployed harsh environments; furthermore the sensitivity needs to be high, and they also need to be supported by robust data management systems to be able to collect the data, manipulate it for decision support analysis in fertilizer management.

The benefits of the wireless sensor network platform invention, compared to traditional industry standard technologies are:

Longer membrane lifetime, and durability;

Increased sensitivity

Increased platform flexibility (easily reconfigurable) that with minor hardware changes different parameters can be monitored.

4.6.2 The Beneficiaries

In general – much of the information prepared by the agricultural ICT backbone can be used by several stakeholders and will be a benefit for several businesses. It means chain-partners will be ready to pay to get access to the information! The model in detail has to be worked out together with local structures and representatives from different stakeholders!

A public-private used ICT infrastructure, consisting of new ortho-images for the country covering GIS and IT solutions for rural area management in connection with land-management and extension-services, agriculture management and logistics can be used by different governmental organizations and can also be used by private structures and is:

- Supporting the Minister of Agriculture for his needs to organize subsidies,
- Supporting the Minister responsible for landscape changes, for cadaster, ground tax
- Supporting consultants in their advisory work
- Supporting food chain partners for traceability and for the documentation
- Supporting logistic service experts to do the right actions at the right field to find the right roads to the field and be there at the right time as well as deliver goods to the food industry "just in time"; it is a support to all suppliers and buyers of farm goods
- Supporting the agro control organization for subsidies
- Supporting the bankers to get a business-plan to be able to finance better
- Supporting the insurance company to make policies for the crops on the fields
- Supporting ecology experts or also natural-risk-managers
- Supporting the human medicine experts to judge the influence of food and environment on health

Supporting last but not least the farmer to give him tools for his needs

CHAPTER 5

SOFTWARE UTILIZATION

5.1 WORKING WITH ARDUINO IDE

The Arduino IDE software (short for Integrated Development Environment) is the foundation of what has made the Arduino platform so successful. With it, Makers can program a wide range of compatible microcontroller boards using Arduino's relatively approachable programming language. Behind the scenes, the IDE software translates your instructions into a more complex code required for your board's specific chip.

Aside from generally cleaning up a number of known bugs, the new update introduces a number of new tools and features.

Arduino-Builder is a new command-line tool that allows advanced users to compile code with greater flexibility and customization. It can also run as a standalone program.

A Pluggable USB core (and Pluggable HID core) allows users to create low level libraries that allow your board to take advantage of the MIDI, HID, or Mass Storage behaviors associated with computer USB peripherals. In short, your Arduino's USB connection can more easily mimic the behavior of a USB-connected MIDI instrument, mouse, computer keyboard, or storage device.

A Serial Plotter function has been added, allowing you to natively graph serial data from your Arduino to your computer in real time. If you're tired of seeing your Arduino's analogy sensor input data pour onto your screen like *The Matrix*, this looks like a prettier way to visualize what's going on.

You can read more about the IDE 1.6.6 update on the Arduino.cc blog, as well as a full list of revisions on GitHub. Again, as with any new software release, it may be worthwhile to wait to download the update until bugs have been discovered and addressed. I'd also recommend taking a look at the updated FAQ to get a sense of what changes to the software may be confusing people.

5.2 SOFTWARE AND PROGRAMMING TOOLS

A program for Arduino may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension .pde.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program argued to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

The open-source nature of the Arduino project has facilitated the publication of many free software libraries that other developers use to augment their projects.

5.3 PROGRAM STRUCTURE

A minimal Arduino C/C++ program consist of only two functions

- Setup (): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- Loop (): After setup () has been called, function loop () is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

CHAPTER 6

PROPOSED METHOD

In this system we demonstrate a NPK sensor device for continuous nutrient determination and pH, Soil moisture, Temperature and Humidity which are also some essential parameters for fertilizing. The primary aim of this system to develop a sensitive and reliable agricultural device using sensors for monitoring the nutrients in soil sample for long-term applications

6.1 BLOCK DIAGRAM

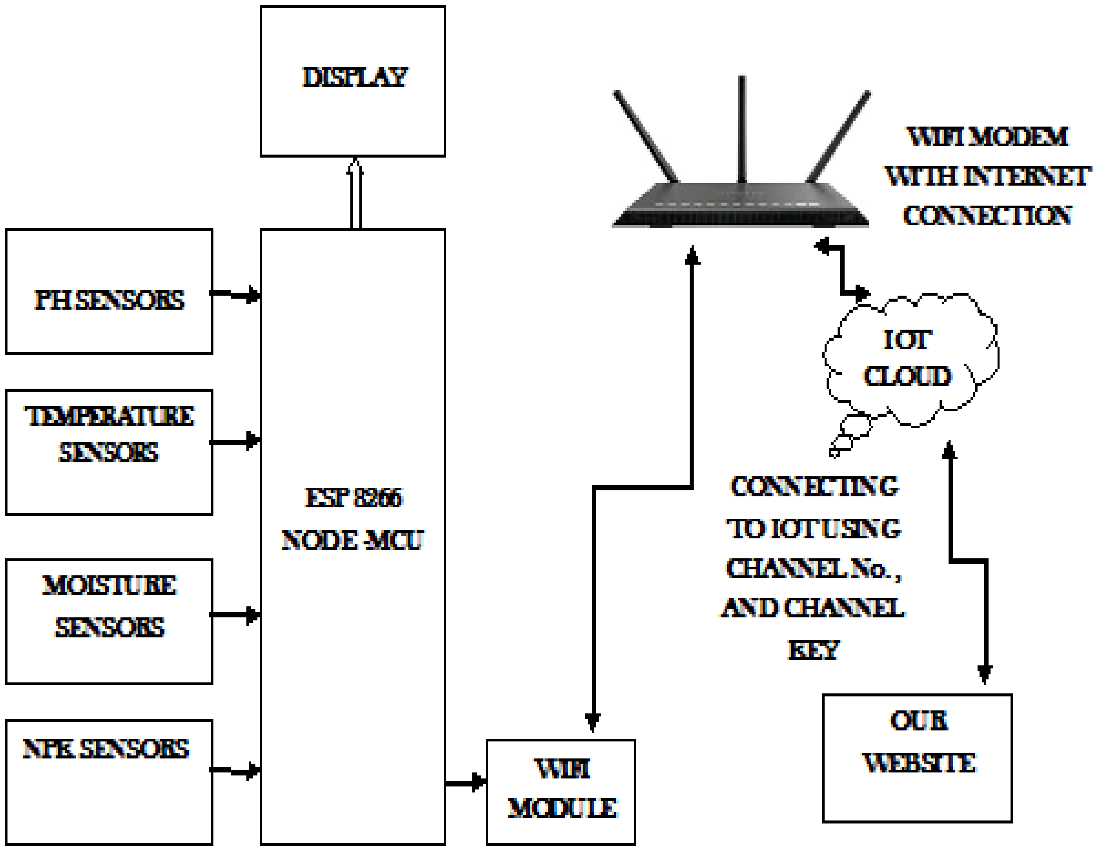

FIG 6.1 BLOCKS DIAGRAM

The Agricultural Device for Evaluation of Soil Parameters consists of pH Sensors, moisture sensors, temperature sensors, NPK sensors and ESP NODE-MCU, soil sample, LCD display and PC.

Here the pH sensors used to measure hydrogen-ion activity (acidity or alkalinity) in soil. Fundamentally, a pH meter consists of a voltmeter attached to a pH-responsive electrode and a reference (unvarying) electrode. PH probes measure pH by measuring the voltage or potential difference of the soil, whereas the LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature and at the soil moisture sensor used is capacitive type. The sensor gives analog output of zero volts when there is 100% moisture and 5V for 0% moisture and the DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like ESP8266 NODE-MCU, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability. The DHT11 Humidity and Temperature Sensor consist of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by any microcontroller or microprocessor for further analysis.

6.2 WORKING PRINCIPLE

Here the NODE MCU gets the input from pH Level Sensors, Temperature sensors, Moisture sensors and NPK Sensors.

It sends the data to both display device and Wi-Fi module. The data processed in the microcontroller is sent to the Cloud through WIFI

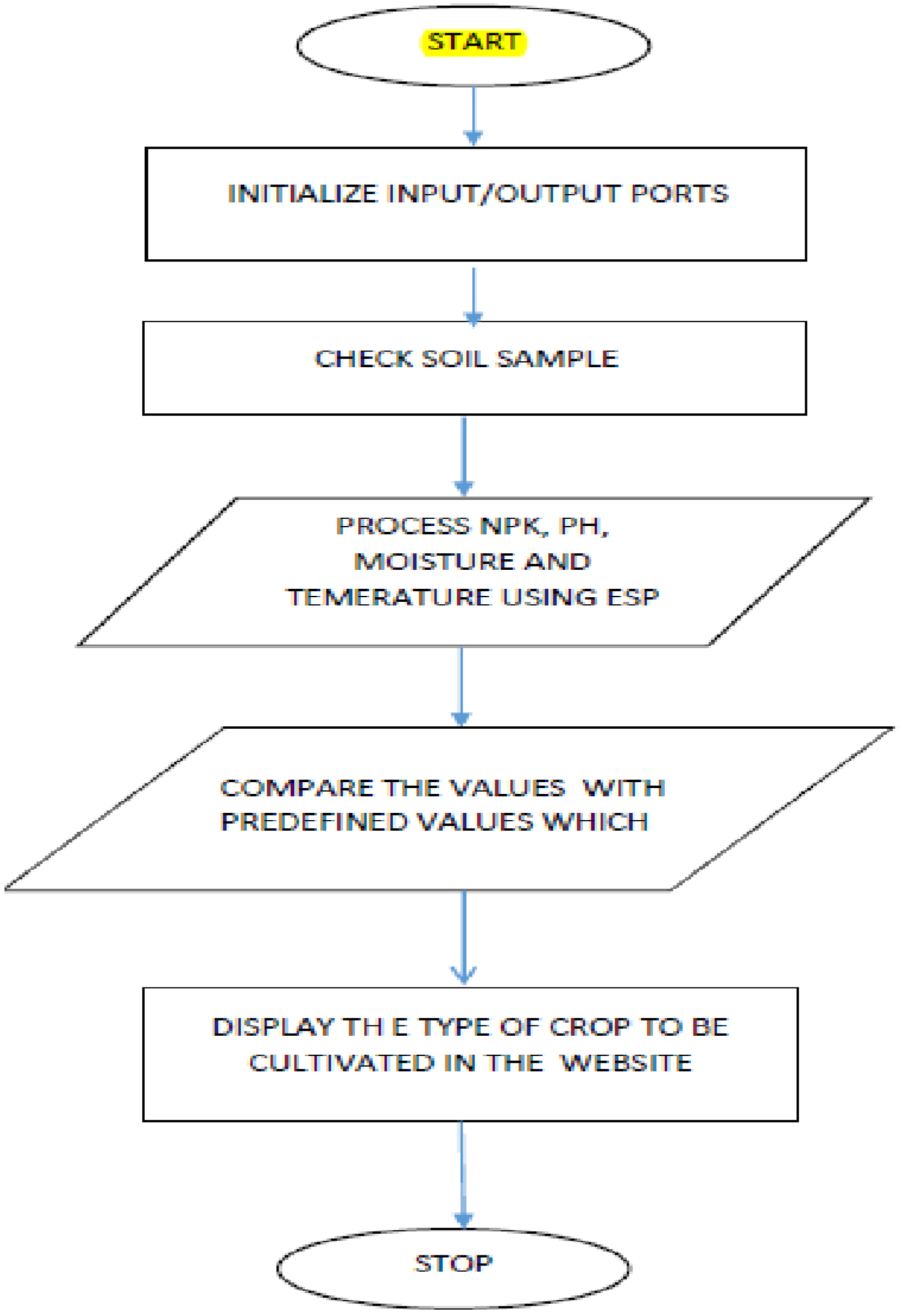

FIG 6.2 FLOW CHART FOR THE BASIC OPERATION OF THE SYSTEM

Modem using internet connection. The data are stored in the IOT cloud. The data are compared with the existing predefined data in the database. This database is collected from conducting various soils testing on various soil using chemicals in the local laboratories. After comparing the data processed by and predefined values the website displays the suggested crops can cultivate in the soil and accurae amount of fertilizers can use in the soil.

6.3 SAMPLE CODE

```
#include <DHT.h>   // Including library for dht

#include <ESP8266WiFi.h>    // esp library


#include <OneWire.h>    //DS18B20 library

#include <DallasTemperature.h>




String apiKey = "ZYUVMVOA57QEBQGV";     //  Enter your Write API
key from ThingSpeak

const char *ssid =  "Nokia 5";     // replace with your wifi ssid and wpa2 key

const char *pass =  "9600595529";

const char* server = "api.thingspeak.com";
```

```
int sensor_pin = A0;      //pin A0 to  moisture sensor

int output_value ;

#define DHTPIN 0          //pin where the dht11 is connected

DHT dht(DHTPIN, DHT11);


#define ONE_WIRE_BUS 2    //DS18B20  Pin

OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);

WiFiClient client;

void setup()

{

    Serial.begin(115200);

    delay(10);


    dht.begin();       // start DHT11 library

    sensors.begin();   // start DS18B20 library

    Serial.println("");

    Serial.println("Connecting to ");

    Serial.println(ssid);
```

```
 WiFi.begin(ssid, pass);


 while (WiFi.status() != WL_CONNECTED)
 {
   delay(500);
   Serial.print("...");
 }
 Serial.println("");
 Serial.println("WiFi connected");
 Serial.println("Reading From the Sensor ...");

}

void loop()
{
     float aH = dht.readHumidity();
 float aT = dht.readTemperature();
 output_value= analogRead(sensor_pin);
 output_value = map(output_value,550,0,0,100);
```

```
output_value = output_value + 15;
float sM = output_value;
if (sM < 0)
{
 sM = 0;
 }
 else
 {
  sM = output_value;
 }
 sensors.requestTemperatures(); // call sensors.requestTemperatures() to issue a global temperature, request to all devices on the bus & Send the command to get temperatures
 float sT = sensors.getTempCByIndex(0);
 float pH = 06.92;


            if (client.connect(server,80))   //   "184.106.153.149" or api.thingspeak.com
              {
                 String postStr = apiKey;
```

```
postStr +="&field1=";
postStr += String(aT);
postStr +="&field2=";
postStr += String(aH);
postStr +="&field3=";
postStr += String(sM);
postStr +="&field4=";
postStr += String(sT);
postStr +="&field5=";
postStr += String(pH);
postStr += "\r\n\r\n\r\n";

client.print("POST /update HTTP/1.1\n");
client.print("Host: api.thingspeak.com\n");
client.print("Connection: close\n");
client.print("X-THINGSPEAKAPIKEY: "+apiKey+"\n");
client.print("Content-Type:
application/x-www-form-urlencoded\n");
client.print("Content-Length: ");
```

```
client.print(postStr.length());
client.print("\n\n\n");
client.print(postStr);

Serial.print("AirTemperature: ");
Serial.print(aT);
Serial.print("°C   ");
Serial.print("AirHumidity: ");
Serial.print(aH);
Serial.print("%    ");
Serial.print("SoilMositure : ");
Serial.print(sM);
Serial.print("%    ");
Serial.print("SoilTemperature : ");
Serial.print(sT);
Serial.print("°C   ");
Serial.print("pH Level : ");
Serial.print(pH);
Serial.print("");
```

```
            }
        client.stop();

        Serial.println(" ");
  // thingspeak needs minimum 15 sec delay between updates, i've set it to 30 seconds
  delay(10000);
}
```

CHAPTER 7

RESULTS AND DISCUSSION

The following are the various modules of our project which we tested individually and on integrating as a whole, our model achieved the results by giving the results in our website through a WI-FI modem using cloud data.

FIG 7.1 RESULT GRAPH

The above graphs in the Fig.7.1 are created from the results for pH, Temperature, moisture, air humidity and air temperature obtained from the data sent through Wi-Fi from the sensors. From these graphs, we are able to find the characteristics of the soil clearly. The above results are obtained by data that we get from the microcontroller which we used in our project.

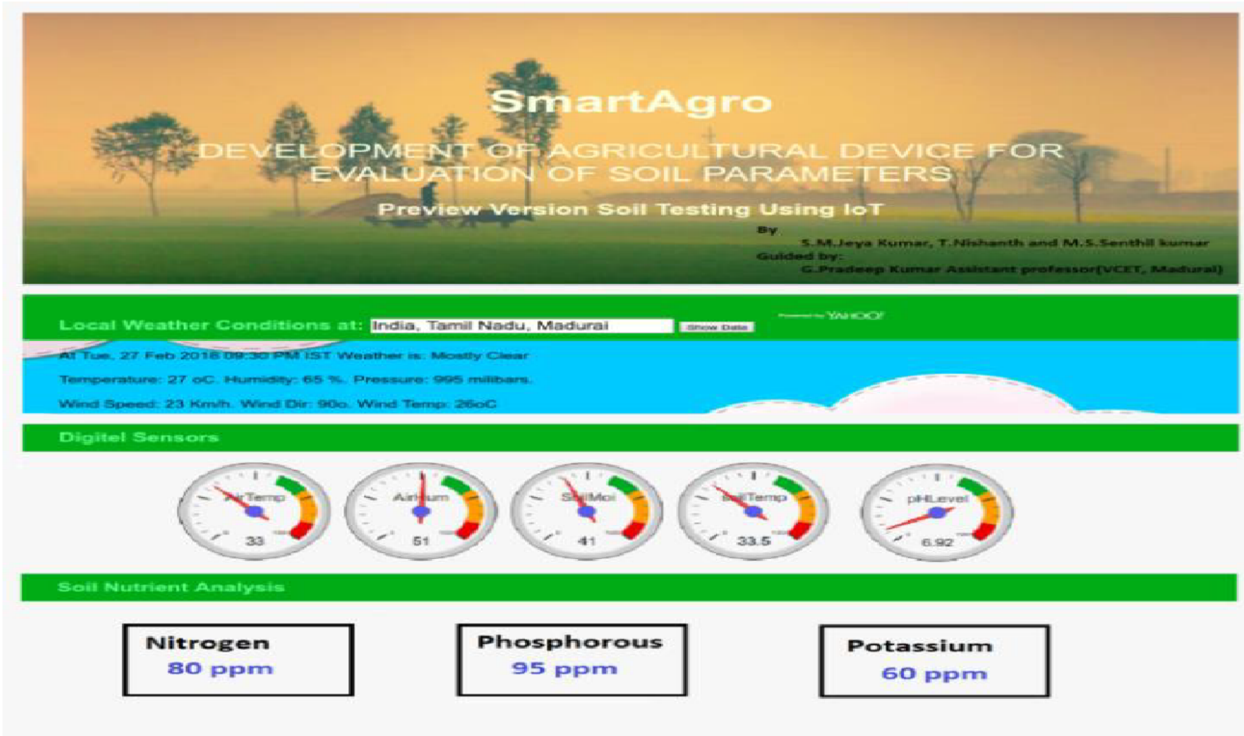

FIG 7.2 SNAPSHOT OF THE WEBSITE DEVELOPED

The results are regularly updated in the website we created. The NPK levels, pH values, temperature, light are all displayed in this website. The type of yield according to the results is also displayed.

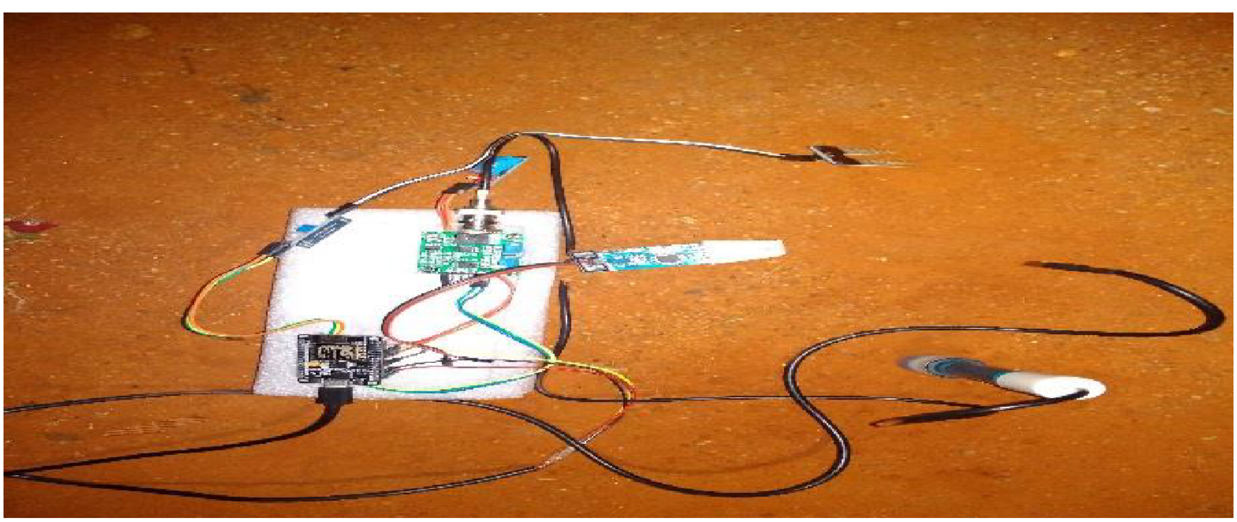

Fig 7.3 TESTING OF SOIL USING THE KIT

TESTED SOIL PARAMETERS

SI.NO	SOIL NAME	NPK AND PH VALUES(PER ACRE)(LAB RESULT)	NPK AND PH VALUES(PER ACRE)(EXPERIMENTAL RESULT)	SUITABLE CROPS
1	Alluvial soil	N=0.25ppm	N=0.28ppm	Coffee, Pepper, Onion
		P=11ppm	P=1.3ppm	
		K=115ppm	K=112ppm	
		Ph=6.9	Ph=6.7	
2	Black soil	N=0.48ppm	N=0.56ppm	Citrus, Cotton, Onion, Chillies, Brinjal
		P=21ppm	P=22ppm	
		K=120ppm	K=122ppm	
		Ph=6.8	Ph=6.5	
3	Laterite soils	N=0.85ppm	N=0.89ppm	Citrus, Cotton, Onion, Chillies, Brinjal
		P=19ppm	P=21ppm	
		K=105ppm	K=103ppm	
		Ph=7.1	Ph=7.0	
4	Red soil	N=0.40ppm	N=0.43ppm	Coconut, Arekanut, Rice
		P=17.6ppm	P=18ppm	
		K=162ppm	K=164ppm	
		Ph=5.5	Ph=5.6	
5	Alkaline soil	N=0.7ppm	N=0.75ppm	Coconut, Arekanut, Rice
		P=16.5ppm	P=16.8ppm	
		K=85ppm	K=84ppm	
		Ph=7.7	Ph=7.8	
6	marshy soils	N=0.75ppm	N=0.78ppm	Coconut, Arekanut, Rice
		P=16.5ppm	P=18.9ppm	
		K=85ppm	K=160ppm	
		Ph=7.5	Ph=7.96	
7	Peaty soil	N=1.08ppm	N=1.1ppm	Coconut, Arekanut, Rice
		P=20.9ppm	P=21.2ppm	
		K=86ppm	K=88ppm	
		Ph=8.3	Ph=8.4	

Table 1 SOIL PARAMETERS

CHAPTER 8

CONCLUSION

Time is the critical factor for soil nutrient detection since the variability of soil nutrient levels may be quiet high over time. Due to complex soil pretreatment and chemical analysis, standard testing time for NPK is time consuming. Here NPK, pH, soil moisture and Temperature values of soil sample are measured in real time and compared with the pre-stored values received from the agricultural department. The system also provides the information about the crops that can be grown in respective soils. This sensor based agricultural device provides the results instantaneously and also for precision agriculture the cost of each sensor needs to be low and the stability of the sensor membrane needs to be high, especially when such sensor deployed harsh environments; furthermore the sensitivity needs to be high, and they also need to be supported by robust data management systems to be able to collect the data, manipulate it for decision support analysis in fertilizer management.

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