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Studies on Development and Testing of Sensor for Automatic Irrigation System

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***Abstract*— *In India, agriculture is the main sector for increasing the food production. In India, agriculture depends on the monsoons which is not sufficient source of water. So the irrigation is used in agriculture field. Every type of plant requires different amount of water to grow. To reduce the wastage of water and apply the optimum amount of water to the plants irrigation scheduling is needed. For irrigation scheduling it requires to determine the moisture content present in the soil. So to determine the moisture content the methods are very time consuming and less accurate. This project is an attempt to reduce the time consumption to determine the moisture content and to make it automatic and easy to use. We developed a moisture sensing kit and compared its reading with the gravimetric method. Also we design the automatic motor operating irrigation system on the basis of that moisture sensor reading. That is the motor is on when moisture is less than 50% and continues up to 80%.If moisture is greater than 80% then motor will automatically stopped. Also we provide GSM system with that microcontroller. If moisture is less than 50% then message will be automatically receive on the mobile. The aim of our project is to provide new agriculture technology by programming.*

***Keywords*— Moisture sensor, Gravimetric method, Motor, GSM Sim module.**

I. INTRODUCTION

When the population increases, the basic need such as food and water is increasing day by day. Thus there is a need of saving water resources and utilize them in an efficient manner. Hence, water is one of the most important elements in our daily life, thus we must use efficient ways to utilize water and save it for future generations. For that efficient irrigation management is needed. Irrigation water management practices could greatly benefit by the knowing of moisture in the soil.

To determine the soil moisture content in the soil many methods are being used but these methods are time consuming and less accurate. To do the operation in the least time consuming way electronics components should be used. Soil moisture content is the water present in the soil. By measuring soil moisture at regular interval and at different depths within the root zones, information can be obtained as to the rate at which moisture is being used by the crops at different depths. This provides the practical purpose, irrigation should be applied when moisture content is base for determining when to irrigate and how much water to be applied. For depleted below 50 percent of available moisture.

II. METHODS TO DETERMINE SOIL MOISTURE

2.1. Direct method

2.1.1. Gravimetric methods:

In gravimetric method, basic measurement of soil moisture is made on soil samples of known weight or volume. Soil sample from the particular depths are collected with a soil auger. Soil sample are taken from particular depth at several locations of each soil type. They are collected in the air tight aluminium containers. The soil samples are weighed and they are dried in air oven at 105 °C for about 24 hours until all the moisture is driven off. After removing from oven, kept them for cool to room temperature and weighed again. The difference in their weight is amount of moisture in the soil. The moisture content in soil is calculated by the following formula:-

$$\text{Moisture Content}\,(\%) = \frac{M2 - M3}{M3 - M1} * 100$$

Where,
M_1=Weight of sample box (gm)
M_2=Weight of wet soil + lid (gm)
M_3=Weight of dry soil + lid (gm)

2.1.2. Volumetric Methods:

Soil sample is taken with the core sampler or with a tube auger whose volume is known. The amount of water present in soil sample is calculated by drying it in the oven and calculating by following formula.

Moisture content = Moisture content in weight x Bulk Densityin volume.

2.1.3.Using Methyl Alcohol:

Soil sample is mixed with a known volume of methyl alcohol and then measure the change in specific gravity of alcohol with a hydrometer. This is a shot procedure but it is in common use.

2.1.4. Using calcium chloride:

Soil sample is mixed with the known amount of calcium chloride. Generally calcium chloride reacts with water and removes it in the form of acetylene gas.

2.2. Indirect method

In these methods, no water content in the soil is directly measured but the water potential or stress or tension under which the water is held by the soil is measured. The most common instrument used for estimating soil moisture by indirect method are of following-

2.2.1.Tensiometer:

Tensiometers provide a direct measure of tenacity with which water is held by soil. It consist of 7.5 cm porous ceramic cup, a protective metallic tube, a vacuum gauge and a hollow metallic tube holding all parts together. At the time of installation, the tensiometeris filled with water from the opening at the top and rubber corked it is used when set up in the soil. Moisture from cup moves out with the drying of soil, creating a vacuum in the tube which is measured with the gauge. Care shouldtaken to install tensiometer in the active root zone of the crop. When desired tension is reached, soil is irrigated. The vacuum gauge is graduated to indicate tension values up to one atmosphere and is divided in to fifty divisions each of 0.2 atm value. The tensiometer works satisfactory up to the 0.85 bars of atmosphere.

2.2.2.Gypsum block:

Gypsum blocks resistance units are used for measurement of soil moisture in situ. These were discovrred by Bouycos and Mick in 1940. The blocks are made of various materials like gypsum, nylon fiber, glass material, plaster of Paris or combination of these materials. The blocks are generally rectangular in shape. A pair of electrode is usually made of 20 mesh stainless steel wire screen soldered to copper lead wire. The common dimensions of screen electrodes are 33.75 cm long and 0.25 cm in wide. The usual spacing between electrodes is 2 cm. A similar block dimension is 5.5 cm long, 3.75 cm wide and 2 cm thick.

2.2.3.Pressure plate and pressure membrane apparatus:

Pressure membrane and pressure plate apparatus is used to estimate field capacity, permanent wilting point and moisture content at different pressures. The apparatus consists of air tight chamber in which porous ceramic pressure plate is placed. The pressure plate and soil samples are saturated and they are placed in the metallic chamber. The required pressure, say 0.33 or 15 bars is applied through a compressor. The water from soil sample which is held at less than the pressure, applied trickles out of the outlet till equilibrium against applied pressure is achieved after that, soil samples are taken out from oven for determining the moisture content.

2.2.4. Neutron probe:

Soil moisture can be estimated quickly and continuously another with the neutron moisture meter without disturbing the soil. Another advantage is that soil moisture can be estimated from the large volume of soil. Diameter around the neutron probe in wet soil and 50 cm in the dry soil.Itincludes the probe and a scalar or rate meter. The probe contains fast neutron source, which may be a mixture of radium and beryllium and beryllium. Access tubes are aluminium tubes of 50 to 100 cm length and are placed in the field where moisture to be estimated.

To determine the soil moisture by the methods listed above requires extensive amount of time, so the alternative for this is to use the electronic Instruments like the instrument called soil moisture sensor. The soil moisture sensor is used to measure volumetric water content from the soil.

III. MATERIAL AND METHODS

In this study, we are using two methods of determining moisture content-

3.1. Automatic moisture sensing method

3.2. Gravimetric method

Then,

3.1. Automatic moisture sensing method

3.1.1.Material: For the moisture sensing method Following material is used,

3.1.1.1.Moisture Sensor:

Moisture sensor is a two-probe sensor which is made up of pure nickel. Nickel has fair conductive properties and also strength to get buried in the soil for long time. It will not get corroded in soil. The length of the nickel probes is 9.5 cm and width of each probe is 0.7cm.The distance between the two probes is 0.5cm the tips of sensor probes are designed in the shape of triangle so that can beeasilyburied in the soil.

Plate No. 3.1: Moisture sensor

3.1.1.2. Microcontroller (Arduino Mega):

The Arduino Mega is a microcontroller based on the ATmega2560.It has 54 digital input pins/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, the power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with the USB cable or power it with a AC-to-DC adapter or battery to get started.

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Plate No. 3.2: Microcontroller (Arduino Mega)

3.1.1.3.LCD screen:

LCD screen is an electronic display module. A 16x2 cm LCD display is very basic module and is very commonly used in various devices and circuits.

Plate No. 3.3:LCD Screen

3.1.1.4.Breadboard:

A breadboard is thesolderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connects the holes on the top of board. Note that the top and bottom rows of holes are connected horizontally internally and split in the middle while the remaining holes are connected vertically.

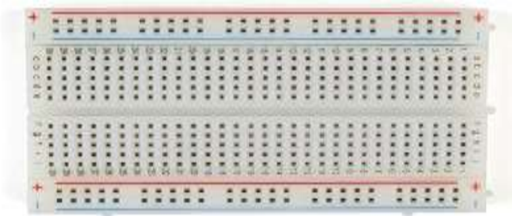

Plate No. 3.4: Breadbord

3.1.1.5.Jumper wires:

Jumper wires are simple wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are used withbreadboards and other prototyping tools in order to make it easy to change a circuit as needed.

Plate No. 3.5: Jumper Wires

3.1.1.6.Relay:

A relay is an electrical switch which opens and closes under the control of another electrical circuit. In the general, the switch is operated by an electromagnet to open or close one or many sets of contacts. A relay is able to control and output circuit of higher power than the input circuit.

Plate No. 3.6: Relay

3.1.1.7.GSM module:

It is a specialised type of modem which accepts a SIM cards, and operates over a subscription to a mobile operator, just like a mobile phone. GSM networks operates in a number of different carrier frequency range, with most 2G GSM network operating in the 900 MHz bands. A GSM modem exposes an interface. The mobile operate charges for this message sending and receiving as if it was performed directly on a mobile phone.

Plate No. 3.7: GSM module

3.1.1.8.Motors:

This system requires the 12V DC permanent magnet motor.

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Plate No. 3.8: Motors

3.1.2. Methodology:

1.Join the circuit as shownin the circuit diagram (Plate No.9).

2.Figure(Plate No.10) shows the proper placement of the Soil Moisture Sensor. The prongs must be oriented horizontally, but rotated onto their side like a knife poised to cut food - so that water does not pool on the flat surface of the prongs. The horizontal orientation of the sensor ensures the measurement is made at particular soil depth. The entire sensor can be placed in vertical, but because soil moisture often varies by depth, this is not usually the desired orientation. To position the sensor, use a thin implement such as a trenching shovel to make pilot hole in the soil. Place the sensor into the hole,checking with the entire length of the sensor is covered. Press the soil along either side of the sensor with your fingers. Pressing will be continuing until you have made at least five passes along the sensor. This step is important, as the soil around the sensor surface has the strongest influence on the sensor reading.

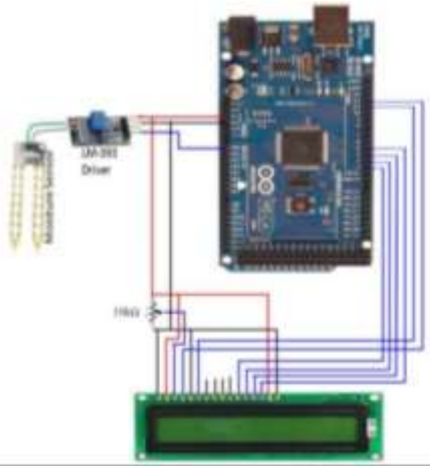

Plate No. 3.9:Circuit Diagram

3.Take the reading displayed on the LCD screen.

Plate No. 3.10: Moisture Sensor under the soil

3.1.3.Software used:

The software called Arduino is used. The software requires computer program to do all the operation. The microcontroller analyses all the data collected by the soil moisture sensor with the help of the program dumped in it and it displays the output on LCD screen.

3.2.Gravimetric Method:

3.2.1.Materials:

1. Aluminum container
2. Air oven
3. Trowel
4. Weighing machine

3.2.2.Methodology:

The soil moisture content may be expressed by weight as the ratio of the mass of water to the dry weight of the soil sample. To determine any of these ratios for specific soil sample, the water mass should be determined by drying the soil to constant weight and measuring the soil sample weight after and before drying. The water mass is the difference between the weights of the wetsoil sample and oven dry samples. The criterion for a dry soil sample is the soil sample that has been dried to constant weight in oven at temperature between 100-110 °C (105 °C is typical). It seems that this range of temperature has been based on water boiling temperature and does not consider the soil physical and chemical characteristics.

3.2.3.Procedure:

1. Weighaluminum tin and record this weight.
2. Place a soil sample of about 10gm in the tin and record this weight.

3.Place the sample in the oven 105°C and dry for 24 hours or overnight.

4.Weigh the sample and record this weight.

5.Return the sample to the oven and then dry for several hours, and determine the weight.

6.Repeat above 5 step until there is no difference between any two consecutive measurements of the weight.

3.2.4.Computation:

$$\text{Moisture Content} = \frac{\text{M2} - \text{M3}}{\text{M3} - \text{M1}} * 100$$

M_1=Weight of sample box (gm)

M_2=Weight of wet soil + lid (gm)

M_3=Weight of dry soil + lid (gm)

IV. RESULTS

The moisture sensor is a fork like plate having aluminium inside. The two terminals are connected to microcontroller. Microcontroller is small PCB designed operate the electronic devices by commanding them with the help of programming language. The moisture sensor needs minimum 5v power supply to operate.

4.1. Moisture Sensor Method:

The following values of moisture content in soil are taken from the college campus from 3 Oct 2018.

Table No. 4.1: Moisture contents by moisture sensor

Soil type	Dry	Medium	Wet
Reading (%)	11	49	95

The moisture sensor readings in the dry soil is 11%, second reading in the medium wet soil is which is 49% and for third readings of moisture sensor in the wet soil is 95%.

4.2. Gravimetric method

The soil sample is taken from the different moisture medium of soil (dry,medium, wet) and at the same time as the moisture sensor reading were taken. The samples are collected in the sample box.

Table No. 4.2: Moisture contents by gravimetric method

Sr. No.	**Weight of sample box (M1) (gm)**	**Weight of wet soil + lead (M2) (gm)**	**Weight of dry soil +lead (M3) (gm)**	**Moisture content (%)**
1	36	74	70	11
2	35	70	60	40
3	35	71	55	80

The first soil sample of was taken from same place from where the first moisture sensor readings was taken. The resulting moisture content is 11%. The remaining soil samples were taken from the respective places as the moisture sensor readings and soil samples for gravimetric method were taken. the resulting moisture content is 40%, 80% respectively.

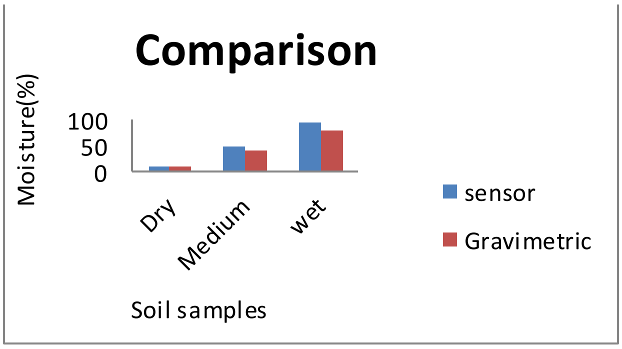

Figure No. 4.1: Comparison Graph

V. CONCLUSION

From this project we conclude that:

1) Gravimetric method is time consuming method but the moisture sensor gives the reading within 3 to 5 seconds.

2) The comparison of these two methods shows that the moisture sensor reading differ from the gravimetric method readings by approximately 10%.

3) The readings given by moisture sensor do not differ constant.

4) Moisture sensor kit operation is user friendly.

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