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Nikunjkumar Chauhan
Irrigation and Drainage Engineering, AAU, Godhra, Gujarat, India

Urvashiben Parmar
Soil and Water conservation Engineering, AAU, Godhra, Gujarat, India

Er. Vishal Mehra
College of Agricultural Information, AAU, Ananad, Gujarat, India

Corresponding Author:
Nikunjkumar Chauhan
Irrigation and Drainage Engineering, AAU, Godhra, Gujarat, India

Wireless automatic irrigation system for sandy loam soil

Nikunjkumar Chauhan, Urvashiben Parmar and Er. Vishal Mehra

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Abstract
Irrigation extremely important practice is agricultural and most water-consuming which has to be reduced. An efficient irrigation system which includes soil moisture sensors can help in the efficient management of irrigation practices. The research includes detailed lab calibration of Df robot soil moisture sensor and development of wireless auto irrigation system using NodeMCU microcontroller. Sensing unit which measures soil moisture and sends data wirelessly. The controlling unit was able to receive & display soil moisture data and take irrigation decision. Microcontroller with relay was used for switching action. An android application is also developed for displaying and manually controlling the water pump. Calibrated DF robot soil moisture shows reading similar to the gravimetric analysis for sandy loam soil. Developed wireless automatic irrigation system worked satisfactorily for sandy loam soil with efficient measurement of soil moisture.

Keywords: Soil moisture sensor, calibration, microcontrollers, auto irrigation, smart irrigation

1. Introduction
Irrigation is an essential practice in many agricultural cropping systems in semiarid and arid areas, and efficient water applications and management are major concerns [1]. About 69% of freshwater is currently used in irrigation in the world [2]. When we talk about India it's very close to 91%. Indian people use nearly 91% freshwater for irrigation purposes and 7% in domestic uses [3]. Production is less according to the quantity of water utilizes by the farmers due to improper irrigation process. If farmers are introduced to soil moisture based automatic irrigation system? The system can measure soil moisture continuously and remotely make decisions on irrigation. With the help of this system, water wastage can be reduced, productivity can be enhanced and it will save money and hence it will be cost-effective. Farmers give irrigation without knowledge of moisture present in the soil and without knowing the lowest and maximum moisture required for soil. Soil Moisture sensor will help in decision making. All Soil have different moisture requirement for proper growth of crops. This research aims to introduce farmers with soil moisture based automatic irrigation systems by providing easy identification symbol for low moisture in the field for sandy loam soil through the mobile app. This will help to proper irrigation management and water-saving in irrigation. The increasing world population has lids to an exponential increase in food demand. This event has necessitated the need for more land to be cultivated. Due to the change of weather patterns brought about by global.
warming, irrigation remains the only reliable method of crop production. With more and more land now being under irrigation, there is a need for optimal use of water. In some last year's knowledge in electronics have many developments. The microcontroller also has major revolutions. The microcontroller has been used together with various sensors to measure and control physical quantities like temperature, humidity, heat, and light. By controlling these physical quantities using the microcontroller- based automatic systems has been developed. In agricultural irrigation, the process can also be automated. To overcome the water availability problem, we can optimize the use of water by an automatic irrigation system. Automation of the irrigation systems is one of the most convenient, efficient and effective methods of water optimization. The systems help in saving water and thus more land can be brought under irrigation. Crops grown under controlled conditions tend to be healthier and thus give more yields. Controlled watering system results in a reduction of fertilizer use and thus fertilizer costs go down This aim entire research is to design and implementation of a microcontroller-based automatic irrigation system, depending on the volumetric water content reading of the sensor. Moisture sensor will be the input of the system and LED, Wi-Fi module NodeMCU8266 and relay will be the output of the microcontroller.

2. Material and Methods

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall [4]. In irrigation soil moisture present at the time of irrigation is the main factor for the decision to start irrigation. There are various types of soil moisture measurement methods are available for measuring soil moisture using different principles. This method is categorized in direct and indirect methods. Direct methods include the gravimetric soil moisture method. The gravimetric soil moisture method is the standard method used for soil moisture estimation. Indirect methods are measurement by different types of sensors like resistive soil moisture sensor, capacitive soil moisture sensor, neutron probe, and others. In the soil there is a limited range of soil moisture is available for the plant to extract is called plant available water which is defined as the difference between field capacity and permanent wilting point at any given depth in a soil is called plant available water [5]. Where field capacity of the soil is the amount of water a soil can hold after allowing for 2-3 days of drainage under normal conditions [5] and the permanent wilting point is when the soil continues to dry, there is a very little amount of water is present in the soil that cannot be extracted from soil by plants roots. [6]. This soil moisture limit for irrigation also varies with different soil texture type. These soil moisture limits help irrigation decisions. At permeant welting point soil moisture reduces to very low and plants reach the high moisture stress level. These affect the productivity of the crop so in real life situation we do not allow soil moisture to a permanent wilting point in the farm. We start irrigation before soil moisture reaches the permeant wilting point and these soil moisture points to decide when to start irrigation is also different for individual soil texture. The soil moisture at which irrigation should start for different soil texture is given below in table and this research uses 15% VWC (Volumetric water content) for the starting of irrigation having sandy loam soil in our local area

2.1 DF-Robot capacitive soil moisture sensor: It is capacitive type soil moisture sensor developed by DFrobot company. The sensor is made such a way that is corrosion restive and has longer life duration working. It has an operating voltage of 3.3 to 5.5 DC V and 5mA operating current. The dimensions of the sensors are Dimensions: 3.86 x 0.905 inches.

Fig 1: DF robot soil moisture sensor

2.2 NodeMCU Microcontroller: NodeMCU is Arduino based microcontroller having inbuilt ESP8266 Wi-Fi chip. It has 3.3 DC V operating voltage and current consumption is about 10uA~170mA. It has Tensilica L106 32-bit Processor with processor speed 80~160MHz.

Fig 2: NodeMCU microcontroller

2.3 Relay: A relay is an electromechanical switch. It is used for switching high current device that cannot be switched by the transistor. The relay consists of one electromagnetic coil and three terminals for switching. One among these three terminals is a common terminal that floats between the other two terminals. These two terminals are normally close (NC) and normally open (NO) terminal.

Fig 3: Relay

3. Design and Implementation

3.1 Sensing unit

Sensing unit was designed for the measurement of soil moisture. In sensing unit DFrobot soil moisture sensor was connected with A0 analog port of NodeMCU micro controller. Sensing unit was powered with 3.7 V 2000 mAh battery for backup power.

3.2 Sensor calibration
The sensor was celebrated to give proper Soil moisture reading in VWC by percentage. The sensor shows different voltage output in different condition of soil moisture. To Calibrate sensor voltage output is compared with actual soil moisture. Lab calibration method was performed for the sensor. In which we have created

different samples by adding a known amount of water in sandy loam soil and measured the readings of the sensor in soil and the gravimetric method was used to find volumetric water content.

3.3 Controller unit
Controller unit was consisting of NodeMCU microcontroller with a relay module to control the water pump in the irrigation system. In controller unit 16×2 I2C LCD was also attached for displaying soil moisture reading.

3.4 NodeMCU Programming & Application NodeMCU was programmer using Arduino IDE software and using ESP8266 supported library. Supporting android application was developed using "MIT App inventor" online application development platform.

4. Result and Discussions
4.1 Calibration
The sensor was successfully calibrated for measurement of soil moisture in VWC by percentage using lab calibration method. Before lab calibration soil properties ware analyzed in which we find out that soil was having 6.9 pH, Sandy loam Soil texture and 1.22 dry bulk density. The soil was prepared by drying them at 105° temperature for 24 hours to remove all existing soil moisture. The soil was placed in the eight 1000mL beakers and 0- 350 mL range distilled water was added to eight beakers.

Fig 4: Soil Samples

The soil was properly mixed with water using an external plate and bulk density was maintained when beaker ware refill with soil. Soil moisture sensor with NodeMCU was used to measure voltage reading. The sensor was placed in one of the eight beakers then voltage reading was measured in the serial monitor of Arduino IDE and also 20 grams of soil were taken for gravimetric analysis. All eight-sample soil moisture ware used to measure voltage reading and gravimetric analysis. The graph was a plot between voltage reading vs VWC by gravimetric measurement. Relationship equation between VWC and voltage was founded form the graphical data.

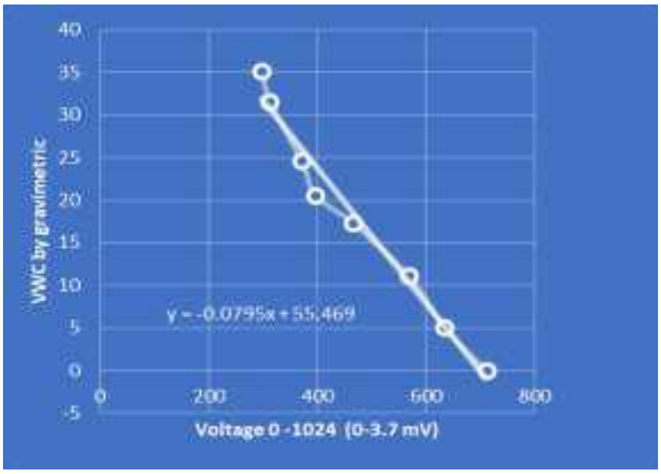

Fig 5: Calibration graph

4.2 Validation of Sensor
Calibrated soil moisture sensor was used to measure soil moisture of random soil. Soil moisture from different three locations was measured by the sensor then also soil sample was taken for gravimetric analysis. Soil moisture measured by the sensor was near the gravimetric measurement.

Fig 6: Validation graph

4.3 Auto-Irrigation system
Designed Sensing unit was able to measure soil moisture by using calibrated DF robot soil moisture sensor and it was sending data to the controller unit using Wi-Fi.

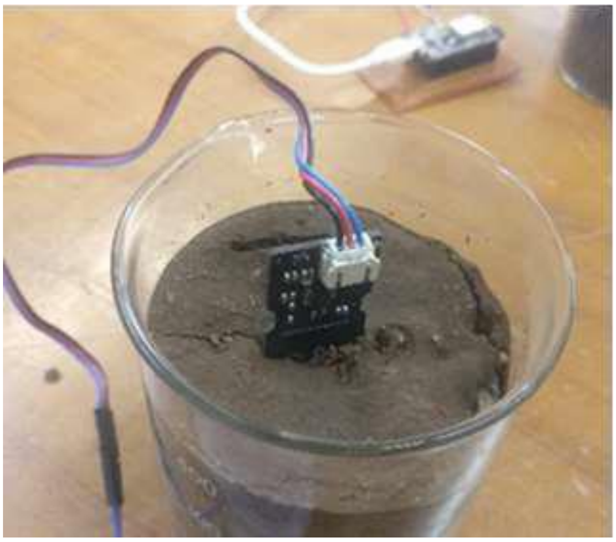

Fig 7: Sensing unit

Fig 8: Controlling unit

Controller unit was able to start irrigation water pump when soil moister reach to 15% VWC for sandy loam soil. LCD display attached to the controller was also showing soil moisture data received from the sensing unit.

Fig 9: Android Application

Android Application was able to display soil moisture data and controlling of water pump manually. The system was tested with low soil moisture in which the system automatically triggered a water pump when soil moisture was less than 15% VWC predefine limit and after reaching upper moisture limit water pump was turned off. Manually controlling the water pump with the android application was also working fine.

5. Conclusions

The System with sensing unit and controlling unit was successfully developed for sandy loam Soil. The system was able to display soil moisture on the android application and on LCD. The pump controlled in both automagical and manual mode. It was observed that the system increases on-field water use efficiencies.

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