International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-7 May, 2019

Soil Moisture Monitoring System Using IOT

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Abstract: ***Interconnection of number of devices through internet describes the Internet of things (IoT). Every object is connected with each other through unique identifier so that data can be transferred without human to human interaction. The proposed concept of the automated irrigation system uses a NodeMCU and other modules so that agricultural lands are irrigated automatically without the presence of the human i.e. the motor in field switches ON when the soil moisture value goes below a customizable threshold value and gets OFF when it is above or equal to the threshold value. For larger depths. Moisture content in the soil can be found using HYDRUS software. The IoT features provided by NodeMCU are used to transfer the data like moisture value in the soil, temperature etc. from agriculture field onto the cloud. Previous works involve irrigation without human intervention, but this work provides many more add-ons like being able to access the field condition using mobile or through web page. The user is also given opportunity to control the motor using his/her mobile with a pre-defined condition of mobile and NodeMCU getting connected to the same internet. Hydrus-2D is used to predict the moisture levels at a depth of greater than 30cm in different soils. It can be used in gardens and can be extended to agricultural fields. This type of advanced and personalized set-up can be very useful for todays farmers. This can decrease man force and cause increase in production and its quality, thereby benefitting the farmer economically. The personalization of the set-up can be done using Arduino IDE and Blynk mobile application.***

Keywords:* Blynk, *Hydrus-2D, NodeMCU, Soil Moisture

I. INTRODUCTION

In order to improve the Subsurface drip irrigation (SDI being adopted in areas to conserve water; we have proposed this work [1]. Soil moisture (SM) is a crucial part in the lifecycle of a plant, which influences crop development resulting in high yield. SM is extremely unpredictable and influenced by a variety of things such as soil type, water absorption capacity, climatic conditions, and changes with alteration of depth. During initial days, soil moisture sensors couldn't produce accurate values. The upgradations made in the measuring Soil moisture values produced sensors which can produce highly accurate values.

Soil moisture can simply be defined as the amount of water present in the soil. Soil moisture influences the physical, chemical, and biological characteristics of the soil.

Saturation, and evapotranspiration all depend heavily on the moisture content in the root zone and the entire soil profile. Information of the spatial distribution of soil moisture is also important (Grayson et al., 1999; Bronstert and Ba'rdossy 1999). Past examinations have featured spatial organization at 0– 30 cm profundity at certain seasons of the year and an increasingly random example at other occasions (Grayson et al., 1997; Western and Grayson 1998). Such variation has implications for runoff generation and the scale characteristics connected to spatial averaging of procedures, for example, evapotranspiration.

The value of Soil moisture determines the water movement and aeration of the soil. Soil moisture is a crucial parameter in the fields of agricultural, geotechnical, hydrological, and environmental engineering. For exactness agriculture, the scheduling of irrigation is profoundly subject to soil moisture content and plant condition. Soil moisture is of critical significance to hydrological forms at a variety of scales (Ba'rdossy and Lehmann 1998; Western et al., 2002). Procedures including surface and subsurface runoff generation, the formation of zones of the soil.

Understanding the physical behavior of soil water content started with Briggs and McLane in 1897, which was later carried forward by Buckingham, Gardener and Richard. These works provided a conceptual partitioning of soil water content, gravitational water, slender water, and hygroscopic water. The gravitational water depletes away because of the gravitational force, and the capillary action. Be that as it may, the hygroscopic water cannot drain due to both of these forces. The gravitational water empties out of soil inside 2– 3 days after rainfall. Along these lines, the capillary water and hygroscopic water are the two main components of the water content of regular soils. In the course of the only remaining century, scientists have been proceeding to create different procedures to measure soil water content. Be that as it may, planning a strong, minimal effort, dependable, and constant estimating soil dampness sensor is as yet a difficult assignment. There are a few procedures for estimating soil moisture, thermogravimetric, soil-resistivity, capacitance, time-domain reflectometry, frequency-domain, reflectometry, and neutron scattering.Wireless Sensor Network (WSN) is the innovation, in which the data gathered from the field of intrigue is transmitted through wireless connection. WSN can be used in different fields, for example, monitoring, wireless measurements, controlling, and so on.

Revised Manuscript Received on May 10, 2019.

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In the field of accuracy agriculture and organic farming, it is vital to constantly monitor the fields as they are site explicit. Monitoring plant wellbeing is fundamental which improves the profitability of sustenance grains. Soil dampness is one of the crude factors for plant wellbeing. The water that remaining parts in soil as a slim film help in providing nutrients to the plant growth.

Surface soil moisture is an important variable for understanding different hydrological forms, as it firmly impacts the surface-subsurface overflow at watershed scale. It also assumes a critical job in weather and atmosphere expectation thinks about as it takes an interest straightforwardly in conveyance of energy flux between the soil and atmosphere (Vereecken et al., 2007; 2008). Precise expectation of surface soil moisture at different spatial and temporal scales is essential to improve hydrologic and climatic demonstrating and forecast (Brocca et al., 2010). Portrayal of fluctuation in surface soil moisture at various spatial and temporal scales is a noteworthy challenge on account of multi-scale heterogeneity displayed by soils. To evaluate the spatial and temporal variety of surface soil moisture, remote detecting and ground based estimations are most usually used. Ground put together estimations furnish exact data with respect to soil moisture information at a local-scale (Western et al., 2002). Be that as it may, these estimations require precise calibration of the estimating instrument, are costly, tedious, and give information at few chose focuses. Further, it is exceptionally experimenting to decipher the spatial and transient examples of surface soil moisture at various scales from estimations accessible at few chose points.

II. RELATED WORK

A. Traditional Methods for Soil Moisture Measurement

In the Traditional process, a soil sample is allowed to evaporate in order to make the soil moisture free. Calcium Carbide method is one of the ways to find soil moisture. Here Calcium Carbide is made to react with moisture in soil. Due to this the amount of Acetone produced is varied through which the moisture value is found out. Thermo-gravimetric method is widely used to find out the exact soil moisture value. Less than hundred grams of wet soil is taken and allowed to dry in an oven for twenty-four hours at above 100ºC. The weight of the soil which is getting dried is noted parallelly by which soil moisture value is determined.

B. Advanced Methods for Soil Moisture Measurement

In this process of Soil moisture measurement, things like resistance, extent of penetration of Infrared rays are initially calculated. The values recorded here are of high precision, but cost of the equipment is more. A micro-processor is built-in to produce accurate results in modern-day soil moisture sensors. The latest sensors consist of only single probe with a unit on top of it for reading the incoming values from the soil.

C. Soil Moisture Sensor

Soil moisture sensor measures the volumetric water content in soil. These sensors find the value by measuring the parameters like dielectric current in the soil between the two leads of the sensor. Another class of sensors measure another property of moisture in soils called water potential. These sensors are normally alluded to as soil water potential sensors and include tensiometers and gypsum blocks.

III. PROPOSED METHODOLOGY

A. Working of YL-69

Volumetric content of water is measured by two probes of YL-69 sensor. The two probes act as dielectric and pass electricity between them including the soil. The soil moisture value is found out indirectly by finding the resistance between the 2 leads/probes of the sensor.

When there is less resistance it indicates that the electric conductivity is more which in turn shows that soil has higher amounts of moisture. Similarly, the higher is the resistance, the lesser is the conductivity of electricity which shows that soil is free from moisture.

B. Block Diagram

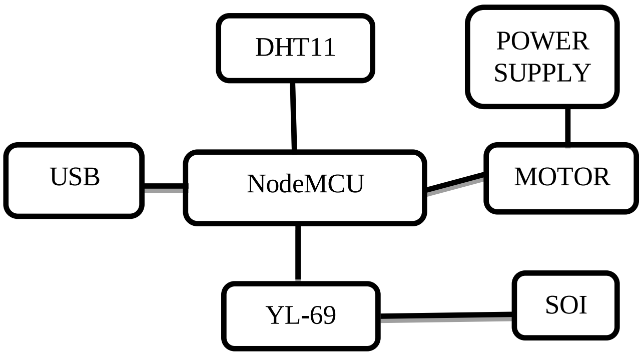

Fig.1 Block diagram

C. Specifications

The specifications of YL-69 are as follows:

V_{in}	3.3 –5V
V_{out}	0-4.2V
I_{input}	Up to 35mA
Output Mode	Digital and Analog

Table1. Specifications of YL-69

D. Interfacing YL-69 and NodeMCU

Analog mode of connection is used in this approach as we need to control the motor according to the soil moisture levels obtained. Digital mode of sensor doesn’t offer us this facility. The output Analog values ranges from 0-1023. An inbuilt potentiometer LM393 is available in YL-69. The obtained analog soil moisture value is compared with the threshold value mentioned in Arduino and necessary action is taken based on the result of comparison.

Motor pump turns ON if sensed value crosses a predefined value and gets OFF when it reaches the predefined value.

IV. SOFTWARE APPROCH

A. Numerical Modelling Theory

Soil water from the porous ceramic emitter into the soil is simulated using HYDRUS-2D software package (version 2.03) Considering a homogeneous and isotropic soil, the governing two-dimensional flow equation is described by Richards equation (Richards, 1931; Celia et al., 1990), and the equation is solved by the Galerkin finite-element methods equation (1)

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[K(h)\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial z}\left[K(h)\frac{\partial h}{\partial z}\right] \quad + \frac{\partial K(h)}{\partial z} \qquad (1)$$

The soil water retention, (h), and hydraulic conductivity, K(h), were described using the analytical functions of van Genuchten (1980) as by equation (2)

$$S_e = \frac{\theta(h) - \theta_r}{\theta_s - \theta_r} = \frac{1}{(1+|\alpha h^n|)}(n = 1) \qquad (2)$$

Location of the ceramic emitter and the transport domain with applied boundary conditions (I, Lip; II, Emitter-circular tube.

$$K(h) = k_s S_e^{0.5}[1 - (1 - S_e^{\frac{1}{m}})m] \qquad (3)$$

where S_e is the relative saturation; K_s is the saturated hydraulic conductivity; θ_r and θ_s are the residual and saturated water contents $L^3\ L^{-3}$ respectively , α and is an empirical parameter L^{-1} inversely is connected to the initial air value, n and m are all van Mualem and Genuchten parameters of the shape. The HYDRUS model inputs for simulating water flow included flow domain geometry, soil hydraulic parameters and initial and boundary conditions. Geometry and boundary conditions for defining the physical problem.

a. Emitter Hydraulic Properties

In the recreations, the water powered parameters for permeable clay producer likewise have six (θ_r, θ_S , α ,n, Ks, l). All through the reproductions, the permeable fired producer keeps immersed. at the point when is a little value, the (θ_h) would not change with the water capability of permeable earthenware producer, and would be immersed water content, so in our study, the estimation of is resolved as 1.00 × $10^{-8}\ cm^{-1}$ (Siyal et al., 2009). What's more, in this circumstance, other unsaturated parameter (θ_r, θ_S , α ,n, Ks, l) values are not affectability to the outcomes (Siyal et al., 2009). Along these lines, the estimation of θ_r, n and l are received as 0.078, 1.9 and 0.5, separately. To get a precise estimation of soaked water content θ_S and the immersed pressure driven conductivity (k_s) of permeable artistic producer, the permeable clay producer was partitioned into two sections (base and round cylinder) and the soaked water content (θ_{sc}) , θ_{sb} was measured by the drying method, meanwhile the saturated hydraulic conductivity (K_{eb}, K_{ec}) was measured in the laboratory using the constant head method. The hydraulic conductivity of the saturated emitter was determined according Darcy' Law (Bear, 1972) using equation (4) and equation (5)

$$K_{eb} = \frac{Q_{eb}\,.}{A}\frac{L_{eb}}{H} \qquad (4)$$

$$K_{ec} = \frac{Q_{eb}}{2\pi}\,ln\,\frac{r_2/r_1}{H.L_{ec}} \qquad (5)$$

where K_{eb} is the saturated hydraulic conductivity of the bottom of the porous ceramic emitter LT^{-1}, Q_{eb} is the discharge of the bottom of the porous ceramic emitter L^3, L_{eb} is the thickness of the bottom of the porous ceramic emitter. A is the seepage area of the bottom of the porous ceramic emitter.

b. Initial Conditions

The initial water contents were set uniform across the flow domain, about 0.138 $cm^3\ \ cm^{-3}$, (40% of field capacity), 0.207 $cm^3\ \ cm^{-3}$ (60% of field capacity), 0.276$cm^3\,cm^{-3}$ (80% of field capacity), respectively. The input initial water contents of simulations and the water content values were converted to pressure head values using with the clay loam parameters given about −7889, −1059 and −342 cm. It was assumed that the initial soil profile in horizontal directions was homogeneous and the ceramic emitter was saturated firstly.

V. APPLICATIONS OF SOIL MOISTURE SENSOR:

Soil Moisture Sensor is utilized in a wide variety of applications, mostly in horticulture. Some of the important applications include providing adequate amount of water, reduces man force and electricity consumption. It is also the basis for Smart Irrigation System.

VI. RESULTS

A. Hardware

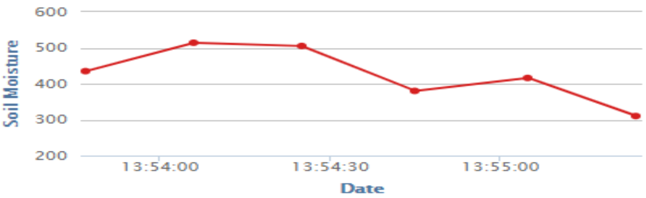

Fig.2 Values of Soil Moisture at different time intervals

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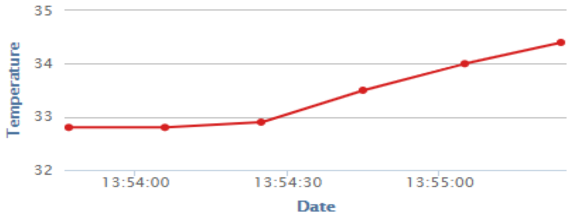

Fig.3 Values of Temperature at different time intervals

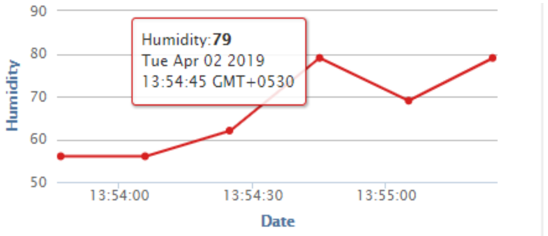

Fig.4 Values of Humidity at different time intervals

The NodeMCU writes the values of Soil Moisture, Temperature, Humidity in the field onto the ThingSpeak IOT analytics platform every 15 seconds and are plotted in the above way. A ThingSpeak channel is created in the name of the farmer and he/she can access it and analyze the parameters in the field by signing into it.

B. Hydrus Simulation

In HYDRUS the selection of soil type can be considered from soil CatLog displayed in HYDRUS software. Initially one type of soil material (sandy loam) is to be selected and with some initial geometry conditions like depth of the soil, number of layers of the soil layers to be implemented are taken into consideration. In this simulation we perform two different simulations by considering two different types of soil materials. We also give the input that how many times it has to be printed the changes that occurs in the soil. Here we assume the number of printing times to be 6(T0, T1, T2, T3, T4, T5) and the time steps that are to be printed.

We also fix the atmospheric boundary conditions like the content of rainfall.We assume average rainfall of 8 hours per day and also we given the condition of rainfall is less than the average saturation rainfall then the water distribution in the soil can be seen in figure 5 where the rainfall is greater than that of the saturation rainfall whereas figure 6 shows the rainfall less than that of the saturation rainfall under same conditions.

Figure 7 describes the surface runoff of the top layer (rainfall<saturation point) and figure 8(rainfall>saturation point). We can clearly see that the runoff will be tending to zero because of over moisture.

In figure 9 and 10 it is clearly seen that the distribution of water inside the soil after continuous rainfall. We can conclude that more the rainfall more the even distribution of achieved. The difference in figure 11 and figure 7 is the number of soil layers that are implemented, if two types of soils with different saturation and evaporations are considered then the water distribution inside them can be observed. If the top layer soil is more fertile the water content distribution is more uniform whereas the bottom layer which is not uniform the distribution of water content is uneven.

As we have two types of soil materials, we can see a vary in the surface runoff surface. As the second layer is less conductive the surface runs-off very fast.

C. Water content distribution:

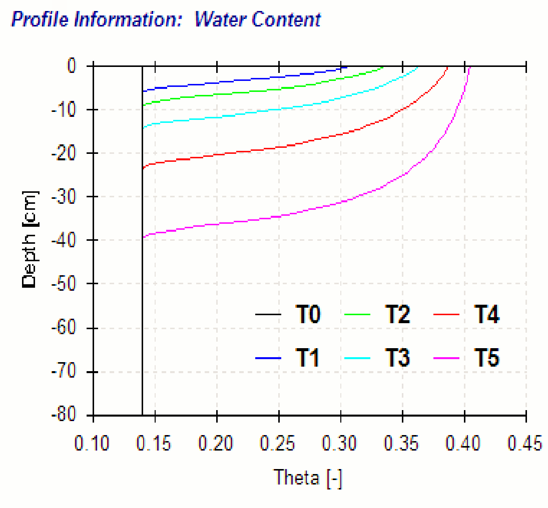

Fig.5 Water Content

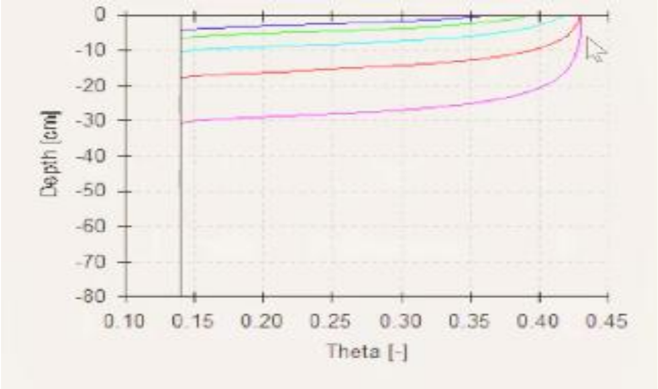

Fig.6 Theta vs Depth

D. Surface Runoff At Different Conditions:

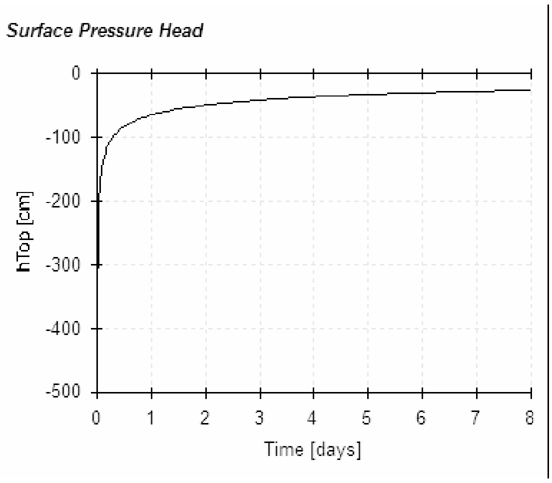

Fig.7 Time vs hTop

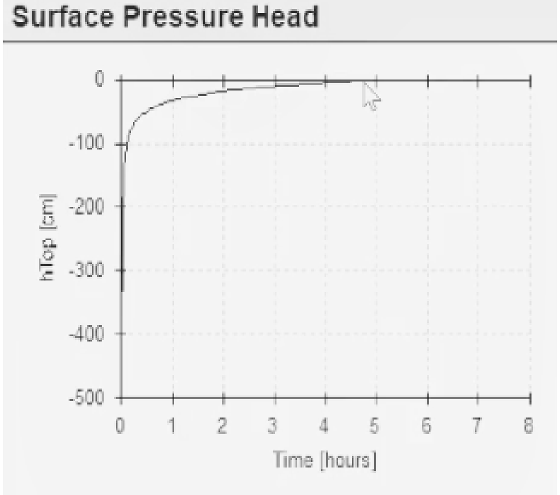

Fig.8 Surface Pressure Head

E. Water Distribution After Continuous Rainfall:

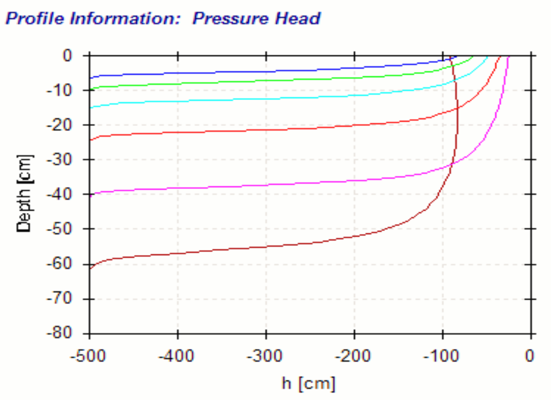

Fig.9 Pressure Head

F. For Two Different Surfaces Water Content Distribution:

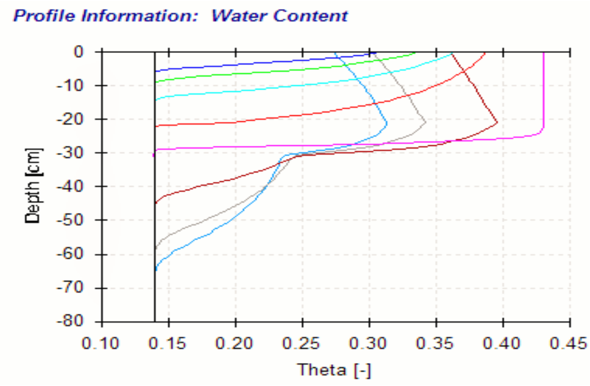

Fig.10 Theta vs Depth

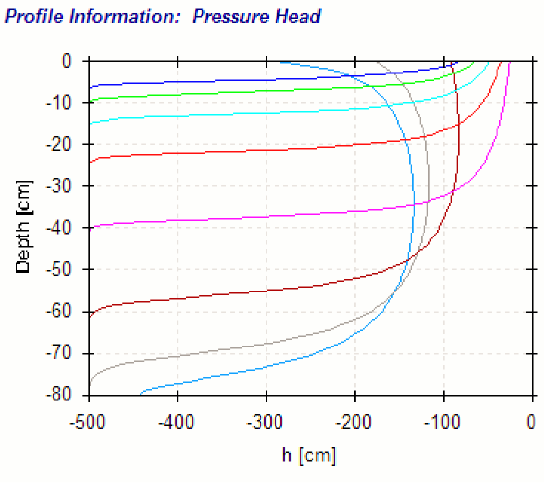

Fig.11 Pressure Head

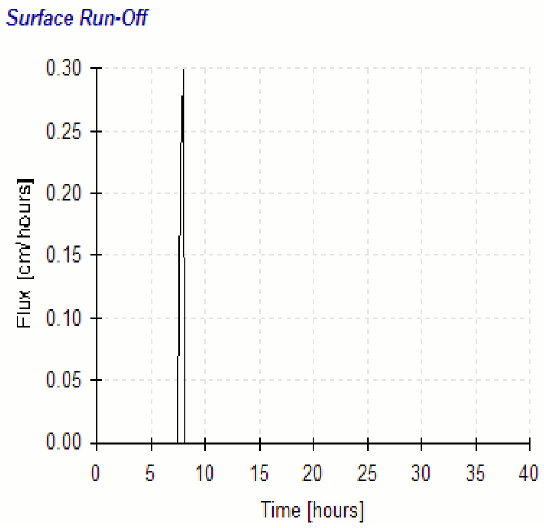

Fig.12 Surface Run-Off

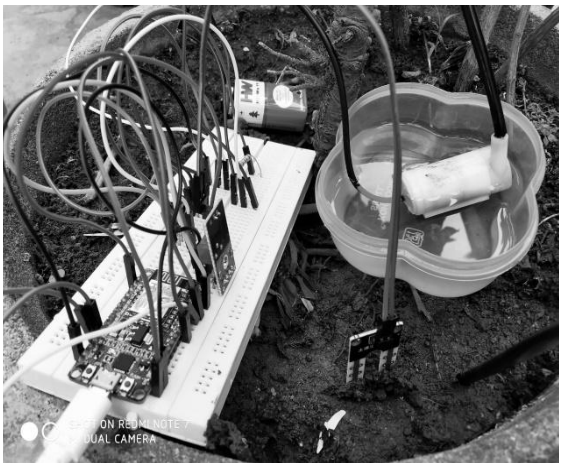

Fig.13 Soil Moisture Monitoring System set-up

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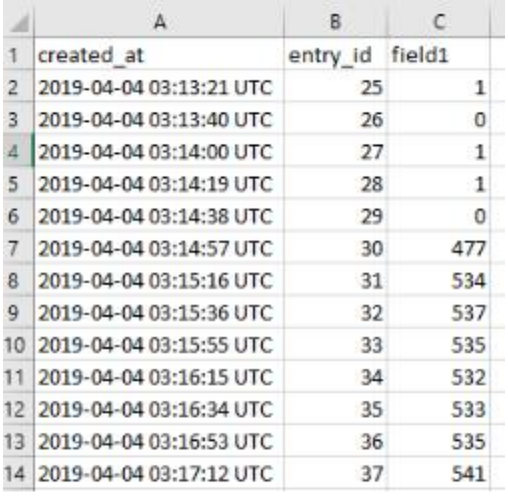

	A	B	C
1	created_at	entry_id	field1
2	2019-04-04 03:13:21 UTC	25	1
3	2019-04-04 03:13:40 UTC	26	0
4	2019-04-04 03:14:00 UTC	27	1
5	2019-04-04 03:14:19 UTC	28	1
6	2019-04-04 03:14:38 UTC	29	0
7	2019-04-04 03:14:57 UTC	30	477
8	2019-04-04 03:15:16 UTC	31	534
9	2019-04-04 03:15:36 UTC	32	537
10	2019-04-04 03:15:55 UTC	33	535
11	2019-04-04 03:16:15 UTC	34	532
12	2019-04-04 03:16:34 UTC	35	533
13	2019-04-04 03:16:53 UTC	36	535
14	2019-04-04 03:17:12 UTC	37	541

Table2. Soil Moisture values at different times

The values can be exported in an Excel sheet and can be checked by a single click itself from the ThingSpeak Channel using the option Export Recent Data

VII. CONCLUSION:

We have developed a Smart Irrigation system prototype in which the motor pump gets ON immediately when the moisture in the soil goes below a threshold value. The pump stops itself when the threshold value is reached. Soil Moisture, temperature values can be accessed by farmer from his place through the Blynk App in the mobile or using ThingSpeak Channel. We have also created the flexibility to control the motor using the Blynk App in the mobile. The functionality of the set-up can be altered by using Arduino IDE and using Blynk App. We have also found out soil moisture values for different levels of depth of soil. The technique of controlling the motor in the field using mobile, accessing field parameters through web-page or mobile makes the paper novel. Thus, it can act as a cost-effective set-up for farmers in any developing country.

VIII. FUTURESCOPE:

The prototype can be further advanced on to the real agricultural fields by incorporating a relay module which acts as an electromagnet switch which changes its states depending upon the way the NodeMCU (or any other micro-controller) is programmed. IOT allows you to automate and control the tasks that are done daily, avoiding human intervention. The right amount of water to the crops increases the productivity and decreases the power consumption, manual work to the farmer.

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