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Correlation between Soil Resistance and pH using Arduino UNO

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Abstract— Increase in population of the world is demanding a need for advancement in cultivation to meet up the future food needs. It is essential to know the soil moisture and soil pH levels to maximize the output. Our research work in this paper focuses on low cost homemade moisture sensor and the pH sensor with accuracy and simple working procedure. Measuring soil moisture is an effective way to know the amount of water required for cultivation. pH measurement is an effective way to know the types of crops that can be cultivated along with a sound knowledge in nutrients availability. Both sensors are tested with several samples of soil and are able to meet with the required accuracy.

Index Terms—Arduino UNO; embedded system; low cost homemade moisture sensor; pH sensor; soil resistance; soil pH; soil moisture.

I. INTRODUCTION

Soil moisture is the amount of water contained in the soil. Soil moisture is an important factor in controlling the exchange of water and heat energy between land surface and atmosphere through evaporation and plant transpiration. Soil pH gives the acidity or alkalinity of the soil. Soil pH is the key variable which affects the plant nutrient availability by controlling various chemical forms of the nutrients. Optimum pH range for most of the plants is between 5.5 to 7 [6]. Thermogravimetric is the standard method for measuring the soil moisture. It requires an oven for dry known volume of soil at 105^0C and hence determines the weight loss. This method is time consuming and destructive [4].

Main technology in soil moisture sensor is based on electrical resistance of the soil. In our paper, we have focused on the correlation between the soil resistance and soil pH obtained using homemade moisture sensor and a pH sensor.

II. LITERATURE SURVEY

A. Measurement of soil moisture using microwave radiometer

O.P.N.C et al.[4] proposed a microwave radiometer technique for the measurement of soil moisture. Microwave sensors are sensitive to the presence of soil moisture. Passive microwave sensors have being used for studying soil for determining moisture content. Emissivity is an important parameter for microwave remote sensing, which provides information about soil. Emissivity can be measured using radiometer. Radiometers are passive microwave sensors which can collect incoming radiations, amplify as well as process the signal and then gives the output which is linearly related to the incoming radiations which have been collected by the antenna. The radiometer used here consists of LNBC (Low Noise Block down Converter) and power meter. The LNBC converts the signal into a lower frequency and sense them out to the cable connector, which is being connected to satellite receiver via co-axial cable. The receiver output is connected to microwave power meter. The EM radiations emitted by dry and wet soil measured at different look angles (10^0 to 60^0) with a step of 5^0. The measured power is then converted to brightness temperature and brightness temperature is correlated with soil moisture. This system is bulky and expensive.

B. An optical reflectance technique for soil moisture measurement

B et al.[5] proposed measurement of soil moisture using an optical reflectance method. An encased, simple light source is proposed which produces reflectance from a coated, porous membrane whose moisture content is a result of being in close contact with a moist section of the soil. A photodiode and a photo cell detector capable of sensing 1.4 mm wavelength of light is being reflected by the most porous membrane surface which is used to quantify the moisture content. Reflectance measurement technique such as this have been used to obtain soil moisture content measurements to an accuracy better than 1%. This system requires more number of components.

C. Soil moisture detection using electrical capacitance tomography (ect) sensor

N.B.A. Karim and I.B. Ismail [2] proposed electrical capacitance tomography for the measurement of soil moisture. ECT sensor with 12 electrodes are used for the visualization measurement of permittivity materials such as dry sand and saturated soils (clay and sand). The measurements obtained are recorded and analyzed using Linear Back Projection (LBP) image reconstruction. Preliminary results shows that there is a positive co-relation with increasing water volume. This system is complex.

D. Monitoring moisture of soil using low cost homemade soil moisture sensor and Arduino UNO

Matti Satish Kumar et al.[1] proposed monitoring moisture of soil using low cost homemade soil moisture sensor. Here, they present a method to manufacture soil moisture sensor at low cost to estimate content of moisture in soil. Hence provide information regarding the quantity of water needed for cultivation.

III. MOISTURE SENSOR

Figure 1: Moisture sensor [1]

The moisture sensor is designed with a piece of thermocol sheet and two copper wires. Copper wires are then inserted into the thermocol sheet at a constant distance which act as a sensor.

Hence the wire to be inserted into the soil are striped off. The wires are supported by long straight sticks to avoid bending. Multiple number of sensors can be used to increase the accuracy.

IV. PH SENSOR

Figure 2: pH Sensor [6]

Two electrodes of the sensor are to be inserted into the soil for obtaining necessary pH values.

V. PH SOURCES AND NUTRIENT AVAILABILITY

Acidity in soil comes from H^+, Al^{3+} ions. Al^{3+} ions are important in acidic soil between pH 4 and 6. Other factors include rainfall, fertilizer use, plant root activity, weathering of soil and acid rain. Acidifying agents like Sulphur (S), Iron Sulphate ($FeSO_4$) are added to reduce the pH.

Similarly, a soil is alkaline due to the presence of high concentration of base cations such as K^+, Ca^{2+}, Mg^{2+}, Na^{2+}. Alkaline soil is characterized by the presence of carbonate. Soil area with limestone will be more alkaline. Liming process is done to increase the pH where calcium and magnesium rich compounds are added to the soil to neutralize the soil acidity.

Availability of macronutrients and micronutrients are affected by the soil pH. Macronutrients include Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S) where most of them are found abundantly in alkaline soil. Micronutrients or trace nutrients include Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Molybdenum (Mo), Boron (B) where most of them are found abundantly in acidic soil. Most nutrient deficiencies can be avoided between 5.5 pH and 7 pH.

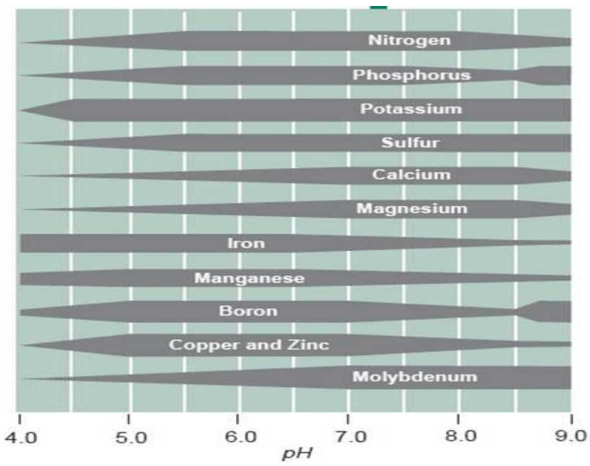


Figure 3: Nutrients availability [6]

Crop	**Soil pH**				
	4.7	*5*	*5.7*	*6.8*	*7.5*
	Relative Yield (100 is the best, 0 is the worst)				
Corn	*34*	*73*	*83*	*100*	*85*
Wheat	*68*	*78*	*89*	*100*	*99*
Soybeans	*65*	*79*	*80*	*100*	*93*
Oats	*77*	*93*	*99*	*98*	*100*
Barley	*0*	*23*	*80*	*95*	*100*
Alfalfa	*2*	*9*	*42*	*100*	*100*
Timothy(Grass)	*31*	*47*	*66*	*100*	*95*

Figure 4: Crop Yields relative to pH [6]

VI. PROCEDURE

It is an Arduino project for a soil moisture sensor that will light up LEDs at certain moisture levels along with the pH sensor. Both resistance and pH values are displayed on LCD. It uses Arduino UNO controller board [7]. Arduino accepts values from soil moisture sensor and pH sensor as resistance and milli voltage.

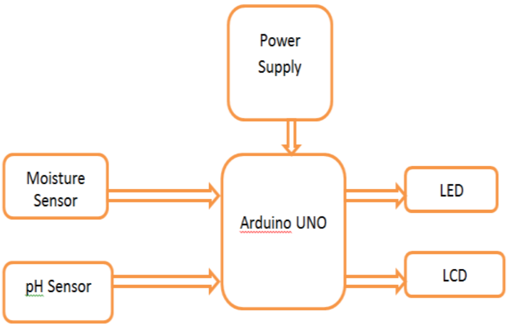


Figure 5: Block Diagram

VII. PROPOSED METHOD

Same sample of soil is examined by changing the amount of water. Different values of resistance and pH is tabulated and displayed on LCD along with understanding conductivity using LEDs.

3 zones of conductivity are considered.

- First zone is dry zone and is indicated by red LED on PCB.
- Second zone is medium zone and is indicated by green LED on PCB.
- Third zone is wet zone and is indicated by white LED on PCB.

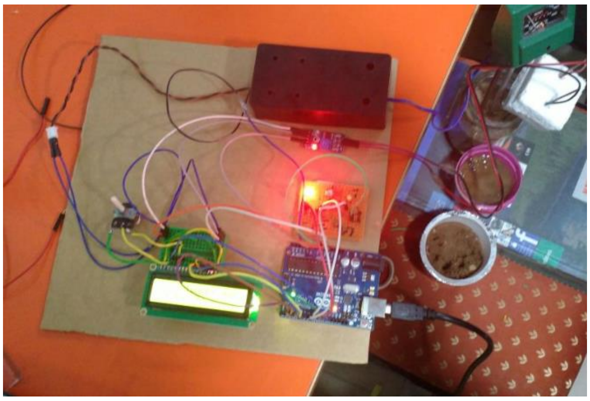


Figure 6: Setup for measuring soil moisture and pH of a sample

By this method, we can understand the zone under which a sample of soil is coming and its requirements for good cultivation.

VIII. RESULTS

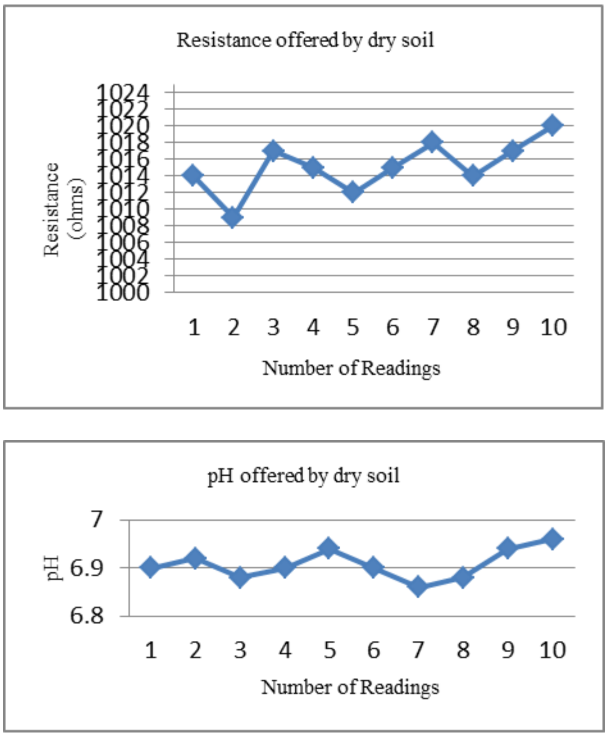


Figure 7: Resistance and pH of dry soil

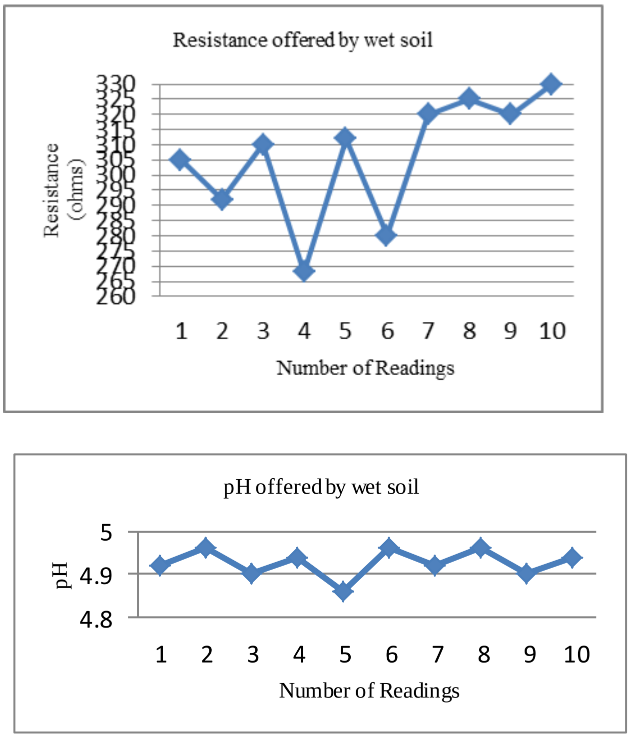
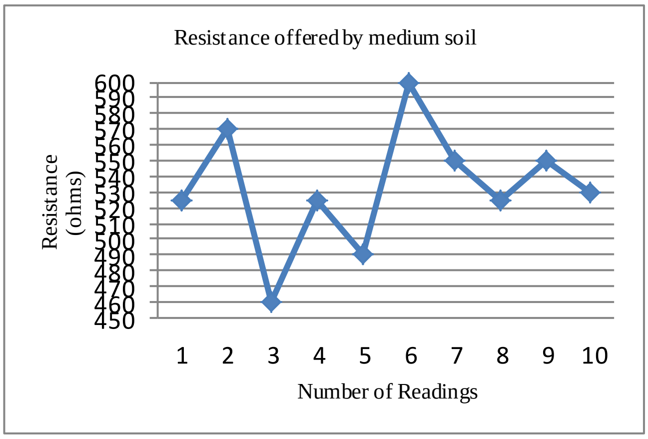


Figure 8: Resistance and pH of wet soil



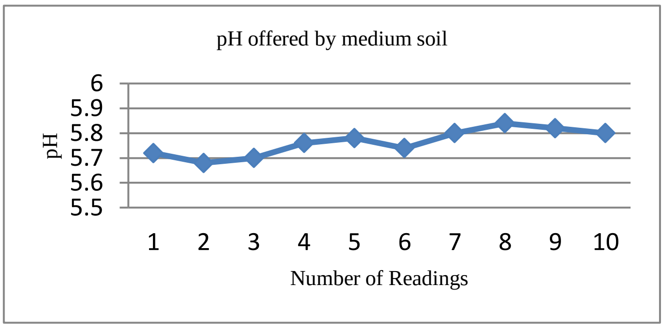


Figure 9: Resistance and pH of medium soil

IX. APPLICATIONS

- Soil pH is used to adjust the acidity where there are no toxins in soil and the availability of nutrients are at its maximum for good cultivation.
- With pH, farmers can have a good understanding about the nutrient availability and about the crops that can be cultivated in the corresponding pH values.
- Moisture sensor can be used as an alert system when moisture level falls outside a suitable zone for irrigation. When a soil moisture sensor is connected to an irrigation clock which will convert it into a smart irrigation controller that prevents an irrigation cycle when the soil is wet.
- Soil moisture sensors are helpful in sport turfs especially for golfs.

X. CONCLUSION

Resistance values of dry soil are more than the resistance of wet soil because conductivity of soil increases with wet soil due to increase in movement of ions. Similarly, pH values of dry soil is more than the wet soil. Six sensors can be simultaneously used to improve reading accuracy using Arduino UNO which has six analog input ports. Our method is simple in procedure which makes it significant when compared to other methods.

XI. INFERENCES

- From the readings, an empirical relationship between soil resistance and soil pH can be established such that soil resistance and soil pH varies proportionally.
- Nutrients are highest and toxins are lowest at 5.5 – 7 pH.
- Crops that are suitable for cultivation in 5.5-7 pH range are Corn, Wheat, Barley, Oats, Tomato, Radish, Beetroot, Beans, Watermelon, Potato, Soybeans etc.
- Nutrients rich in 5.5 – 7 pH are Copper(Cu), Zinc (Zn), Boron (B), Manganese (Mn), Iron (Fe), Molybdenum (Mo) ,Potassium (K), Nitrogen (N), Phosphorous (P).
- For dry, wet and medium soil, farmers can predict the pH range as well as can predict both the nutrient availability and crops for cultivation.

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