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Soil Nutrient Identification Using Arduino

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ABSTRACT

Continuous cropping without the adequate measurement and provisioning of the soil nutrient may endanger the sustainability of the agriculture. Soil nutrient measurement is greatly required for proper plant growth and effective fertilization. A key in soil testing for formulated fertilization is to determine the amount of soil nutrients, followed by recommendation of the nutrient needs and site specific fertilization. Nitrogen, Phosphorus and Potassium are the three important nutrients required for the plant growth. In the present work electrochemical sensor has been developed to determine the N, P, K and other types of nutrients present in the soil. The electrochemical sensor is based on the principle of absorption of ions from the aqueous solution of soil. Here the sensor along with the Arduino Microcontroller circuits is built to detect the deficient component of the soil.

Keywords: Nitrogen (N), Phosphorus (P), Potassium (K), Electrochemical sensor, Arduino microcontroller and Nutrients.

1. INTRODUCTION

Production of crop depends on the interaction between soil and plant properties. Maximization of production of crops is reflected by biological, physical, chemical condition of the soil. Root absorbs required amount of nutrients and water from the soil where biochemical reactions takes place. Plant rate of nutrient absorption depends on the minerals available in the soil. Production of crops degrades with the insufficient rate of supply of any necessary nutrients. Although the requirement of particular nutrient is determined by the plant in the soil, some of the nutrients are necessary for all the plants in great amount known as Macro moles or Macronutrients. Root environment of the plant can be changed by supplying the nutrient from outside the soil is known as fertilization.

However proper distribution of fertilizer is required for proper crop production. Over and under provisioning of the fertilizer can greatly reduce the harvest production rate. Traditional fertilization system in Bangladesh relies on farmers experience in cultivation and weather condition. This type of manual fertilization without proper justification of soil condition is error prone. To fulfill the increasing demand of growing population over years there is a need of increasing food production. Improper use of fertilizers in turn results into poor quality in fruits, vegetable lagging in size, taste, quality, quantity.

Quantity of NPK is dependent on crop type and on plant growth status. How much quantity of fertilizer to be used is further dependent on present contents of NPK nutrients in the soil. Since the macronutrients vary even on small scale throughout the cultivated field, numerous researchers have attempted to develop the sensor to map these nutrient contents. To get the correct amount of nutrients to be provided and to choose the right crop for multiple cropping in the same land, we need to measure the actual amount of nutrients present in the soil. For achieving the sustainable agriculture maintaining and for minimizing any country's economic losses and environmental impacts, proper management of essential soil nutrients play a vital role. Technology plays an expedient role for improvement of environment and for achieving the economic goals.

2. EXISTING SYSTEM

The 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.

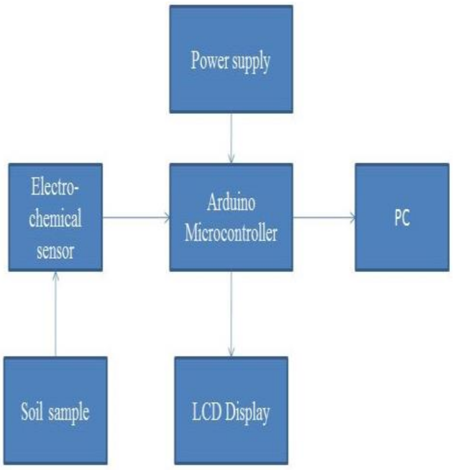
The principle of optical NPK fiber is based on the interaction between incident light and the soil surface properties, such that the reflected light vary due to the soil physical and chemical properties. This sensor works on the colorimetric principle, which deals with the measurement of colored intensity. 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 subtractor.

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. Results are not accurate and it requires more time.

3. PROPOSED SYSTEM

In this system we demonstrate an automatic electrochemical sensor system for continuous nutrient determination. The flow-through electrochemical sensor system with two electrode system work based on flow injection analysis (FIA) technique for detecting the nutrients. The primary aim of this system to develop a sensitive and reliable electrochemical sensor system for monitoring the nutrients in soil sample for long-term applications.

3.1 Block Diagram



4. BLOCK DIAGRAM DESCRIPTION

The soil nutrient identification system consists of electrochemical sensor, arduino microcontroller, serial port, cable connector, regulated power supply, soil sample, LCD display and PC.

4.1 Electrochemical Sensor

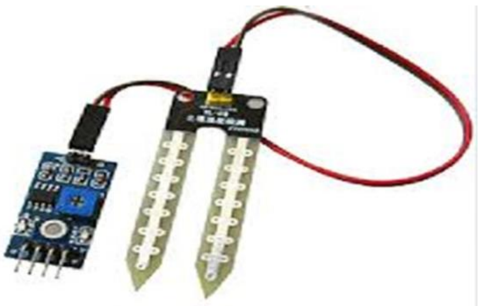


Figure 4.1 Electrochemical sensor

The electrochemical sensor consists of two electrodes which responds to targeted ion and transforms the reactions to detectable electrical signals. Ion Selective Electrode (ISE) and Ion Selective Field Effect Transistor (ISFET) are the two types of commonly used potentiometric electrochemical sensor for soil nutrient detection. Here ISEs is not suitable for real-time sensing applications because of their time delay (several minutes). An electrochemical sensor consists of a diffusion barrier, a sensing electrode and a counter electrode. In an environment free of chemically reactive gases, oxygen diffuses into the cell and adsorbs on both electrode. The result is a stable potential between the two in which the little current flows. The cell chemical process at this point,

$$O_2 + 2H_2O + 4e^- \dashrightarrow 4OH^-$$

Oxygen enters through the sensor through the capillary where it comes in contact with the cathode and it immediately reduced to hydroxyl ions. This type of electrochemical sensor is based on ISFET technology. The electrochemical sensor have the potential to be produced in batches to very small size by using MEMS-based micro fabrication technology at low costs. Besides, small sized sensors require small volume of reagent and samples, which can also reduce the cost in soil testing.

4.2 Ion Selective Field Effect Transistor

ISFET is the integration of ISE and field effect transistor (FET). The ion selective membrane is placed on top of the insulation layer of FET structure, so the threshold voltage of ISFET can be chemically modulated and the measured voltage is related to concentration of the targeted ion. ISFETs have several advantages over ISEs, such as small dimensions, low output impedance, high signal to noise ratio, fast response and the ability to integrate multi-ISFETs on one chip. This type tends to detect not only N, P, K but also other nutrients such as ammonium (NH_4), manganese, cobalt, sulphur, iron, calcium etc.

4.3 Arduino UNO Microcontroller

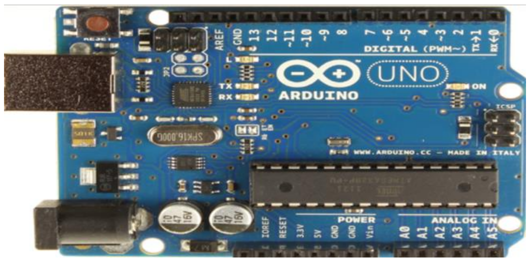


Figure: Arduino Uno Microcontroller

Arduino is an open source computer hardware that designs and manufactures microcontroller based kits for building digital devices and interactive objects that can sense and control objects in physical world. These system provides sets of digital analog I/O pins, serial communication interfaces, USB port for loading programs from the personal computer. For programming the microcontrollers, it provides an integrated development environment (IDE) based on processing project which support for C, C++, Java programming languages. The main features includes Atmega 328, 32 KB of flash memory of which 0.5 KB used by bootloader, 2KB of SRAM, 1KB of EEPROM, 16MHz clock speed, ICSP header, power jack, 6 analog I/O pins, 14 digital I/O pins, 6 pulse width modulation output pins, input voltage is 7-12v and its operating voltage is 5v.

5. CIRCUIT DESCRIPTION

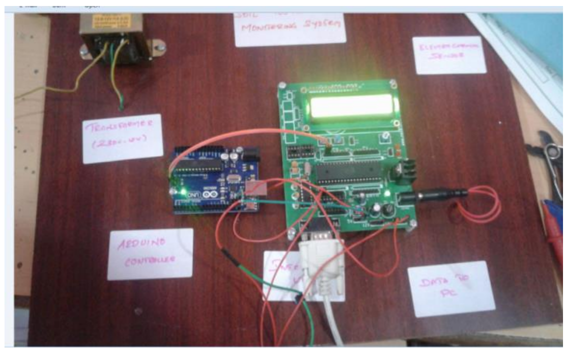


Figure: Circuit Design

Here the electrochemical sensor is connected to the analog input port of arduino controller board and the LCD module is connected to arduino output port. The electrochemical sensor with two electrode is dipped into soil sample, where the soil sample is taken as little wet dry matter. The power supply is ON, where current passes through the circuit. When the current passes through the electrode, oxygen diffuses into the cell and absorbs by both electrode. The arduino get the analog input signal from the electrochemical sensor, where the sensor senses the nutrient present given soil sample and the signal sends to the arduino. Then the flow injection analysis (FIA) will be carried out inside the arduino. It will be programmed using arduino communication software. After programming, it will be compiled and converted to the machine language. Then this code file will be dumped to the arduino board. Finally the FIA analysis will be carried inside arduino controller and the output will be displayed in the LCD and PC through the serial communication.

6. EXPERIMENTAL RESULTS

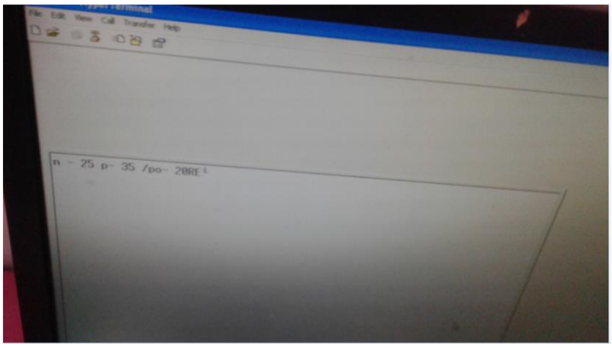


Figure: Output

The output displayed through the PC shows the nutrient present in the soil sample. This shows the accurate percentage value of the nutrients in the soil. The displayed nutrients not only shows the nutrients present in the soil but also in the dissolved water or aqueous solution.

7. 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. Electrochemical sensor rapidly responds to targeted ions in minutes, suitable for in-field rapid detection. The advantages of potentiometric electrochemical sensors are stimulating the interest of applications in soil nutrient detection. They have potential for automated multi-targeted rapid detection of soil nutrients. Advanced engineering technologies have opened our mind and provided new approaches for soil testing to follow the KISS (Keep It Simple and Stupid) principle to treat the complex soil testing procedures with simpler methodology at a lower cost.

REFERENCES

[1] C. M. A. Brett and A. M. Oliveira Brett, Electrochemistry, Principles, Methods and Applications. Chap. 10, *Oxford University Press, Oxford* (1993).

[2] M. L. Stablen, J. W. Ellsworth , D. M. Sullivan, D. Horneck, B. D. Brown, R. G. Stevens, "Monitoring Soil Nutrients Using Management Unit Approach", in *PNW 570-E,* October 2012.

[3] Carrie A. M. Laboski and John B. Peters, "Nutrient Application Guidelines for Field, Vegetable, Fruits and Crops in Wincosin" *(A2809),* 2013.

[4] N. V. Hue, R. Uchida, M. C. Ho, "Sampling and Analysis of Plants and Soil Tissues, How to take representative samples, How the samples are tested", *in Plant Nutrient Management in Hawaii soils, Approaches for Tropical and Sub-tropical Agriculture,* 2014.

[5] C. Jones and J. Jacobsen, "Plant Nutrition and Soil Fertility", *in Nutrient Management Modules,* No. 2, 2014.

[6] A Survey on Soil Testing, http://www.vegetablegardener.com/item/2374/soil-testing-savvy", *Accessed on 15th May 2015.*