Measurement of Potassium Levels in the Soil using Embedded System based Soil Analyzer

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Abstract: Potassium is important to the plants for metabolic changes during flowering, and the production of floral clusters. It also promotes general plant-vigor, disease-resistance, and study growth. Hence, in this paper the concentration of potassium ion in aqueous soil samples of Anantapur area is analyzed. Combination of ISE and reference electrode is used to determine the ion activities of potassium ion in aqueous soil samples. This method is very simple and fast when compared with the other methods. The soil samples tested with the embedded system based soil analyzer.

***Keywords: ESBSA (Embedded System Based Soil Analyzer); ISEs** (Ion Selective Electrodes);*

Introduction: The main objective of this research is to develop "EMBEDDED BASED SOIL ANALYZER" which is used to analyze the Potassium levels present in the soil. As Agriculture is one of the most important occupations in INDIA, it is very much essential to know the nutrients present in the soil for a suitable crop. However, in every district only one or two organizations are there for the testing of soil. To increase this facility, adding today's technology towards agricultural fields, a cost effective soil-testing instrument is developed. In this paper the measurement of Potassium levels present in the soil is demonstrated with the help of ESBSA.

Figure.1 consists of two sensors (i.e. temperature, and potassium) which are connected to ADC MCP3208. The main function of analog to digital converter is to convert analog values into digital values. The output of ADC is given to Rabbit Processor (Rabbit 3000). The main reason for using Rabbit Processor is for its excellent feature of inbuilt TCP/IP. The measured data is represented in the form of web pages, using HTML and the processing of data using Dynamic C functions. The Rabbit is created as web server and is connected to PC by using Ethernet cross cable (RJ45). Then the Rabbit processor and the PC are in LAN (Local Area Network). Here data is accessed through Rabbit processor, webpage can be viewed on PC, and hence, we can access physical data through LAN.

Fig.1. Measurement Of Potassium using Embedded system based Soil Analyzer

This experiment is to develop and implement an embedded system based soil analyzer, which is an internet based measurement system for analysis of different parameters. In this paper the estimation of Potassium present in the soil sample is explained. The ESBSA is connected to local computer via Ethernet port using RJ45 Ethernet cable. Then internet is provided to the local PC, Apache Web Server Software is used to configure the PC and made the local PC as Web Server. Using this software proxy pass and proxy reverse operations are provided to have online communication. Now the local system is ready to communicate the information online. Therefore, with the ESBSA, measured and calibrated data can be accessed globally.

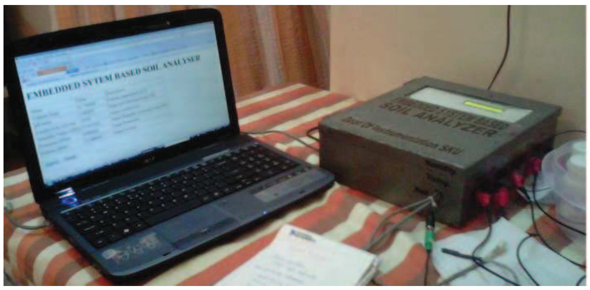

Fig:2 Local PC interfaced with ESBSA

Potassium in Soil Sample measurement technique:

- Prepare two standard concentrations C1 and C2 of the sample potassium.First, dip the Potassium and reference electrodes in the more dilute standard solution of concentration C1 and note down the reading E1 mV. Then rinse both electrodes with double distilled water blot dry with a soft tissue paper. Now dip the electrodes in more concentrated standard of concentration C2, and note the stable reading E2 mV.
- Now immerse the electrodes in the sample and note down the potential reading Ex mV.
  Now sample concentration Cx can be calculated from the equation.
  $Cx = C2 / \text{anti-log}(\Delta/S)$.
  Where $\Delta = E2 - E1$, S = Slope of the electrode.

The Potassium Ion-Selective Electrode has a solid-state PVC polymer matrix membrane which is designed for the detection of potassium ions **(K^+)** in aqueous solutions and is suitable for both field and laboratory applications. The Potassium Ion is a monovalent action. One mole of
(**K+**) has a mass of 39.098grams; 1000 ppm is 0.026 M.

Sample Preparation

After removing any stones or fresh organic material (roots, twigs, leaves, worms, insects etc), and breaking up any large lumps, soil samples must be air dried by laying out in a thin layer on metal or plastic trays in a current of air at no more than 30℃ until dry. Then they must be crushed in a pestle and mortar to pass through a 2mm sieve. About 200g of material should be sufficient for duplicate analysis and storage.

Weigh accurately about 50g of dry soil sample and add exactly 100ml of de-ionized water and shake vigorously for 30 seconds to ensure good dispersion, then leave to stand for 15 mins. After this time, shake again for 5 seconds, and allow to stand again. Repeat this procedure three times before finally allowing to settle. When the solution is clear, take exactly 50 mls (by decanting or pipetting) and mix with 1 ml of buffer solution in a plastic beaker.

Procedure for determining the concentration of POTASSIUM (K^+) in SOILS

Water-soluble Potassium is extracted from dried soil samples by dispersion in de-ionized water and analyzed by direct potentiometer.

FIG 3: Potassium Sensor electrode and reference electrode are immersed in 10^{-3} M buffer solution

Calibration

Before soil sample measurement, the electrodes must be calibrated by measuring a series of known standard solutions, made by serial dilution of the 1000ppm standard solution. For a full calibration, prepare 100ml of solutions containing 1000, 100, 10, 1, and 0.1ppm K. If the approximate range of concentrations of the samples is known, and this is within the specified linear range of the ISE, then it is only necessary to make two solutions which span this range: e.g. if samples are known to lie between, say, 30 and 130ppm then we could use standards of 10 and 200ppm or even 20 and 150ppm.2 ml of buffer solution must be added to each 100ml standard and mixed thoroughly to compensate for different activity coefficients between samples and standards.

Sample Measurement

Briefly, it is important to note that the electrodes must be washed and dried between each sample, to avoid cross contamination, and sufficient time must be allowed (2 or 3 minutes), before taking a reading after immersion, to permit the electrode signal to reach a stable value. For the highest precision, frequent recalibration is recommended (see operating instructions).

The results will be displayed as ppm and mol/l in the solution. Since buffer solution has been added equally to standards and samples, these figures will not need adjusting for this addition. However, the concentration in the solution (in ppm = micrograms per ml) must be multiplied by 100 and divided by the sample weight to give the concentration in the soil (in micrograms per gram).

Temperature Compensation:

The ISE (POTASSIUM) is a temperature dependent one. Hence, in this research a temperature compensated Potassium measurement system is developed. LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4℃ at room temperature and ±3⁄4℃ over a full −55 to +150℃ temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies.

Hardware Description:

1. Here, we use rabbit-3000 processor along with RCM-3700 development kit.

2. The RCM-3700 has 40 pins out of which we use 7 pins from port-B and 6 pins from port-A for our application.

3. The 4 pins of port-B are configured as input and output pins, 6 pins of port-A are configured for LCD Display.

4. In which PB-5 is used for clock, PB-7 for D-out, PB-4 for D-in, PB-2 for chip select, PA-4, PA-5, PA-6, PA-7 are used for data transfer, PA-0 for R/W, PA-1 for Enabling the LCD.

5. 40th pin is connected to VCC (+5v) and pins 19 and 20 are connected to ground.

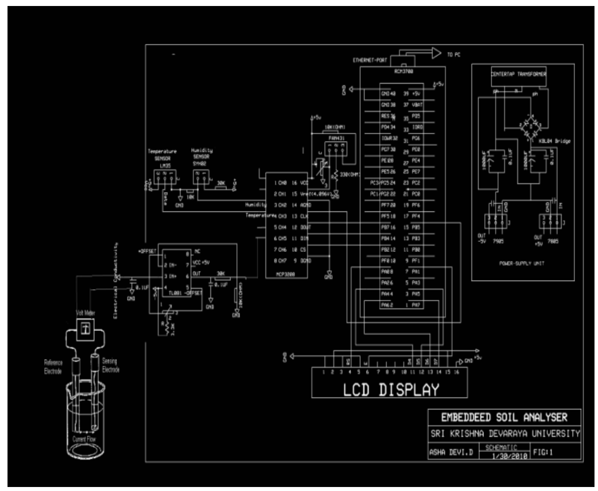

Fig.4: Schematic Diagram of Embedded Soil Analyzer

6. LCD INTERFACE:

1, 3, 5, 16th pins are connected to ground;

2,15th pins are connected to 5volts;

4th pin (RS) is connected to PA-0, 6th pin (E) is connected to PA-1, and 11, 12, 13, 14th pins are connected to PA-4, 5, 6, 7 pins for data transferring.

7. In MCP3208, ch-0,1,2,4,5 & 7(not used) Temperature sensor-ch-3, Potassium sensor – ch-5

8. As written in the software, when input changes the corresponding output is changed and output display is refreshed.

9. Here when enable button is active, it is indicated in Ethernet cable by blinking of light.

10. If we want to end the process, enable is disabled or connection is removed.

11.Appache Web Server software is used to configure the local PC as a server.

12.LCD display is used for standalone results.

Results:

S.no.	Soil samples	Measurement @ Anantapur Soil office	Present study M/ppm
1	6364	20.98	21.33
2	6365	19.42	19.45
3	6366	45.36	45.34
4	6367	23.38	23.14
5	6368	24.48	24.56

Table .1: Potassium levels measured in soil samples

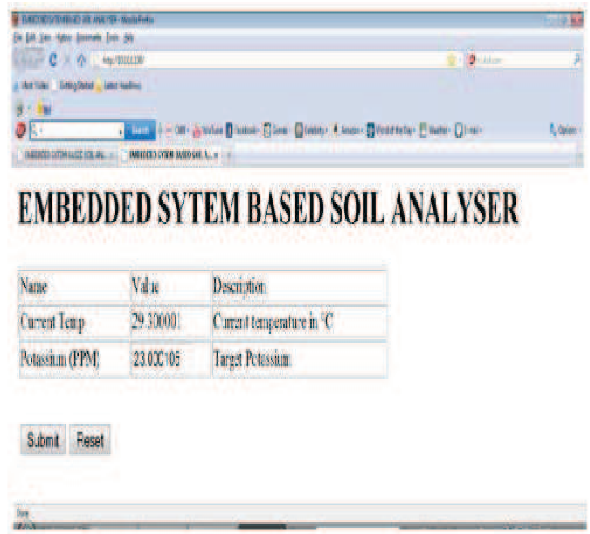

Fig: 5: On line measurement of potassium sample

Conclusion:

By Using "EMBEDD SYSTEM BASED SOIL ANALYSER", we measure Potassium levels present in the soil at respective temperature and humidity using ION SELECTIVE ELECTRODES.

Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. It helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. Potassium is supplied to plants by soil minerals, organic materials, and fertilizer.

From the study of potassium ion content in soils, collected from literature values and soil office readings, soils which are having less than 150 Kg/Hectare K2O is poor in potassium deposits. When it is between 150-250 Kg/Hectare K2O of soils are having medium levels of potassium. Finally, the soils, with greater than 250 Kg/Hectare K2O deposits, considered to have sufficient potassium deposits.

This system is connected to RABBIT Processor, which has special feature of built in TCP/IP, by which we can upload the data to the Internet. This device is more economical, reliable, and portable. Using this instrument, farmers can access the data through Net from remote area. By this, farmer can evaluate the soil nutrients present in the soil and can analyze the amount of nutrients present in the soil and lack of percentage of nutrients to be added for a specific crop by using predefined data provided. A farmer can have the suggestions from soil analysts or agricultural scientists through Internet, so that he can improve the crop yields in an efficient manner.

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