

Embedded Instrumentation Based Soil Sodium Measurement System

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Abstract: The chief characteristic of sodic soils from the agriculture study point is that contain sufficient exchangeable sodium to adversely affect the growth of most crop plants. For the purpose of definition sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15.

In the present study used a combination of ISE and reference electrode is used to determine the ion activities of sodium in aqueous soil examples. This method is very simple and fast when compared to the other methods. The soil samples test with the embedded instrumentation based soil analyser.

Key words: sodic, soil, crop, exchangeable sodium percentage, soil analyser, ion selective electrode.

I. Introduction

The activity of ions will be determined by means of ion selective electrodes. In very dilute solutions the activity corresponds approximately to the concentration of the respective ion.

The main objective of this research is to develop embedded instrumentation based soil sodium analyser which is used to analyse the sodium levels in the soil. Agriculture is one of the most important occupation in India, it is very much essential to know the nutrients present in the soil for a suitable crop. However in every district there are only one or two organizations for soil testing. To increase this facility using today's technology towards agriculture fields a embedded instrumentation based soil sodium measurement system was developed.

II. Theory

Under field conditions after an irrigation or rainfall sodic soils typically have convex surfaces. The soil a few centimeters below the surface may be saturated with water while at the same time the surface is dry and hard. Upon dehydration cracks 1-2 cm across and several centimeters deep form and close and wetted. The cracks generally appears at the same place on the surface each time the soil dries unless it has been disturbed mechanically.

The principal cause of alkaline reaction of soils is the hydrolysis of either the exchangeable cations or of such salts as CaCO₃, MgCO₃, and NaCO₃ etc. as below.



As show in above reaction exchangeable cations (Na⁺², K⁺²) did not combine with OH⁻ and these are hydrolysed easily due to its less tightly held ions which results in increased pH.



From the above reaction CaCO₃ with water results in weakly ionized carbonic acid and free hydroxyl ions. CaCO₃ and MgCO₃ do not hydrolyse more due to their low solubility's which results in pH not higher than about 8.0 to 8.2. But whereas Na₂CO₃ gives pH more than 8.2 and reaches nearly 10.0 to 10.5 due to its higher solubility.

Sodium Ion Selective Electrode

Many recent developments in analytical measurements are based on methods utilizing ion selective electrodes. In many applications ion selective electrode methods are being substituted for existing analytical methods with resulting increasing in efficiency and simplicity of measurement.

Ion selective electrodes are classified by the type of ion selective membrane used in their construction and by the ion for which they are selective. The membrane in a solid state electrode is a thin section of an inorganic crystal. Liquid ion exchange membranes consist of an inert porous plastic substrate which is saturated with a water immiscible organic solvent containing an inorganic salt of the ion be measured. A glass membrane is a thin section of glass which is formulated to be responsive to the ion of interest. Sodium ion selective electrode is shown in fig 1.



Figure 1: Sodium Ion selective combination electrode

The response of electrode i.e potential developed is a function of the ionic activity of a species solution. When the activity increases the electrode potential becomes more positive if the electrode sensing a cation more negative if the electrode sensing an anion. The behaviour of the electrode potential is determine by the Nernst equation.

$$E = E_a + 2.3 RT/nF \log a$$

Where	E	is the measured total potential of the system.
	E_a	is the portion of the total potential due to choice of reference electrodes and internal solution
	R	is universal gas constant ($8.314 \text{ J.K}^{-1}.\text{mol}^{-1}$)
	F	is Faradays constant (96458 c.mol^{-1})
	n	is the charge on the ion
	T	is the temperature in kelvin
	A	is the activity of the ion in the sample solution

For a tenfold change in ionic activity the electrode potential changes. If the ion being measured is monovalent is 59.2 mV. If the ion being measured is divalent potential is 29.6 mV. The electrode slope may be slightly less than the theoretical which may lead to measurement errors if compensation is not provided.

Sodium Measurement System

The block diagram of the sodium measurement system is shown in fig 2. The slope of the electrode will be in the range of 50 mV to 60 mV. This voltage is amplified by a amplifier and digitized by an Analog to Digital converter. The digital signals are transferred to PC/Laptop using a microcontroller. A program written in computer display the corresponding sodium values. Computerizations of measurements have lot of advantages. These measurements can be used to control process parameters in production of chemicals, fertilizers and food production.

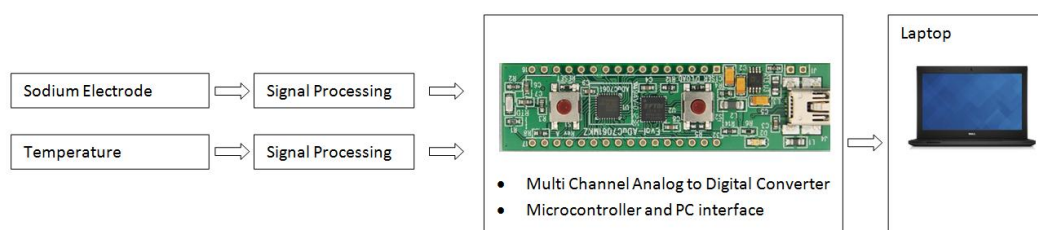
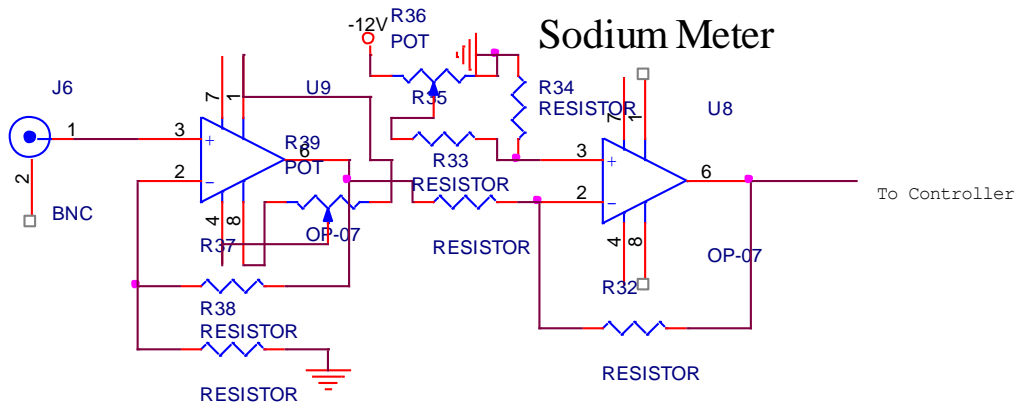


Figure 2: Sodium Measurement Block Diagram



Preparation of the Standard Solutions:

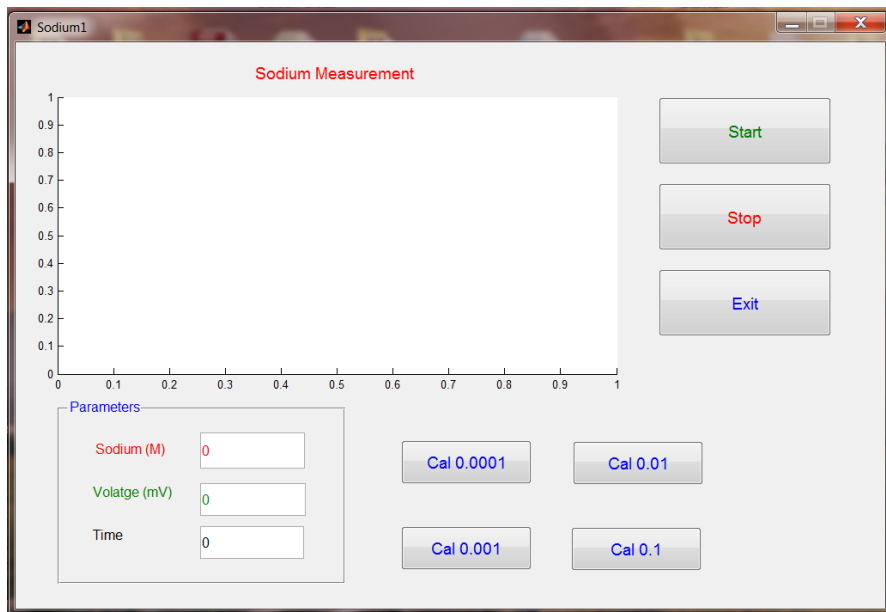
To prepare the standard solutions, primarily, make a stock solution of 0.1M NaCl that is prepared by dissolving 584.4 milli grams of sodium chloride salt in 100ml of distilled water. To prepare 0.01M NaCl solution, take 10ml of 0.1M NaCl solution and dilute it to 100ml of distilled water. For 0.001M NaCl solution take 10ml of 0.01M NaCl solution and dilute it to 100ml with distilled water. Similarly, for 0.0001M NaCl solution take 10ml of 0.001M NaCl solution and dilute it to 100ml with distilled water.

Calibration Procedure:

For ready use, the electrode is conditioned in 0.1M NaCl solution. In the calibration process, the slope of the sodium electrode is calculated.

Slope is defined as the observed change in potential (mV) with a decade change in concentration. Obtaining the slope ensures good operation of the electrode. Slope measurement involves the following steps.

1. Connect sodium and reference electrodes.
2. Prepare the 0.1M and 0.01M standard solutions.
3. Clean the electrodes with double distilled water and blot them dry.
4. Dip the electrodes in 0.01M NaCl solution. When reading is stable, press the button CAL 0.01M on the GUI.
5. Wipe the electrodes with tissue paper and drip in 0.1M solution. When reading is stable, press the button CAL 0.1M on the GUI.
6. The difference between the above two mV readings is the slope of the electrode measurement which must be in the range of +53 to +59mV. The slope and offset values are stored inside the PC. Now the system is ready for the measurement of sodium concentration in the range 0.01M to 0.1M.



III. Results

S.No	Standard Solutions Concentration in M	Concentration in ppm	Present Study ppm	Flame Photometer ppm
1	0.0001	2.290	2.360	2.10
2	0.001	22.99	23.92	22.10
3	0.01	229.9	232.02	231.00
4	0.1	2299	2302.21	2301.00

IV. Conclusion

By using “Instrumentation based soil analyser”, we measure Sodium levels at respective ELECTRODE.

This system is connected to PIC Microcontroller, which has special feature of built in Analog to Digital converter. This device is more economical, reliable, and portable. Using this instrument, farmers can measure conductivity manually or in real time with regular intervals. Real time monitoring is important, where the electrode is fitted in the drip irrigation system, where we can monitor the sodium of the fluids pumped in the drip irrigation channels. Using this system farmer can evaluate the soil 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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