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Communications

Development of a Simple Conductivity Meter to Test Soil Electrical Conductivity at the Field Level

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Soil salinity is one of the most common problems in agricultural fields. Saline soils reduce crop yield. The most common method for testing soil salinity is the test of Electrical Conductivity (EC) of a given soil solution by using a soil conductivity meter. Many farmers are unaware of their soil salinity because soil testing facilities are not available at the field level in Sri Lanka. Therefore, the requirement for a simple conductivity meter that can be used in the field is high. Thus, in this study, the aim is to develop a simple soil electrical conductivity meter by using a D400 transistor, 50K volume control, and an LED. The developed simple soil electrical conductivity meter was calibrated using standard KCl solutions with conductivities of 0.2 ms/m and 0.4 ms/m respectively. Finally, the EC of eighteen soil samples around Sri Lanka was tested using a laboratory soil conductivity meter (Spectrum Tech. ECTestr 11+) and the developed simple conductivity meter. Our results indicate that this simple conductivity meter works well with Sri Lankan soil and could be promoted among farmers to test and increase awareness about soil salinity.

Soil is the most important factor in agriculture and provides structural support for plants as well as their source of water and nutrients. It is important to frequently analyze soil quality parameters to increase crop production and sustainability. Soil salinity is defined as the high concentration of soluble salts in the soil, including Na^{+}, Ca^{2+}, and Mg^{2+}. The high salinity of the soil reduces crop yield by 20% - 50% [1]. Salt accumulation can occur in the root zone and this leads to reduced plant growth, reduced yield, and in severe cases crop failure. [2]

Electrical conductivity (EC) is the measure of a material's capacity to accommodate the transport of an electric charge. Soil salinity is assessed by measuring the electrical conductivity of the 1:5 soil-water suspension [3]. Soil is considered saline soil when it exceeds 0.4 mS / m [1]. Many factors such as temperature, fertilizer use, salinity, irrigation, and temperature affect soil conductivity. Also, it is an excellent indicator of nutrient uptake and loss, soil texture, and available water capacity.

High salinity in the soil solution affects nutrient and water uptake by plants because the high salt concentration in the soil solution reduces the plant's ability to take up water. Moreover, the high electrical conductivity of the soil solution or nutrient solution is usually an indication of a high concentration of specific ions that may be toxic to the plant. The measurement of soil electrical conductivity in the agricultural field can be done by different types of sensors based on different electrical and magnetic phenomena. They can be classified as electrical resistivity (ER), electromagnetic induction (EMI), and reflectometry. [4]

In Sri Lanka, there are only a few soil testing laboratories established island-wide. They do not have enough manpower and capacity to analyze samples from all farm fields in Sri Lanka and farmers have to wait for three to four weeks to get the soil test results [5]. The use of soil test kits is a better alternative for reducing time and costly laboratory tests. However, many test kits do not include a conductivity meter. Therefore, a more reliable and simple soil conductivity meter is required for testing soil conductivity at the field level. Thus, in this study, we developed a simple conductivity meter to test the soil conductivity of eighteen soil samples around Sri Lanka. All results were compared with the appropriate laboratory tests and the accuracy of this method was also evaluated.
A simple conductivity meter was developed using a D400 transistor and a 50KΩ variable resistor [See Figures 1 and 2]. Here a transistor is used to amplify the current and all the devices cost around 300 LKR. The conductivity probe was made using a plastic tube and two stainless steel electrodes.

Figure 1: The circuit design of the developed simple conductivity meter

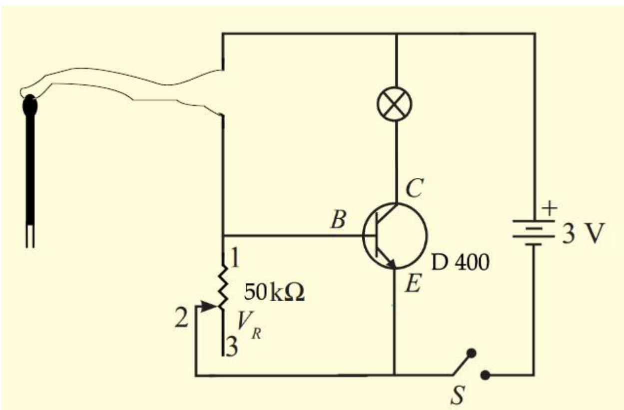
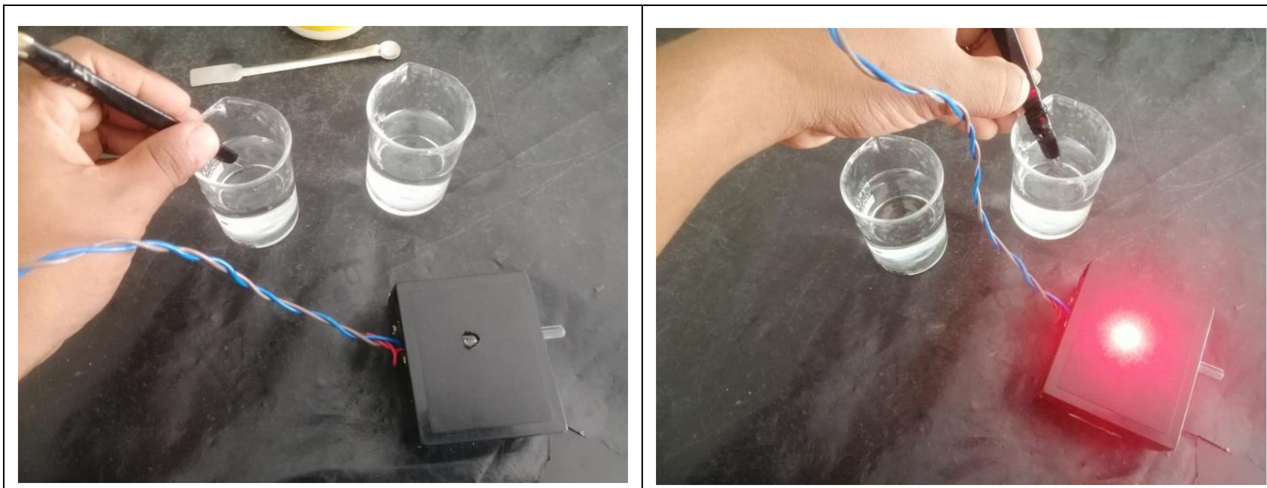


Figure 2: Circuit diagram of the Conductivity meter

When using the conductivity meter prob should immersed in standard KCl solution with EC of 0.2 ms /m, the 50KΩ variable resistor should be rotated to one side until the LED turns off. The reason is that no current is passing through the transistor at that time. After that, when

the probe is immersed in standard KCl solution with EC of 0.4 ms /m, enough current is passed through the solution and the transistor turns on. so that the LED lights up.
Two KCl solutions with different EC values (0.20 ms/m and 0.40 ms/m) were prepared. Then the probe was immersed in a standard KCl solution with EC of 0.2 ms /m, and the variable resistor was tuned until the LED bulb was turned off [see Figure 3a]. Then the probe was washed with deionized water and wiped, and it was dipped in the KCl solution with EC of 0.4 ms/m. The LED was lit at this time [see Figure 3b].



a　　b

Figure 3: EC meter in the KCl solution with EC of 0.2 ms / m (a) and with EC of 0.4 ms / m (b)

Eighteen soil samples around Sri Lanka that were received from the Rice Research and Development Institute, Bathalagoda, Sri Lanka were prepared to test soil conductivity. To test each soil sample, 10 g of soil sample was mixed with 50.0 cm^3 of deionized water (1:5 soil-water suspension) and shaken for 30 minutes in a mechanical shaker.
Then the soil-water suspension was tested for EC using both the developed simple EC meter and a laboratory conductivity meter (Spectrum Tech. ECTestr 11+). All the samples were tested three times.
Results for the conductivity readings of eighteen soil samples using the simple conductivity meter developed and the laboratory conductivity meter are shown in table 1.

Table 1 - conductivity meter readings for soils around Sri Lanka in both methods (Developed Simple EC Meter and Spectrum Tech. ECTestr 11+ soil EC meter).

Sample No:	Area	Conductivity meter reading (ms/m)	Observation of the LED (Lighten up or not)	Conclusion (EC high or low)
1	Mannar	0.11 ± 0.01	×	low
2	Madhu	0.06 ± 0.01	×	low
3	Puttalam	0.63 ± 0.01	√	high
4	Trinkomalee	0.18 ± 0.017	×	low
5	Kanthale	0.11 ± 0.02	×	low
6	Kilinochchi	0.04 ± 0.01	×	low
7	Mulathivu	0.43± 0.26	√	high

8	Paranthan	0.02± 0.01	×	low
9	Kaluthara	0.01± 0.00	×	low
10	Anuradhapura	0.12 ± 0.017	×	low
11	Kurunegala	0.23± 0.017	×	low
12	Ambalanthota	0.19± 0.017	×	low
13	Hambanthota	0.37± 0.01	√	high
14	Aranaganvila	0.05± 0.00	×	low
15	Badulla	0.13± 0.017	×	low
16	Rathnapura	0.78± 0.01	√	high
17	Ampara	0.08± 0.017	×	low
18	Kandy	0.44± 0.026	√	high

We have observed that this simple EC meter works well with all the soil samples that were collected and tested around Sri Lanka. Due to the low production cost and easy use, the simple conductivity meter devised in this work show potential in popularizing among farmers to use simple conductivity meter themselves and test their soil salinity on their own. The working range of the conductivity meter can be adjusted easily by changing the conductivities of the standard solutions. Also, standard solutions should be provided with this equipment and they should be instructed to calibrate it every time they use it. After identifying the saline soil by using the conductivity meter, the farmers should also be advised on the appropriate soil treatments. Promoting this simple soil testing conductivity meter will provide farmers to test and avoid soil salinity to increase crop production in Sri Lanka.

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