DETERMINATION OF SOME PHYSICAL PROPERTIES AND ELECTRICAL CONDUCTIVITY OF LOAMY SOIL WITH ADDITIVES.

ABSTRACT

In this study, the electrical conductivity and physical properties of loamy soil samples is determined. The electrical conductivity meter was used to obtain the electrical conductivity and some standard methods have been adopted to obtain other properties. It is observed that the soil combined with NPK had the highest electrical conductivity with the least coming from the soil (control). It is concluded that NPK raises the electrical conductivity of the soil. This goes forth to show a measure of the amount of salts in soil (salinity of soil), which is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide. It is recommended that soil with organic manure should be used in order to maintain low salinity and good soil health.

Keywords: Denitrification, Nitrification, Nitrogen Oxides Saline/Sodic Soil, Electrical Conductivity (EC), Soil Organic Carbon Content (OC).

1. INTRODUCTION

Soil data is used for the assessment of land condition, modelling soil function. Primary threats to soil function include soil salinization and decreasing levels of soil organic matter content [1].

Soil salinity is a major physico-chemical constraint in environments typical of the south-west Pacific region, with an impact on yields at the farm scale and the regional scale [2-3].

The decline in soil organic matter content (and carbon) in Australia has been considerable and is due to land clearance, removal of native vegetation and implementation of conventional cropping practices[4-5]. The impacts, however, of current farming systems and management practices on organic matter distribution are not as clearly distinguished as climatic and soil differences [6-7]. While there have been recent efforts to understand the nature of key factors influencing the distribution of organic carbon content across Australia [8], there are still significant gaps in contemporary soil information on the decline in soil organic matter. Likewise, accurate assessments of soils affected by salinization are problematic owing to this dearth of soil data and information [1].

Soil organic carbon content and soil electrical conductivity are properties fundamental to these types of assessments. There has been considerable effort in the last decade to conserve and make available soil profile data for future applications [9].

Studies to date have shown that broad environmental influences such as climate, landform and parent material over variable time frames are key factors in explaining the distribution and occurrence of soil properties, including electrical conductivity (EC) and soil organic carbon content (OC).

Soil EC is a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide. Excess salts hinder plant growth by affecting the soil-water balance. Soils containing excess salts occur naturally in arid and semiarid climates. Salt levels can increase as a result of cropping, irrigation, and land management. Although EC does not provide a direct measurement of specific ions or salt compounds, it has been correlated to concentrations of nitrates, potassium, sodium, chloride, sulfate, and ammonia. For certain non-saline soils, determining EC can be a convenient and economical way to estimate the amount of nitrogen (N) available for plant growth.

There have been lots of researches bothering on the electrical conductivity measurement of soil via some measurement techniques. For instance, [10] proposed an empirical relationship (the Archie's law) based on laboratory measurements of clean sand stone samples. Nevertheless, the Archie's law is only suitable for saturated rock or sandy soil. [11 - 12] observed through laboratory tests that the electrical resistivity of soils decreases when water content increases. The structures, i.e. the void distribution, geometry of pores, connectivity, and porosity, determine the proportion of air to water according to the water potential. [13] linked resistivity variations with the structure of pedological materials, identifying that the high and low resistivity values were related to macro- and meso-porosity, respectively. Temperature can excite and change the viscosity of a fluid and thereafter influence the electrical conductivity [14]. By conducting laboratory experiments on 30 samples of saline and alkaline soils, [14] showed that conductivity increased by 2.02% per ◦C (in the range of 15–35◦C). However, the studies on problematic unsaturated soils such as expansive soil, lateritic soil, and loess, are rarely reported. Lateritic soil is widely distributed in several south western provinces of China such as Hunan, Guizhou, Yunnan, and Guangxi. Lateritic soil is usually considered as a good natural foundation and building material. However, the lateritic soil has many unfavorable properties, such as shrinkage, cracks, water sensitivity and uneven distribution. Thus, usage of lateritic soil as a building material leads to various challenging issues in constructions of highway and high speed railway in these southwestern provinces in China. In those projects, the crack depth, water content and distribution are approximately obtained by borehole surveying, exploration holes, trenching exploration, and pit test. These geotechnical investigations involved extensive workload, time-consuming and low effect. Electrical conductivity experiment offers an attractive tool for describing the subsurface properties without digging, and thus much time and effort can be saved.

Examining of soil water content which is probably the most easily identified soil property is an essential matter for agricultural arrangement. Information about water content in near-surface soil is vital for estimating land atmospheric interaction, water balance, infiltration, and deep percolation or recharge. The information acquired from surveying is crucial for optimizing crop yields, accomplishing high irrigation efficiencies, minimizing lost yield due to salinization and waterlogging, and planning irrigation scheduling. Soil electrical conductivity is a function of clay content, water content and salinity [17].

Lately unparalleled attention has been given to the study of the salinity content of the soil in various arid regions of the world via artificial intelligence and other technique [16–21]. However, to the best of our knowledge, no study in the literature had tackled the electrical conductivity of loamy soil with various organic and inorganic manures, which are often used to improve agricultural yields by farmers.

This paper is organized as follows. Section 2, we present the materials used to carry out the research and the method adopted. In section 3, we displayed the results obtained and in section 4, we discuss the results obtained from section 3. In section 5, the research is concluded with a highlight of our findings.

2. MATERIALS AND METHODS

2.1. Materials

Plates, bowls or small containers, Table spoon, 100-mL graduated cylinder, stirring rod slightly longer than graduated cylinder, manure (organic and inorganic), and loamy soil, Drying oven, Dryers, pH meter with glass electrodes, Thermometer, Glass beaker (100 ml), Glass rod, Digital conductivity meter, Conductivity cell, Glass beaker (100 ml) and Glass rod.

2.2. Methods

2.2.1 Determination of the Porosity

Standard test is with manure, soil and a mixture of these (1/1 by volume). Of course, other soils and mixtures may be added.

Fill the graduated cylinder about half full with the sample. Tap the cylinder firmly with your fingers several times to settle the sample. Record the *'Volume of packed sample'*. Pour the sample out and save it to use. Fill the graduated cylinder to the 70-mL level with water. Slowly add the sample from the saved sample. Stir with rod to break up clumps, then let stand for 5 minutes to allow bubbles to escape. Record the final *'Volume of sample/water mixture'*.

Calculate the volume of solids in your tested samples:

$$Volume\,of\;solids\left(mL\right)=Volume\,of\;sample\,/\,water\,mixture-70mL\,water \tag{1.1}$$

Calculate the total pore space volume:

$$Volume\,of\;pore\,space\left(mL\right)=Volume\,of\;packed\,sample-Volume\,of\;solids\left(mL\right) \tag{1.2}$$

Determine the porosity:

$$Porosity\,of\;sample=\frac{Volume\,of\;pore\,sample\left(mL\right)\times100\%}{Volume\,of\;packed\,sample\left(mL\right)} \tag{1.3}$$

Compare the porosity of manure, soil and manure-soil mixture (and optional other types of soil, with and without compost added).

2.2.2 Moisture Content.

5-10g of previously grounded sample was weighed out. The sample was placed in drying oven at 105^0C for at least 12hrs. The sample was allowed to in the dryer. The sample was reweighed with precaution not to expose it to the atmosphere. The moisture content is calculated as follows:

$$Moisture\,content\,(\%) = 100\frac{(B-A)-(C-A)}{(B-A)} \tag{1.4}$$

where:

A= weight of clean, dry scale pan(g)
B= weight of scale pan + wet sample(g)
C= weight of scale pan + dry sample(g)

2.2.3 Determination of specific gravity

An empty specific gravity (SG) bottle was weighed and weight recorded as W_1. The empty SG bottle was filled to the mark with distilled water and weighed W_2. The SG bottle was washed, dried and allowed to cool. It was filled to the mark with the oil sample and weight noted as W_3.

$$Specfic\,gravity = \frac{W_3 - W_1}{W_2 - W_1} \tag{1.5}$$

2.2.4 Determination of Ph

Weigh 20 gm of the sample into a beaker. Add 50 ml of distilled water and stir with a glass rod thoroughly for about 5 minutes and keep for half an hour. In the meantime turn the pH meter ON, allow it to warm up for 15 minutes. Standardize the glass electrode using standard buffer of pH = 7 and calibrate with the buffer pH = 4 or pH = 9.2. Dip the electrodes in the beakers containing the sample water suspension with constant stirring. While recording pH, switch the pH meter to pH reading, wait 30 seconds and record th pH value to the nearest 0.1 unit. Put the pH meter in standby mode immediately after recording. Remove the electrodes from sample suspension and clean the electrodes with distilled water. Rinse the electrodes after each determination and carefully blot them dry with filter paper before the next determination. Standardize the glass electrodes after every 10. Dip the electrodes in distilled water, when not in use and ensure that the reference electrode always contains saturated potassium chloride solution in contact with solid potassium chloride crystals. Three to four drops of toluene are added in standard buffer solutions to prevent growth of mould.

2.2.5 Measurement of Electrical Conductivity (EC) in Soil

Calibrate the conductivity cell with the help of standard KCL solution and determine the cell constant. The soil water suspension of 20 gm: 50 ml ratio prepared for the determination of pH can also be used for conductivity measurements. After recording the pH, allow the soil water suspension in the beaker to settle for additional half an hour (the total intermittently shaking period is 1 hr.) After the calibration dip the conductivity cell in the supernatant liquid of the soil water suspension. Read the conductivity of test solution in proper conductance range, Remove the cell from soil suspension, clean with distilled water and dip into a beaker of distilled water. EC is expressed as dS.m–1. Dip the conductivity cell in distilled water when not in use. Record the temperature of soil water suspension during the test.

3. RESULTS

In this study, the electrical and physical properties of various samples have been obtained. Table 1 shows the numerical values of these properties and Figs. (1-5) shows the comparative bar chart of the various properties.

Table 1: Electrical conductivities and Physical parameters of the soil samples

Sample	pH	Electrical Conductivity (µS/cm)	Moisture Content (%)	Porosity (%)	Density (g/ml)
Soil (Control)	6.6	25.8	22.5	75.8	0.631
Soil + NPK	6.6	480.9	28.3	82.9	1.193
Soil + Poultry dung	7.4	116.6	34.5	80.4	0.567
Soil + Cow dung	7.5	386.6	44.9	67.8	1.458
Soil + Urea	7.3	35.7	45.2	75.2	1.553

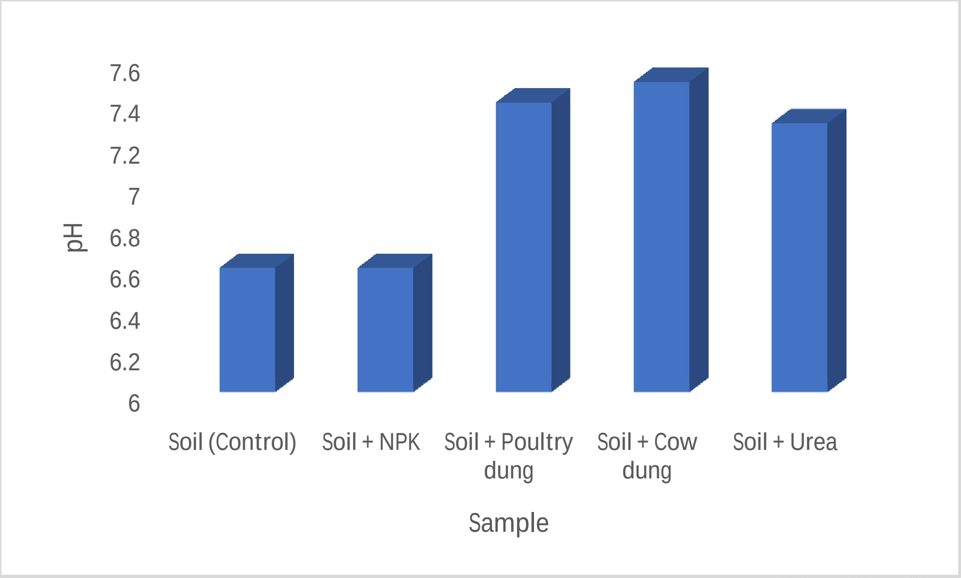

Figure 1: pH of samples.

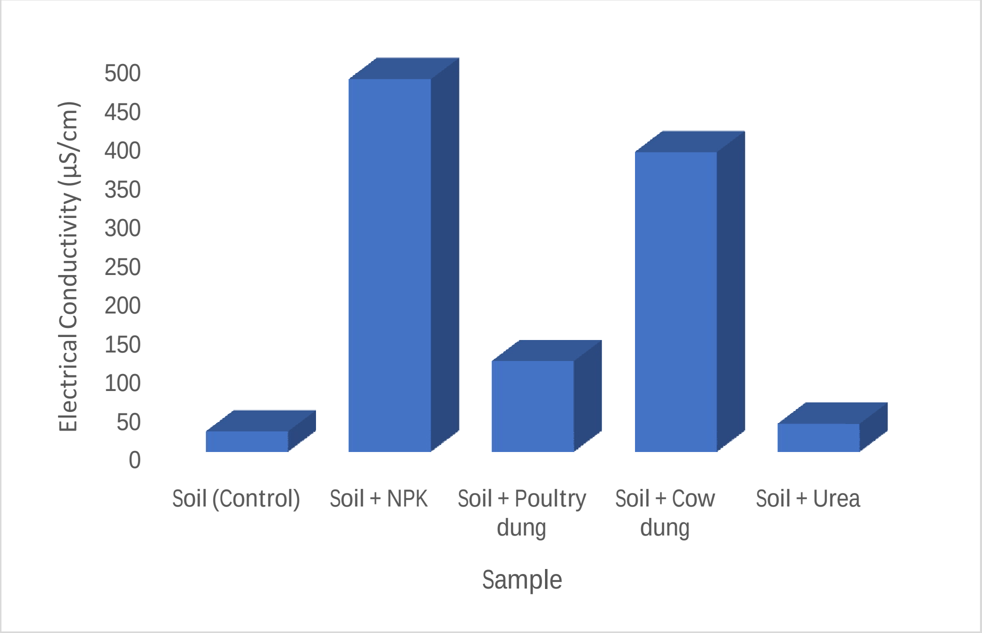

Figure 2: Electrical Conductivity of samples

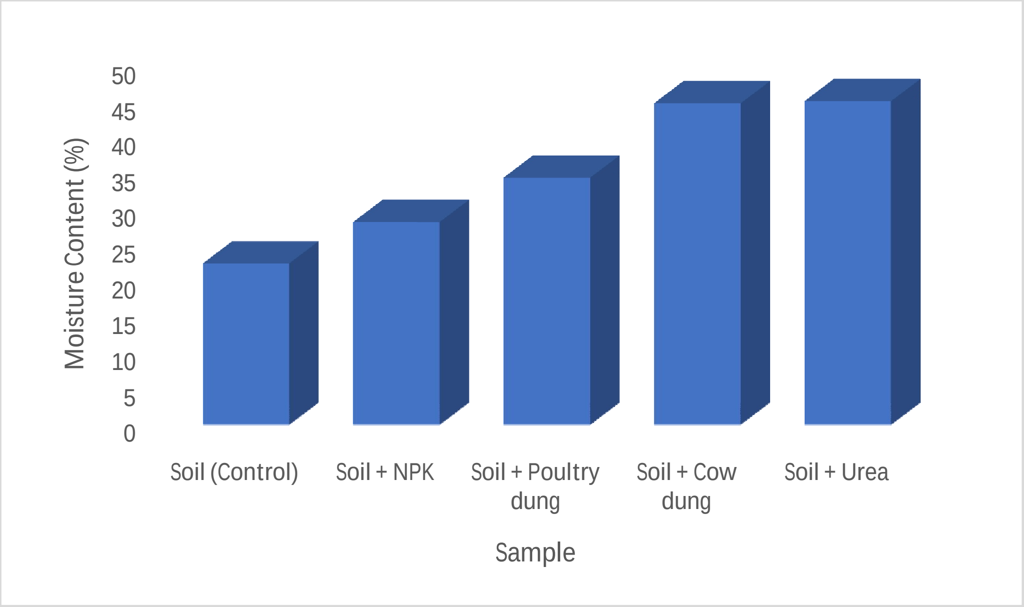

Figure 3: Moisture Content of samples

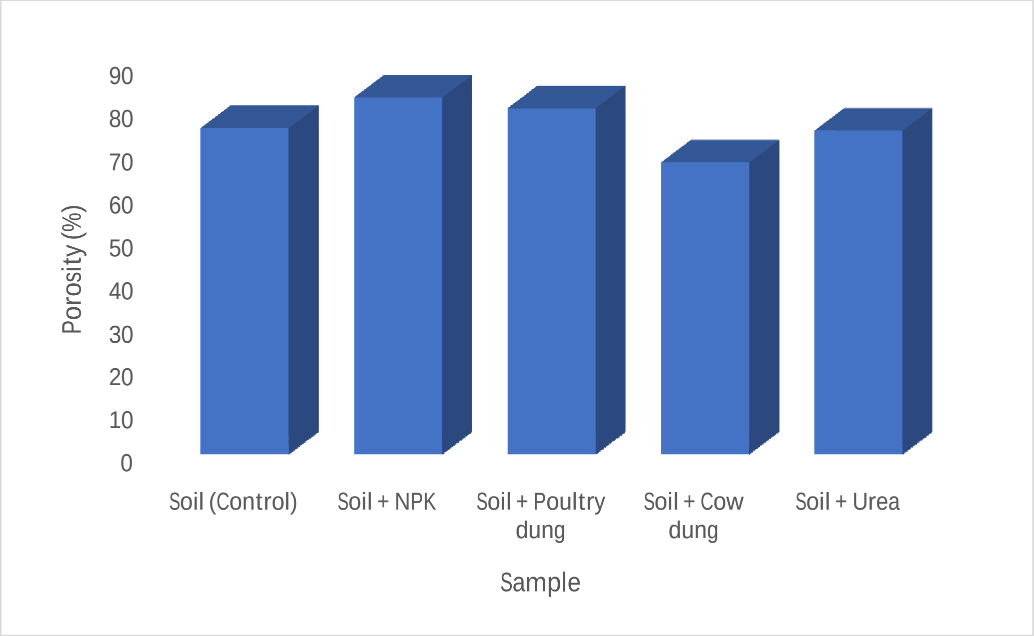

Figure 4: Porosity of samples

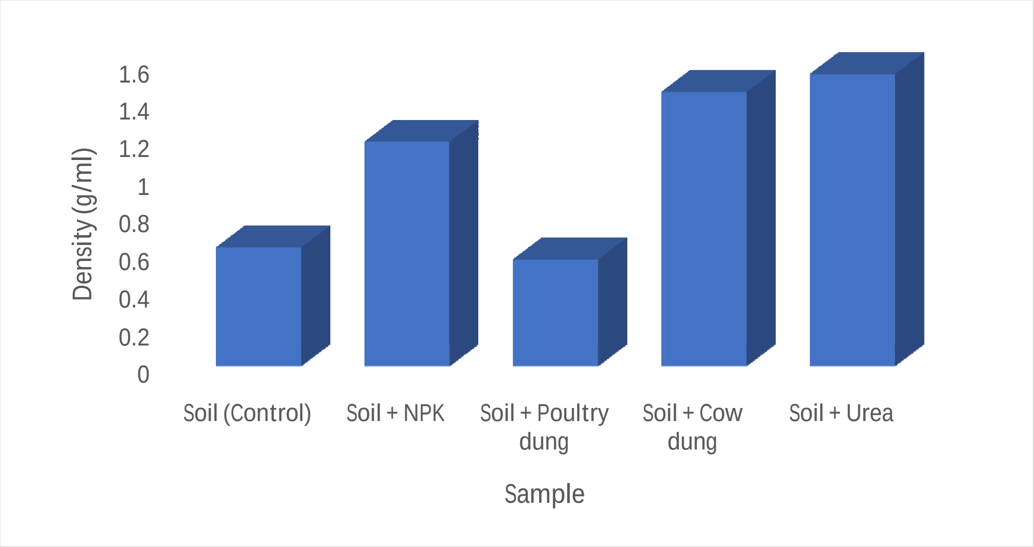

Figure 5: Soil Density of samples

4 Discussions

Fig 1 shows a bar chart of pH of the five samples. Comparatively, it seen that the Soil combined with Cowdung had highest pH followed by soil plus poultry droppings, soil plus urea , soil (control) and soil plus NPK in that order. Fig. 2 shows the bar chart of electrical conductivity for soil samples. The soil combined NPK had the highest electrical conductivity with Soil plus Cowdung coming next, followed by Soil plus poultry droppings, Soil plus urea and soil. Fig. 3 shows the Bar chart of Moisture content (%) for soil samples. The Soil combined with urea had the highest moisture content, followed by soil plus cowdung, soil plus poultry, soil plus NPK and soil (control) respectively. Fig. 4 shows the bar chart of porosity (%) of samples. The porosity of the soil samples was found to increase in the following order: soil plus NPK (highest), soil plus poultry, soil (control), soil plus urea and soil plus cow dung. Fig. 5 shows the bar chart soil density of samples. The sample with the highest density was found to be soil combined with urea, followed by; soil plus cowdung, soil plus NPK, soil (control) and soil plus poultry.

5. CONCLUSION

In this study, we determine the electrical conductivity, moisture content, density, pH and porosity of the loamy soil samples. Several methods have been used to obtain these properties. It is observed that the soil combined with NPK had the highest electrical conductivity with the least coming from the soil (control). It is concluded that NPK raises the electrical conductivity of the soil. This goes to show a measure of the amount of salts in soil (salinity of soil). It is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide.

List of Abbreviations

Electrical conductivity (EC)

Organic Carbon Content (OC)

Specific gravity (SG)

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