Moisture measurement and chemical analysis of three soil profiles in South Delhi, India

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Moisture content, organic carbon and nitrogen, available in the soil, are the most important elements that control plant growth. The present paper presents measurement of moisture content in three soil profiles located within the Jawaharlal Nehru University Campus, South Delhi, India. The organic carbon and nitrogen, available in these soil profiles were also analyzed by using standard techniques. An attempt has been made to correlate variations in the contents of moisture, organic carbon and nitrogen, obtained at various levels of the soil profiles, with the plant growth.

Key-words – Soil moisture, Organic carbon, Nitrogen in soil, Delhi, India.

INTRODUCTION

SOIL is a dynamic natural body developed as a result of pedogenic processes during and after weathering of rocks. It consists of mineral and organic constituents, possesses definite physical, chemical, mineralogical and biological properties, and has varying depths over the surface of the earth. It also provides a medium for the growth of land plants and is a primary resource on which the man depends for his existence.

Soil moisture is the basic component of hydrological and mineralogical cycles and plays a vital role in the functioning of ecosystem and in energy exchange processes occurring in the land-atmosphere interface. The knowledge of temporal and spatial variations in soil moisture is an important input to hydrological, agricultural and climatological management policies. Soil moisture determines the partitioning of heat and moisture and atmospheric forcing at the land surface boundary and helps in understanding global hydrological cycle and its effect on weather and climate. The water holding capacity of soil is controlled by its depth, texture, organic matter content, and mineralogical composition. Water plays a significant role in soil-plant growth relationship and constitutes major part of the plant itself. It is essential for physiological activities, e.g. as solvent for nutrient carrier, and for maintaining turgidity in plants. It therefore acts as a regulator of physical, chemical and biological activities in soil.

Soil organic matter is important in the maintenance and improvement of soil properties. However, only a small fraction of the total nutrient content of soil can be utilized by plants.

Over the past three decades, a number of studies have been carried out to determine the soil moisture (Hipp 1974, Narsimha Rao *et al.* 1990, Jackson 1990, Alex & Behari 1996).

The present paper presents an account of moisture measurement and estimation of organic carbon and nitrogen in three soil profiles located within the Jawaharlal Nehru University Campus, South Delhi, India and relationship of these with plant growth.

MATERIAL AND LOCATION OF SAMPLING SITES

Samples were collected from the following three sites :

Site 1: This site is located near Vatavaran in the Jawaharlal Nehru University (JNU) Campus, South Delhi, India. It is at a lower level than the surrounding area, hence always remains moist.

Site 2: This site is located in front of the Centre of Biotechnology, in JNU Campus. This site remains dry and has little vegetal cover.

Site 3: This site is located in the garden of the School of Environmental Sciences, JNU.

In order to cover a larger area, soil samples were collected randomly from three points at each site. Soil moisture profiles of each site were measured and chemical analysis of the soil samples was carried out.

METHODS

1. Soil moisture measurement

For the measurement of moisture in soil profiles, the fields were specially prepared. The surface was made plane so that it does not remain much compressed. In order to have an appreciable amount of moisture, the field was irrigated with enough amount of water and left for more than 24 hours so that the water may percolate down well and the natural conditions may prevail. The field was covered with plastic sheet to check evaporation.

Soil moisture measurement was done by Infra-Red Method. Small quantity of soil was taken from the experimental sites from different depths (e.g. 0.0 cm, 5.0 cm and 10.0 cm, etc.). A sophisticated instrument known as Sartorius Moisture Analyzer-MA 30 was used to remove moisture from the soil samples. Within 20 seconds, the soil became completely dry and the analyzer directly displayed the gravimetric moisture present in the soil.

2. Soil organic carbon measurement by Rapid Titration Method (Walkley & Black 1934)

The organic carbon in the soil got oxidized by potassium dichromate and concentrated sulphuric acid utilizing the heat of dilution of the latter. The excess potassium dichromate, not reduced by the organic matter of the soil, was determined by back titration with standard ferrous sulphate or ferrous ammonium dichromate.

Reactions:

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3O$$

$$C \text{ (Organic Carbon)} + 2O \rightarrow CO_2$$

$$2FeSO_4 + H_2SO_4 + O \rightarrow Fe_2(SO_4)_3 + H_2O$$

Reagents used in this experiment are : Standard 1N potassium dichromate (49.0 gm of this solution was dissolved in distilled water and volume made up to 1 litre); 0.5N ferrous ammonium sulphate (FAS, 196 gm of hydrated crystalline salt was dissolved in 1 litre of distilled water containing 20 ml of conc. H_2SO_4); Diphenylamine indicator (dissolved in a mixture of 20 ml of water and 100 ml of conc. H_2SO_4); Concentrated sulphuric acid containing 1.25% silver sulphate; and Ortho-phosphoric acid (85%) and/or sodium fluoride.

Procedure : 1.0 gm of soil was taken in dry 500 ml flask. 10 ml of 1N $K_2Cr_2O_7$ was pipetted in and swirled a little. Then 20 ml of H_2SO_4 was added and swirled again two or three times. The flask was allowed to stand for 30 minutes and then 200 ml water was added. 10 ml of phosphoric acid and/or 0.5 g sodium fluoride and 1 ml of diphenylamine indicator was added. The contents were titrated with 0.5N FAS solution till the colour changed from blue-violet to green. Simultaneously a blank is run without soil.

Considering the mass of soil taken = S gm; volume of 0.5N FAS required in blank titration = b ml; and volume of 0.5N FAS required in soil sample titration = c ml; the Percent organic carbon in soil sample will be equal to [10 x (b-c) x 0.003 x 100]/S.

3. Estimation of available nitrogen by Alkaline Permanganate Method (Subbiah & Asija 1956)

The soil was distilled with alkaline potassium permanganate solution which gave ammonia. This ammonia, determined volumetrically, served as an index of the available nitrogen status.

Reagents used in this experiment are : Potassium permanganate solution (0.32%); Sodium hydroxide (2.5%); Liquid paraffin; 0.02 N sulphuric acid (standardized); 2% boric acid solution containing 20 ml of mixed indicator (0.006 gm methyl red plus 0.099 gm bromocresol green dissolved in 100 ml of 95% alcohol) per litre.

Procedure : 20 gm of soil was taken in a 800 ml Kjeldahl flask. To this, 20 ml of water was added, followed by 100 ml each of 0.32% $KMnO_4$ and 2.5% NaOH solutions. The frothing during boiling was prevented by liquid paraffin (1 ml) and bumping by adding a few glass beads. The contents were distilled in Kjeldahl assembly at a steady rate and the liberated ammonia was collected in a conical flask (250 ml) containing 20 ml of boric acid solution (with mixed indicator). With the absorption of ammonia the pinkish colour turned to green. Nearly 100 ml of distillate was collected in about 30 minutes, which is titrated with 0.02N H_2SO_4 to the original shade. Blank correction (without soil) was made for the final calculation.

Considering calibrated normality of standard H_2SO_4 = N; Sample reading = a; Blank reading = b; Mass of sample (in gm) = S; 1 ml of 1N H_2SO_4 =14 mg of nitrogen; the ppm of Nitrogen will be equal to [(a-b) x N x 14 x 1000)/S]

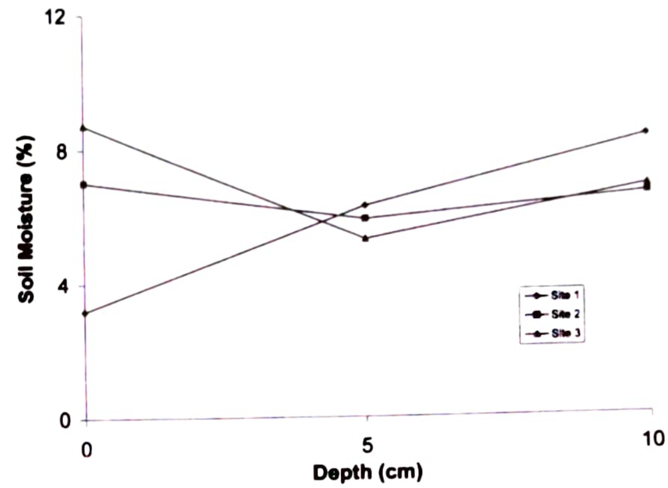
RESULT AND DISCUSSION

Moisture Profile : At Site 1, moisture increases with the depth whereas at Site 2 and 3, moisture first decreases and then increases. This is explained by the timing of the experiment, location of sites and climatic conditions. Sampling was done in February 2002, in the morning, when the temperature was low and rate of evaporation from the soil was also low. The rocky nature of the underneath soil at site 2 decreased its moisture content as most of the water percolated down. At site 3, the area was watered before sampling and hence, the amount of moisture in the surface soil was more than that underneath. The Infra-Red moisture analyzing method was applied as it gives quick and correct measurements. The moisture profile at various sites is shown in Table 1 and Text-fig. 1.

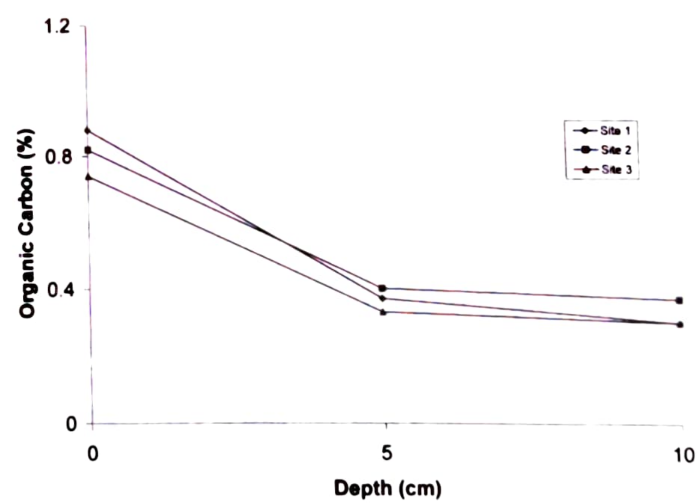
Table 1. Percentages of soil moisture, soil carbon and nitrogen concentration (ppm) in soil samples.

Depth of soil (cm)	Soil Moisture (%)			Soil Carbon (%)			Nitrogen Concentration (ppm)		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
0	3.18	7.01	8.72	0.88	0.82	0.74	114.23	111.41	96.63
5	6.25	5.86	5.27	0.37	0.40	0.33	83.63	87.74	56.16
10	8.30	6.59	6.81	0.30	0.37	0.30	83.97	70.44	54.08

Organic carbon analysis: It has been observed that the percentage of organic carbon decreases with the increase in depth at the three sites. Site 1 shows maximum organic carbon content because this is a well manured and irrigated land and supports good plant growth. Site 2 is also rich in organic carbon. Here the land is covered by grasses and small herbs which, when die, increase the organic carbon content of the soil and add to its fertility. Site 3 is poorest in organic carbon content as the land is bare and the plants are either in pots or are planted quite far from each other. The organic carbon content in the soil at the three sites is shown in Table 1 and Text-fig. 2.



Text-figure 1. Soil moisture in soil samples from three sites in JNU Campus, South Delhi.

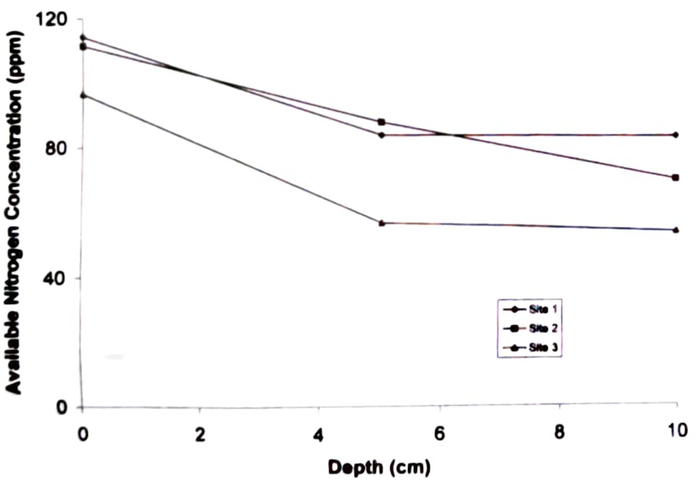


Text-figure 2. Soil carbon in soil samples from three sites in JNU Campus, South Delhi.

Organic carbon plays a very important role in improving physical conditions of the soil. It improves soil aggregation which influences infiltration, movement and retention of soil water, soil aeration, soil temperature, soil strength and root penetration. Higher water retention by soils owing to high organic carbon content is beneficial for water conservation and water use efficiency for crops. Generally, higher the organic matter content, the higher will be the microbial activity and the higher the availability of nutrients to crops.

Available Nitrogen : Site 1 shows maximum available nitrogen due to application of manures and nitrogen fertilizers to increase soil fetility and soil productivity. It is slightly lower at site 2 but higher than site 3, as this is a fallow land and the available nitrogen content in the soil is maintained by the natural processes of decay and decomposition. Site 3 has lowest nitrogen content.

Nitrogen is one of the most critical elements because it is frequently deficient in soil affecting plant growth. The reason is that plants cannot utilize atmospheric nitrogen in the gaseous state. For the nitrogen to be utilized by the plants, it must first be converted into some stable form. There is no good storehouse for available forms of nitrogen, except for the soil organic matter. Therefore, wherever there is more organic matter, there is more nitrogen available. This trend has been observed at all the three sites (Table 1; Text-fig. 3).



Text-figure 3. Nitrogen concentration (ppm) in soil samples from three sites in JNU Campus, South Delhi.

CONCLUSION

Soil moisture content is an important parameter that controls plant growth. It is related to soil texture, structure and the magnitude of physical forces like capillary action, cohesion and adhesion. Size and shape of mineral particles and number of pore spaces are important for the amount of water retained by the soil. Coarse textured sand with larger particles can hold water only loosely due to bigger pore spaces and therefore sandy soils are well drained. The water in such soils generally runs down rapidly reaching to deeper layers. Clayey soils, with higher proportion of colloidal fractions as humus, etc., can retain more water. Loams, a mixture of sand and silt and/or clay, are very fertilie and are considered best soils for plant growth. These are rich in nutrients, have proper aeration, and hold fairly large amount of water. Soil moisture of the soil is also affected by mineralogical contents of the soil.

Organic carbon of the soil supplies energy and nutrients for all forms of plant life. Nitrogen makes plants dark green and more succulent. It also makes cells larger with thinner cell walls.

For the formation of soil humus from organic materials, their C/N ratio is very important. During the decomposition of organic materials by soil organisms, mineralization and immobilization of carbon and nitrogen takes place. With the passage of time, the rate of mineralization of carbon almost equals nitrogen, resulting into near constancy of C/N ratio in the vicinity of 10 to 12. This is an indication of the formation of more or less stable products under the prevailing physical, chemical and microbial environment.

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