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Impact of Soil Moisture and Soil Temperature on the Physico-Chemical Property of Laterite Soil

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Abstract: In the present study an attempt has been made to understand the inter-relationship between soil moisture and in situ temperature of the soil and its impact on specific soil parameters. The data revealed that when there is rise in temperature, adequate moisture loss takes place. Due to loss in moisture there is soil drying which in turn may prevent seed germination. This inter-relationship also impacts on certain basic parameters like density, cationic and anionic generation etc. This study will provide a basic platform for understanding the role of soil moisture and soil temperature extensively.

Key words: Cationic and anionic generation, inter-relationship, soil parameters, atmospheric precipitation.

Introduction

Water, the major constituent of living organism, is also an important element for crop production. It helps in the maintenance of turgidity, absorption of nutrients and metabolic process of the plant (Mcguire et al., 2001; Boddy, 1983; Busse, 1995). Soil get water through atmospheric precipitation, condensed atmospheric precipitation, mist precipitation (horizontal) and ground water accruing at such depths from which water can pass through capillary rise into the soil stratum. Soil water movement is catalyzed through a potential difference between different points in a soil matrix as water moves from higher to lower potential. There are various parameters to initiate the water flow (Durbak, 1998; Davidson, 2000; Tian, 1999).

When fluid water is taken into consideration, it has two flows i.e. saturated flow and unsaturated flow; when all the pores in the soil get filled with water it is called saturated flow. These can be achieved either by heavy rainfall or due to irrigation. The direction of flow is from greater moisture potential to lower moisture potential. Water percolation depends on some vital factors such as soil texture, soil structure, temperature, organic matter and pressure.

In case of unsaturated flow, instead of water, some bores remained filled with air. Soil water movement is very slow in unsaturated condition (Melillo, 1995; Kayahara, 1996; Paustian, 1995). Water vapours also play a major role in determining the soil moisture. It is operated by the process of diffusion and mass flow; the diffusion is activated by vapour pressure differences with respect to temperature and concentration. There are various constants to explain soil moisture content. These are explained as follows: maximum water holding capacity of the soils which represents the percentage of moisture in the soil, during complete filling up of all the pore spaces. In terms of field capacity, it is the capability of the soil to retain water against the downward pull of the force of gravity. Here only the micro-pores are

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filled with water. The retaining atmospheric pressure is 0.33. The hygroscopic co-efficient is the percentage of moisture present in the soil in an atmosphere having 100 percent relative humidity. In terms of wilting coefficient, it is the percentage of moisture present in the soil at which the soil can't supply water to plants at sufficient rate to maintain their turgidity and the plants wilts permanently. Similarly, for transpiration ratio, water used to the quantity of dry matter produced (Batjes, 1996; Lal, 1995).

In addition, soil temperature is an essential parameter which affects the plant growth along with variation in its chemical and biological weathering. Soil temperature is the combined effect of solar radiation and the amount of radiant energy received from Sun i.e. conduction which arise due to the absorption of solar radiation in the surface soil and getting conducted down to the depth of soil and the biological and chemical reaction which when takes place some amount of energy gets released due to exothermicity. The major role of soil temperature is assigned to its effect on fertility of soil and plant growth, which generally influences the germination of seeds, plant growth, absorption of soil water, availability of the nutrients, soil microorganism and decomposition of soil organic matter, soil formation and physical properties of soil and plant diseases (Spears, 2003; Temnuhin, 1996; Vogt, 1995).

In the present study an attempt has been made to estimate the moisture content of the soil along with the soil temperature. The physical and chemical properties of soil keep on varying along with the change in soil moisture and soil temperature. In order to carry out the study, experimental analysis is carried out for soil samples collected in three different slots—pre-monsoon, monsoon and post monsoon—and the data obtained are incorporated to provide basic information for further studies.

Materials and Methods

In order to carry out the study, soil samples (lateritic soil) are collected with the following depth: Surface soil/Soil (from 1 ft depth)/Soil (from 2 ft depth)/Soil (from 5 ft depth). Samples are collected in three seasons: Pre-monsoon/Monsoon/Post monsoon.

The samples are analyzed in triplicate in order to confirm the data. The laterite soil is being collected from a geospatial area considered to be the control point of the city.

The analytical methods are listed below

Parameters to be studied
Soil moisture
Soil temperature
Chemical parameter study
Physical parameter
Method adapted
Gravimetric analysis method
Biometallic thermometer
Wet analysis and atomic absorption spectrophotometry
Standard method

Results and Discussion

The laterite samples are collected at different depth in different seasons. Samples are given the following codes.

Soil collection depth	*Code used*
Surface soil	S-1
Soil (from 1 ft depth)	S-2
Soil (from 2 ft depth)	S-3
Soil (from 5 ft depth)	S-4

Physical Parameters

The physical parameters of the soil samples are represented in Tables 1 (A) and 1 (B). The data are based on certain vital parametric changes with reference to seasonal changes i.e., Pre-monsoon, Monsoon and Post-monsoon. During analysis studies are being made to understand the correlation among various textural arrangements with seasonal changes. The temperature and moisture content of the soil samples are found to be of equal importance for change in internal spacing among the grains. The results revealed that temperature has impact of physical and chemical parameters of the soil.

Change in Soil Parameters with Reference to Soil Temperature

(A) Pre-monsoon Effect

With the seasonal variation, the data generated show a drastic change in the soil temperature. The results revealed various parametric effects as below:

Soil texture analysis: Depending on the increase in soil temperature, there is quite textural variation;

Table 1 (A): Physical parameters of the soil sample with reference to soil texture

	Soil samples	*Sand*	*Silt*	*Clay*	*Density*	*Soil colour*
Pre-monsoon	S – 1	42	50	8	1.3	Red
	S – 2	43	48	9	1.4	Dark red
	S – 3	45	47	8	1.4	Brown
	S – 4	42	48	10	1.6	Dark brown
Monsoon	S – 1	46	41	13	1.2	Red
	S – 2	45	42	13	1.2	Red
	S – 3	47	38	15	1.3	Dark red
	S – 4	48	37	15	1.4	Dark red
Post-monsoon	S – 1	50	30	20	1.1	Red
	S – 2	49	33	18	1.1	Dark red
	S – 3	49	32	19	1.2	Dark red
	S – 4	50	31	19	1.4	Brown

Table 1 (B): Physical parameters of the soil sample with reference to pore size

	Soil samples	*Structure*	*Pore space*	*Soil temperature*	*Soil moisture*
Pre-monsoon	S – 1	Single grained	Micro pore	38 °C	12%
	S – 2	Single grained	Micro pore	36 °C	14%
	S – 3	Plate like str.	Micro pore	37 °C	15%
	S – 4	Plate like str.	Micro pore	35 °C	16%
Monsoon	S – 1	Single grained	Micro pore	34 °C	23%
	S – 2	Plate like str.	Micro pore	32 °C	25%
	S – 3	Plate like str.	Macro pore	32 °C	25%
	S – 4	Plate like str.	Macro pore	30 °C	25%
Post-monsoon	S – 1	Single grained	Micro pore	29 °C	15%
	S – 2	Plate like str.	Macro pore	28 °C	18%
	S – 3	Plate like str.	Macro pore	28 °C	19%
	S – 4	Plate like str.	Micro pore	26°C	20%

when the temperature rise, clay concentrations slowly decrease with increase in sand concentration. In terms of silt there is no defined consistency on texture.

Soil density: Soil density increases gradually as we move towards inner surface. This may be attributed to the fact that with rise in temperature there may be gradual textural variation and pore size increment due to which when we move towards the outer surface there is gradual decrease in soil density.

Soil colour: Soil colour becomes deeper as we move towards the inner core, which probably is due to the gradual accumulation of magnesium silicate on the texture.

Soil reaction: In case of pre-monsoon season, the soil generally remains acidic in the surface and with the gradual increase in depth, it changes to neutral. Conversion from acidic to neutral may be attributed to the increase in moisture content.

Soil pH: pH of the soil keeps on increasing till neutralization with the rise in depth of the surface soil. This may be due to the gradual neutralization of the acidic medium in addition to moisture.

Nitrogen content: Nitrogen content of the soil remains almost constant during pre-monsoon season, present in the range of 0.02% to 0.03%. This may be attributed to the excessive moisture loss during summer and post summer season.

Potassium content: Potassium content of the soil varies between 0.6% and 0.8%.

Phosphorous content: Phosphorous content is found in the range of 0.01% to 0.02% which is comparatively low in concentration.

(B) Monsoon Effect

During monsoon, the soil gets heavily moisturized and there is also remarkable change in the soil temperature. Due to this, there is appreciable change in the soil parameters as discussed.

Soil texture analysis: It is observed that with the decrease in soil temperature sand and clay concentration gradually increase along with a decrease in silt concentration. With reference to silt content, the lower surface shows micro-pores and upper surface shows macro-pores.

Soil density: In monsoon season, there is a gradual rise in soil density as we move inside the soil texture from surface to a depth of 5^{th} towards the inner surface. Similarly, the pore size varies and shows a remarkable variation.

Soil colour: With the rise in water content in soil, there is an appreciable colour change in the soil sample from red to dark red, which is attributed to the leaching out of the major elements such as iron and other soluble oxides.

Soil reaction: During monsoon, the soil on the surface becomes neutral due to accumulation of water into the soil pores to leach out the acidic ions or dilution of the acid mediums. When the soil samples are taken from inner surface, it has been found to be alkaline in nature which may be attributed to the absorption of OH^- ion more and more on the soil matrix.

Soil pH: Due to increase in water concentration, the pH of the soil during monsoon remains neutral in the upper surface and gradually becomes alkaline. These changes in soil parameters are highly influenced by the soil temperature.

Nitrogen content: During monsoon with the accumulation of water, the nitrogen concentration gets enhanced appreciably and estimated in the range of 0.03% to 0.04%. This may be due to the presence of moisture, nitrogen mixing in soil gets enhanced.

Potassium content: The potassium content of the soil varies between 1.2% and 2.7%. This increase in potassium content is attributed to the increase in water content in the soil surface which could accumulate leached out potassium on the soil surface and consecutive layers.

Phosphorus content: The phosphorus content of the soil is found to be present in the range of 0.02% to 0.03% which shows a considerable improvement in phosphorus content in the monsoon season.

(C) Post Monsoon Effect

In post-monsoon season, the moisture content of the soil remains in a moderate concentration and accordingly there is variation in the soil temperature. Soil temperature and moisture combine to create parametric changes in the soil.

Soil texture analysis: In post monsoon season with further decrease in temperature the soil texture remains constant. As the soil texture remains constant, soil structure also appears to continue with micro-pores till the inner surfaces along with macro-pores on the surface only.

Soil density: With the change in season, there is decrease in the soil moisture and simultaneously there

Table 2: Chemical properties of the soil sample

	Soil reaction	*Soil pH*	*Nitrogen %*	*Potassium %*	*Phosphorus %*
Pre-monsoon					
S – 1	Acidity	6.3	0.02	0.6	0.01
S – 2	Acidity	6.7	0.02	0.6	0.01
S – 3	Neutrality	6.9	0.02	0.8	0.02
S – 4	Neutrality	7.0	0.03	0.8	0.02
Monsoon					
S – 1	Neutrality	7.0	0.03	1.2	0.02
S – 2	Neutrality	7.0	0.03	1.8	0.03
S – 3	Alkalinity	7.1	0.03	2.2	0.03
S – 4	Alkalinity	7.1	0.04	2.7	0.03
Post-monsoon					
S – 1	Neutrality	7.2	0.03	2.7	0.03
S – 2	Alkalinity	7.8	0.03	2.9	0.04
S – 3	Alkalinity	7.9	0.04	3.4	0.04
S – 4	Alkalinity	8.3	0.05	3.9	0.04

is gradual decrease in density in the upper layer and gradual increase in soil density.

Soil colour: During post monsoon season, the soil colour appears red in the upper layer and as we go down towards the lower layer colour becomes darker and slowly turns brown.

Soil reaction: In post monsoon season, the soil changes its property from neutral to alkaline. This is mostly attributed to the fact that during monsoon huge salts get absorbed on soil surface which, with due evaporation of moisture, gradually increase in concentration and there to rise in the alkalinity of the soil.

Soil pH: In terms of soil pH, it increases to a higher alkalinity with the increase in depth of surface soil. This is attributed to the accumulation of more salts into the soil which in turn enhance the alkalinity of soil.

Nitrogen content: Nitrogen content of the soil keeps on increasing with rise in depth of the surface soil. It has been observed that when the alkalinity increases the nitrogen content of the soil gradually increases i.e. when pH was 7.2, nitrogen percentage was 0.03% and when pH becomes 8.3 nitrogen becomes 0.05%.

Potassium content: Similar trend, like nitrogen, is being observed for potassium as well. When pH is 7.2 the potassium content is 7.2% which varies up to 3.9 at pH of 8.3. This variation is also related to the absorption of more nutrient in the soil in rainy and post rainy season.

Phosphorus content: Change in soil reactivity and pH has not much impact on the phosphorus content of the soil. There is only some nominal variation in percentage of phosphorus which implies pH rise or fall has no significant effect on phosphorus absorption.

Conclusion

The above study revealed that seasonal variation with soil moisture content and soil temperature difference has considerable impact on soil parameter variation. Out of NPK value of the soil nitrogen and potassium content are significantly affected with temperature and moisture variation whereas the nutrient phosphorus remain unaffected. Similarly, in case of soil density, as we go inside the surface zone, density keeps on increasing. Soil texture along with structure keep on changing from macro to micro-pores with gradual variation in percentage composition of sand, silt and clay.

Soil colour becomes darker as we move towards the inner depth of the soil surface. Depending on the water percolation in the soil, its reaction and pH varies consistently. This experiment concludes that soil moisture and soil temperature are two major parameters which affect the physico-chemical mechanical properties of the soil at the surface and inner surface level.

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