WELCOME

Topic- SOIL PHYSICAL PROPERTIES

Fundamental of Soil Science (NRH-111)

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EFFECT OF PHYSICAL PROPERTIES OF SOIL ON SOIL HEALTH

INTRODUCTION

Physical properties of soils include texture, structure, density, Porosity, consistency, temperature, colour and water content. The physical properties of a soil depend on the amount, size, shape, arrangement and mineral composition of its particles, kind and amount of organic matter and the volume and form of its pores and the way they are occupied by water, air at a particular time.

Important physical properties of soil

1. Soil texture
2. Soil structure
3. Soil density
4. Soil porosity
5. Soil consistence
6. Soil temperature
7. Soil colour
8. Soil air
9. Soil water

What is soil texture

Definition

"Soil texture refers to the relative percentage of sand, silt and clay in a soil".

Natural soil are comprised of soil particles of varying sizes. Texture is an important soil characteristics because it will partly determine water intake rates (absorption), water storage in the soil, the ease of tillage operation, aeration status etc and combinedly influence soil fertility. As per for an example, a coarse sandy soil is easy to cultivate, sufficient aeration for good root growth and wetted, easily but it also dries very rapidly and easily loses plant nutrients through leaching. But incase of high clay soils (7.35% clay) have very small particle that fit tightly together, leaving very little room for water to flow into soil.

Classification of soil particles (International system)

According to International Society of Soil Science (ISSS)

Particle	Diameter in (mm)
Coarse sand	0.2-2
Fine sand	0.02-0.2
Silt	0.002-0.02
Clay	<0.002

Soil texture classes

Textural names are given to soils based upon the relative proportion of each of the three soil separates –

i) Sand

ii) Silt

iii) Clay

Soil that are preponderantly clay, are called clay (textural class), those with high silt content are silt (textural class) those with high sand percentage are sand (textural class). Three broad and fundamental groups of soil textural classes are recognized:-

i) Sands

ii) Loams

iii) Clays

i) Sands

The sand group includes all soils of which the sand separates make up 70% or more of the material by weight.

ii) Loams

Loamy soils containing many sub-divisions does not exhibit the dominant physical properties of any of these three soil separates sand, silt and clay. An ideal loam soil may be defined as a mixture of sand, silt and clay particles which exhibits light and heavy properties in about equal properties. Note that loam does not equal percentage of sand silt and clay. It does, however exhibit approximately equal properties of sand, silt and clay.

iii) Clay

A clay soil must carry at least 35% of the clay separate and in most cases not less than 40%.

For an example, sandy clay soils contain more sand than clay. Similarly silty clay soils contain more silt than that of the clay.

Based on these three broad and fundamental groups, the different textural class names developed by U.S. Department of Agriculture and U.S. Bureau of soils are presented in Table I and II.

Determination of the textural class

There are generally two methods employed for the determination of textural class:

1. Feel method
2. Laboratory method
3. **Feel methods**

By rubbing the moist soil between thumb and fore finger

Sand- Feel Gritty, particles can easily seen

Silt- When dry feels like talcum powder & slightly plastic when wet

Clay- Feel very plastic & Exhibit stickiness when wet and very hard in dry conditions.

2. Laboratory method

International Pipette Method

This method is based on the principle of sedimentation. This method is regarded as a standard method for particle size analysis because of its accuracy but its time consuming

Bouyoucos Hydrometer Method

This method is based on the principle of stokes law. This method is considerably fast and reasonably accurate but not used for soils having high organic matter content, high CaCO3, high salinity.

Effect of soil texture on soil health

Soil texture effects soil physical and chemical properties like –

- Water holding capacity
- Nutrient retention
- Nutrient fixation
- Nutrient availability
- Drainage
- Strength
- Compressibility
- Thermal regime.

What is soil structure

The primary particles (sand, silt and clay) do not exist as such but are bound together with varying degrees of tenacity into larger units or aggregates usually termed as secondary particles. These are naturally occuring semi-permanent clusters or groups of soil particles, the binding forces between which are much stronger than the forces between adjacent aggregates.

Definition

"The arrangement of primary particles and their aggregates into a certain definite pattern is called soil structure."

Before going to through discussion on soil structure we should be well acquaited with the following terms:-

Types of Soil Structure

It is determined by the general shapes and arrangements of peds there are mainly four types of soil structure:-

i) Plate like

The horizontal dimensions are much more developed than the verticle axis resulting a flatterd, compressed or lens like appearance to the peds. When the units are thick, they are called platy and when the units are thin, they are called laminar. The platy types is often inherited from the parent materials.

ii) Prism like

The verticle axis is more developed than others, with flattened sides, giving piller-like shape. It has also two sub types-

a) Columnar

b) Prismatic

iii) Block like

All three dimensions are about the same size and the peds are cube like with flat or rounded faces, block like structure has also two types-

a) Angular blocky

b) Sub-angular blocky

iv) Spheroidal (Sphere like)

All axes are developed equally with the same length, curved and irregular faces. Generally all rounded or sphere like peds may be placed in this type of soil structure. Spheroidal type of soil structure has two structural sub-types:-

a) Granular

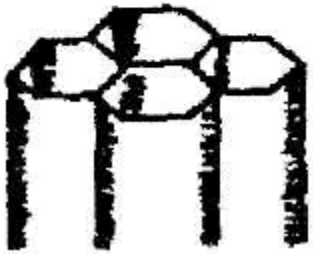
b) Crumby

(i) PLATE-LIKE

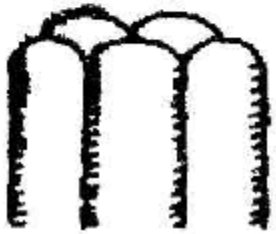
(a) PLATY

(b) LAMINAR

(ii) PRISM-LIKE



(a) PRISMATIC



(b) COLUMNAR

(iii) BLOCK-LIKE

(a) ANGULAR BLOCKY

(b) SUB-ANGULAR BLOCKY

(iv) SPHEROIDAL/SPHERE LIKE

(a) GRANULAR

(b) CRUMBY

Effect of soil structure on soil health

Soil structure influence the physical properties in a various ways:-

i) Aeration status/porosity

ii) Temperature

iii) Density

iv) Consistence

v) Colour

i) Particle density

Particle density of soil is the oven dried mass of soil per unit volume of soil solids. It is also termed as true density. It is depends upon chemical and mineralogical composition of soil.

It id not affected by pore space therefore not related to particle size.

(II) Bulk Density

Bulk density of a soil is the oven dried mass of soil per unit volume of soil. High bulk density generally indicated compactness of soil.

Effect of soil density on soil health

The bulk density varies with the total pore space present in the soil and gives a good estimate of the porosity of soil. Generally soil with low bulk densities have favourable physical conditions.

Porosity of soil

Pore space

The volume of soil mass that is not occupied by soil particles is known as pore space. The pore space is usually occupied by air and water. In the pore space, the plant roots grow and exist.

The size and shape of pores and pore spaces vary considerably.

In general, two sizes are recognized:-

i) Macro or non-capillary pores.

ii) Micro or capillary pores

i) Macro pores

These are the large pores, allow readily movement of air and water and do not hold much water under normal condition. Size of macro pores is greater than 0.08 mm.

ii) Micro pores

In contrast in the micro pores, movement of air and water is restricted to some extent, clay and clayey soils have a greater number of micro pores. Size of micro pores are less than 0.08 mm.

Soil porosity

Soil porosity is the percentage pore space. Porosity refers to that percentage of soil volume which is occupies by pore spaces. It can be calculated by the formula:-

$$\text{Porosity} = 100 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

Since, % pore space + % solid space = 100

and % pore space = 100 - % solid space

$$\%\ \text{Solid space} = \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

Effect of soil porosity on soil health

Porosity of the soil greatly helps to judge the moisture movement with in the soil. Macro pores allow readily movement of air and water. It does not hold water under normal condition. In contrast, micro pores can hold more water and restrict the movement of air and water in the soil.

Soil consistence

Soil consistence represents at varying moisture conditions, the degree and kind of cohesion and adhesion of soil material.

Terms used to describe the consistence of soils

	Wet soils		Moist soils	Dry soils
	Stickness	Plasticity		
	Non-sticky	Non plastic	Loose	Loose
	Slightly	Slightly	Very friable	Soft
Increasing	Sticky	Plastic		
Coherence	Sticky	Plastic	Friable	Slightly hard
	Very sticky	Very plastic	Firm	Hard
			Very firm	Very hard
			Extremely firm	Extremely hard

Effect of soil consistence on soil health

Consistence of soil depends on the texture nature and amount of inorganic and organic colloids, structure and especially the moisture content of soil with decreasing moisture content in general the soil lose their stickiness and plasticity and become friable and soft and finelly when dry become hard and coherent.

Optimum soil consistence increases the water holding capacity and plant food material. Thus increasing the fertility of soil.

SOIL COLOUR

The colour of soil varies widely. It is an easily observable characteristics and is an important criterion in description and classification of soils. Colour of a soil is inherited from its parent rock material. Often the soil colour is a result of soil farming process and is termed as acquired or pedochromic.

Variation in ferric oxide colour with degree of hydration

Haematite	Fe_2O_3	Red
Turgite	$2Fe_2O_3.H_2O$	Red or Reddish brown
Goethite	$Fe_2O_3.H_2O$	Yellowish – brown
Limonite	$2Fe_2O_3.3H_2O$	Yellow, brown
Xanthosiderite	$Fe_2O_3.2H_2O$	Yellow
Limnite	$Fe_2O_3.3H_2O$	Yellow

Determination of soil colour

Soil colour rotation is divided into three parts:-

a) Hue

b) Value

c) Chroma

a) Hue

It denotes the dominated spectral colour (red, yellow, blue and green).

b) Value

It denotes the lightness or darkness of a colour (the amount of reflected light)

c) Chroma

It represents the purity of the colour (strength of the colour).

Effect of soil colour on soil health

Soil colour is indirectly related with soil fertility:-

a) Relation of soil colour with temperatures.

b) Relation of soil colour with organic matter.

c) Relation of the soil colour with drainage.

SOIL TEMPERATURE

- For optimum root development :- 10-27^{0}C
- For optimum crop root development:- 15-45^{0}C
- Alluvial soils absorb about – 40% solar radiation.
- Grass covered soils absorb about – 60% solar radiation.
- On an average, the specific heat of soils ranges from 0.20-0.23.

Sources of soil heat

1. Solar radiation
2. Conduction
3. Biological and chemical reaction
4. Rain

Effect of soil temperature on soil health

There are following effects of soil temperature on fertility of soil and plant growths.

1. Effect of soil temperature on soil micro-organism
2. Effect of soil temperature on the decomposition of soil organic matter.
3. Effect of soil temperature on nutrients availability.
4. Effect of soil temperature on seed germination.
5. Effect of soil temperature on soil formation.
6. Effect of soil temperature on physical properties.

SOIL AIR

"The constant movement of air in the soil mass resulting in the renewal of gases is known as soil aeration"

Composition of soil air and atmospheric air

Air	Percentage by volume		
	Nitrogen	Oxygen	Carbondioxide
Soil air	79.2	20.6	0.25
Atmospheric air	79.0	20.97	0.03

Effects of soil aeration on soil health

In the presence of gaseous oxygen oxidation reactions occurs while in the absence of oxygen, methane gas is produced. In general, the oxidized forms of elements are more desirable for most common crops on acid soils of humid regions.

Soil water

Definition

Water is an important ingredient of soil which fills the part of pores between the soil particle.

- Soil water plays a significant role in controlling energy balance in the soil.

Classification of soil water

There are generally two types of soil water classification based on drying of wet soils and growing plants:-

1. Physical classification
2. Biological classification

1. Physical classification

i) Gravitational water

ii) Capillary water

iii) Hygroscopic water

2. Biological classification

i) Available water

ii) Un-available water

iii) Super fluous water

Effect of soil water on soil health

1. Plant nutrients
2. Weathering process
3. Tillage operation
4. Structure formation
5. Physical, chemical and biological activity
6. Micro organism activity
7. Photosynthesis
8. Plant turgidity
9. Seed germination and plant growth
10. Adverse effects

CONCLUSION

Physical properties exerts a marked influence on the behaviour of soils with regard to plant growth, hydrology environmental management and engineering uses. The nature and properties of the individual particles their size distribution and their arrangement in soils determine the total volume of non solid pore space, as well as the pore sizes, thereby impacting on water and air relationship.

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THANK YOU