COURSE GUIDE

FPY/SIWES PRACTICAL GUIDE MANUAL

SLM 407
SOIL–SITE CLASSIFICATION

Course Team Dr. S. N. Obasi (Course Writer)

NATIONAL OPEN UNIVERSITY OF NIGERIA

© 2020 by NOUN Press
National Open University of Nigeria
Headquarters
University Village
Plot 91, Cadastral Zone
Nnamdi Azikiwe Expressway
Jabi, Abuja

Lagos Office
14/16 Ahmadu Bello Way
Victoria Island, Lagos

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Printed 2020

ISBN: 978-978-970-167-4

CONTENTS **PAGE**

PRACTICAL 1

SITE SELECTION AND DESCRIPTION

CONTENTS

1.0 INTRODUCTION

In soil classification, sites are selected based on the purpose of classification, which could be ad-hoc or multipurpose reasons. It is ad-hoc when the purpose is for a particular or singular use example, irrigation while multipurpose reason has to do with wide range of uses. This is best done using a recently dug pit large enough to allow sufficient examination and description of the different horizons.

Old exposures such as road cuts and ditches may be used, but only after scraping off sufficient material to expose the fresh soil. First, the surface characteristics are recorded. Then, the soil description is done horizon by horizon, starting with the uppermost one. The rules of soil description and the coding of attributes are generally based on the guidelines for soil description according to FAO (1990).

2.0 OBJECTIVE

This exercise is intended to acquaint you with information on why we embark on soil site selection for characterisation and classification.

3.0 PROCEDURE

When the study site is identified using the maps in line with the purpose of the classification, the information below will be provided. This information will however validate the classification exercise.

Describer’s Name(S)

NAME (or initials) Record the observer(s) making the description; e.g.,

Okoli C. Nnamdi or *OCN*.

DATE

MONTH/DAY/YEAR—Record the observation date. Use numeric notation (MM/DD/YYYY); e.g., *02/21/2018* (for Feb. 21, 2018).

Climate

Document the prevailing weather conditions at time of observation (a site condition that affects some field methods; e.g., Ksat). Record the major weather conditions and air temperature; e.g., *Rain, 27 °C*.

Air Temperature: Ambient air temperature at chest height (Celsius or

Fahrenheit); e.g., *27 °C*.

Soil Temperature: Record the ambient soil temperature and depth at which it is determined; e.g., *22 °C, 50 cm*. (*NOTE*: Soil taxonomy generally requires a 50 cm depth.) Soil temperature should only be determined from a freshly excavated surface that reflects the ambient soil conditions. Avoid surfaces equilibrated with air temperatures.

Soil Temperature: Record soil temperature (in °C or °F).

Soil Temperature Depth: Record depth at which the ambient soil temperature is measured; e.g., *50 cm*.

Location

Record precisely the point or site location (e.g., coordinates). Latitude and longitude as measured with a Global Positioning System (GPS) is the preferred descriptor. Report lat. and long. as degrees, minutes, seconds, and decimal seconds with direction, or as degrees and decimal degrees with direction. For example:

LATITUDE—*46° 10' 19.38" N.* or *46°.17205 N*

LONGITUDE—*95° 23' 47.16" W.* or *95°.39643 W*

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.

2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Fill in the following table using the basic information needed in the soil site classification study.

S/N	Parameters	Information
1.	Describer's Name(S)	
2.	*Date*	
3.	Air Temperature	
4.	Soil Temperature	
5.	*Location*	

6.0 REFERENCE

FAO–ISRIC (1990). *Guidelines for profile description*. (3rd ed.). Rome.

PRACTICAL 2

SOIL SAMPLING

CONTENTS

1.0 INTRODUCTION

Soil site selection, regardless of purpose, must consider soilscape relationships. A soil profile description identifies the horizons and their thickness and provides context for data collection and interpretation. Statistical design and analysis (e.g., random, randomized block, grid, transect, traverse, geostatistical) are important aspects of sample collection. Note, however, that statistical blocking by geomorphic context stratifies soil areas by similar geologic and pedogenic processes.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- identify sampling techniques you can employ in the course of soil site classification.

3.0 PROCEDURE

Prepare two or three profile pits along a transect line. Observe the horizonations properly and carry out the different sampling methods from each.

Types of Sampling

i. **Horizon Sampling:** Cost and time limit the number of sample collections.

The most effective and efficient strategy for sampling is by horizon. Soil horizons develop from natural processes acting over time. Variations in soil properties may occur within a horizon, but distinct differences generally occur between horizons. Consequently, soil horizons are a meaningful and comparable schema for sample collection (see graphic). Soil horizons vary in thickness and boundary (e.g., wavy, irregular, broken) within a pedon and across landscapes. Soil profile descriptions and horizon sampling techniques incorporate depth and boundary variability and can produce homogeneous samples. It is advisable to subsample soil horizons about 50 cm thick. Fixed- depth sampling alone does not capture such variation and may lead to the erroneous interpretation of data.

ii. **Incremental Sampling:** Project objectives (e.g., soil genesis or archeological) may require within-horizon detail. Property variation or trends within horizons require samples at specified increments (e.g., every 10 cm). Increment samples should be taken within horizons; sample depths should not cross horizon boundaries. Increment sampling provides more detail than horizon sampling but adds time and expense. This approach is generally limited to special projects.

iii. **Fixed-Depth Sampling**: Specified objectives (e.g., surface compaction studies) may address properties by fixed depths (e.g., 0-5 cm or 5-10 cm) instead of by soil horizons. This approach, while appropriate for certain purposes, precludes data comparison by horizon. Data collected by depth is comparable within a study and to other studies employing the same depths. Fixed-depth samples may straddle horizons that contain contrasting materials (e.g., sandy over clayey strata). The resultant data represents neither horizon and is difficult to interpret. Use this approach with caution.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

- The facilitator/teacher should ensure students take part in all demonstrations/practical.
- The facilitator/teacher should teach in a simple way for easy understanding by the students.
- Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Carry out the different sampling methods in each of the profile pits and record your observations in the table below

S/N	Types of Sampling	Profile pit 1	Profile pit 2	Profile pit 3
1.	Horizon Sampling			
2.	Incremental Sampling			
3.	Fixed-Depth Sampling			

2. Explain the following sampling techniques a. Transect sampling b. Random sampling c. Grid sampling.

PRACTICAL 3

SOIL MASTER HORIZON DESIGNATIONS

CONTENTS

1.0 INTRODUCTION

Horizon symbols consist of one or two capital letters for the master horizon and lower case letter suffixes for subordinate distinctions, with or without a figure suffix. For the presentation and understanding of the soil profile description, it is essential that correct horizon symbols be given.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain the different diagnostics horizon characteristics of soils
- identify how they occur in soil profiles for the purpose of soil classification.

3.0 PROCEDURE

Prepare a profile pit as in fig. 3.1a and fig. 3.1b and under study the master horizons.

Fig. 3.1a

Fig. 3.1b

Master horizons and layers

The capital letters H, O, A, E, B, C, R, I, L and W represent the master horizons or layers in soils or associated with soils. The capital letters are the base symbols to which other characters are added in order to complete the designation. Most horizons and layers are given a single capital letter symbol, but some require two.
Currently, ten master horizons and layers and seven transitional horizons are recognized.

The master horizons and their subdivisions represent layers that show evidence of change and some layers that have not been changed. Most are genetic soil horizons, reflecting a qualitative judgment about the kind of changes that have taken place. Genetic horizons are not equivalent to diagnostic horizons, although they may be identical in soil profiles. Diagnostic horizons are quantitatively defined features used in classification.

H horizons or layers

These are layers dominated by organic material formed from accumulations of undecomposed or partially decomposed organic material at the soil surface, which may be underwater. All H horizons are saturated with water for prolonged periods, or were once saturated but are now drained artificially.

horizons or layers

These are layers dominated by organic material consisting of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss and lichens, that has accumulated on the surface; they may be on top of either mineral or organic soils.

A horizon

These are mineral horizons that formed at the surface or below an O horizon, in which all or much of the original rock structure has been obliterated.

E horizons

These are mineral horizons in which the main feature is loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles, and in which all or much of the original rock structure has been obliterated.

B horizons

These are horizons that formed below an A, E, H or O horizon, and in which the dominant features are the obliteration of all or much of the original rock structure. All kinds of B horizons are, or were originally, subsurface horizons. Included as B horizons are layers of illuvial concentration of carbonates, gypsum or silica that are the result of pedogenetic processes (these layers may or may not be cemented) and brittle layers that have other evidence of alteration, such as prismatic structure or illuvial accumulation of clay.

C horizons or layers

These are horizons or layers, excluding hard bedrock, that are little affected by pedogenetic processes and lack properties of H, O, A, E or B horizons. Most are mineral layers, but some siliceous and calcareous layers, such as shells, coral and diatomaceous earth, are included.

R layers

These consist of hard bedrock underlying the soil. Granite, basalt, quartzite and indurated limestone or sandstone are examples of bedrock that are designated R. Air-dry or drier chunks of an R layer when placed in water will not slake within 24 hours. The R layer is sufficiently coherent when moist to make hand digging with a spade impractical, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may contain cracks, but these are so few and so small that few roots can penetrate. The cracks may be coated or filled with clay or other material.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1. The facilitator/teacher should ensure students take part in all demonstrations/practical.
2. The facilitator/teacher should teach in a simple way for easy understanding by the students.
3. Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

Use the prepared profile pit to identify the following master horizons;
a. *H* horizons ***b.*** *O* horizons ***c.*** *A* horizons ***d.*** E horizons ***e.*** B horizons *f.* C horizons ***g.*** R horizons

PRACTICAL 4

SUBORDINATE DISTINCTIONS WITHIN MASTER HORIZONS

CONTENTS

1.0 INTRODUCTION

Designations of subordinate distinctions and features within the master horizons and layers are based on profile characteristics observable in the field and are applied during the description of the soil at the site. Lower case letters are used as suffixes to designate specific kinds of master horizons and layers, and other features.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- identify the subordinate distinctions within the horizons
- explain how this can help them identify the peculiar qualities of each master horizons.

3.0 PROCEDURE

Lower case letters are used to designate specific features within master horizons. They are listed in alphabetical order below:

a. Highly decomposed organic material. The ‘a’ is used only with the Omaster horizon. The rubbed fibre content < l7 % of the volume.

b. Buried genetic horizon. It is not used in organic soils or to identify a buried O master horizon.

c. Concretions of hard non-concretionary nodules. This symbol is used only for iron, aluminium, manganese, or titanium cemented nodules or concretions.

d. Physical root restriction. It is used to indicate natural occurring or humanly induced layers such as basal till, plow pans, and other mechanical compacted zones. Roots do not enter except along facture planes.

e. Organic material of intermediate decomposition. This symbol is only used in combination with an O master horizon with rubbed fibre content between 17 – 40 % of the volume.

f. Frozen soil. The horizon must contain permanent ice.

g. Gleying: This symbol is used in B and C horizons to indicate low chroma colour (< = 2), caused by reduction of iron in stagnant saturated conditions. The iron may or may not be present in the ferrous form (Fe^{2+}). The g is used to indicate either total gleying or the presence of gleying in a mottled pattern. It is not used in E horizons, which are commonly of low chroma, or in C horizons where the low chroma colours are inherited form the parent material and no evidence of saturation is apparent.

h. illuvial accumulation of organic matter: Used only in B horizon. The h indicates an accumulation of illuvial, amorphous, dispersible organic matter with or without sequioxide component. If the sequioxide component contains enough iron so that the colour value and chroma exceed 3 additionally a s is used (hs). The organoosequioxide complexes may coat sand and silt particles, of occur as discrete pellets, or fill voids and cement the horizon (use of m).

i. Slightly decomposed organic material. Used only in Combination with an O master horizon to designate that the rubbed fibre content is > 40 % or the volume.

k. Accumulation of carbonates, usually calcium carbonate. Used with B and C horizons.

m. Cementation or induration: Used with any master horizon, except R, where > 90 % of the horizon is cemented and roots penetrate only through cracks. Tire cementing material is identified by the appropriate letter.

- **km:** carbonate
- **qm:** silica
- **sm:** iron
- **ym:** gypsum
- **kqm:** both lime and silica
- **zm:** salts more soluble than gypsum

n. Accumulation of sodium: This symbol is used on any master horizon showing morphological properties indicative of high levels of exchangeable sodium.

o. Residual accumulation of sesquioxides.

P. Tillage or other cultivation disturbance (e.g. plowing, hoeing, discing).

This symbol is only used in combination with the master horizon A or O.

q. Accumulation of silica: This symbol is used with any master horizon, except R, where secondary silica has accumulated.

r: Weathered soft bedrock: This symbol is only used in combination with the master C horizon. It designate saprolite or dense till that is hard enough that roofs only penetrate along cracks, but which is soft enough that it can be dug with a spade or shovel.

s: illuvial accumulation or sesquioxides and organic matter. This symbol is only used in combination with B horizons. It indicates the presence or illuvial iron oxides. It is often used in conjunction with h when the color is = < 3 (chroma and value).

ss: Presence of slicken sides. They are formed by shear failure as clay material swell upon wetting. Their presence is an indicator of vertic characteristics.

t: Accumulation of silicate clay: The presence of silicate clay forming coats on ped faces, in pores, or on bridges between sand-sized material grains. The clay coats may be either formed by illuviation or concentrated by migration within the horizon. Usually used ill combination with B horizons, but it may be used in C or R horizons also.

v: Plinthite: This symbol is used in B and C horizons that are humus poor and iron rich. The material usually has reticulate mottling of reds, yellows and gray colours.

w: Development of colour and structure. This symbol is used for B horizons that. have developed structure or colour different, usually redder than that of the A or C horizons, but do not have apparent illuvial accumulations.

x: Fragipan character: This symbol is used to designate genetically developed firmness, brittleness, or high bulk density in B or C horizons. No cementing agent is evident.

y: Accumulation of gypsum. This symbol is used in B and C horizons to indicated genetically accumulated gypsum.

z: Accumulation of salts more soluble than: gypsum. This symbol is used in combination with B and C horizons.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.

2 The facilitator/teacher should teach in a simple way for easy understanding by the students.

3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Prepare a profile pit and carefully observe the subordinate distinctions.
2. With the identified subordinate distinctions, demonstrate how they can be combined with the master horizons during soil characterization and classification.

PRACTICAL 5

DIAGNOSTIC SUBSURFACE HORIZONS

CONTENTS

1.0 INTRODUCTION

The accumulation of substances such as silica, iron, aluminium, carbonate, and other salts can result in cementer layers, which change the physical, chemical, and biological behaviour of the soil. For example, a cemented layer retards percolation, and restrict root activity. Furthermore, the availability of nutrients for plant growth is reduced, i.e., the cation exchange capacity is reduced. There are accumulations in the soil which show the enrichment of one substance and / or the depletion of another substance. This can be expressed by **diagnostic subsurface horizons**, which are listed in alphabetically order below. It should be stressed that some characteristics can be measured only in the laboratory and not in the field.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain diagnostics subsurface horizons
- identify them in the field during soil classification study.

3.0 PROCEDURE

The following subsurface horizons are formed as follows:

- **Agric horizon:** This form directly under the plow layer and has silt, clay, and humus accumulated as thick, dark lamallae.
- **Albic horizon:** Typically this is a light-coloured E horizon with the colour value > = 5 (dry) or > = 4 (moist).
- **Argillic horizon**: It is formed by illuviation of clay (generally a B horizon, where the accumulation of clay is denoted by a lower case ‘t’) and

illuviation argillans are usually observable unless there is evidence of stress cutans. Requirements to meet an argillic horizon are:

- 1/10 as thick as all overlying horizons
- > = 1.2 times more clay than horizon above, or:
- lf eluvial layer < 15 % clay, then > = 3 % more clay, or:
- If eluvial layer > 40 % clay, then > = 8 % more clay.
- **Calcic horizon:** This layer has a secondary accumulation or carbonates, usually of calcium or magnesium. Requirements:
- > = 15 cm thick
- > = 5 % carbonate than an underlying layer
- **Cambic horizon:** This subsurface often shows weak indication of either an argillic or spodic horizon, but not enough to qualify as either. H may be conceptually regarded as a signature of early stages of soil development, i.e. soil structure or colour development. Requirements:
- Texture: loamy very fine sand or finer texture
- Formation of soil structure
- Development of soil colour
- **Duripan:** It is a subsurface horizon cemented by illuvial silica. Air-dry fragments from more than 50 % of the horizon do not slake in water or HCl but do slake in hot concentrated KOH.
- **Fragipan:** These subsoil layers are of high bulk density, brittle when moist, and very hard when dry. They do not soften on welling, but can be broken in the hands. Air-dry fragments slake when immersed in water. Fragipan genesis as outlined in Soil Taxonomy is largely dependent all physical processes and requires a forest vegetation and minimal physical disturbance. Desiccation and shrinking cause development of a network of polygonal cracks in the zone of fragipan formation. Subsequent rewetting washes very fine sand, silt, and clay-sized particles from the overlying horizons into the cracks. Upon wetting, the added materials and plant roots growing into the cracks result in compression or the interprism materials. Close packing and binding of the matrix material with clay is responsible for the hard consistence of the dry prisms. Iron is usually concentrated along the bleached boundaries of the prisms. It has also been postulated that clay and sequioxides cements to be binding agents in fragipans.
- **Glossic horizon:** It occurs usually between an overlying albic horizon and an underlying argillic, kandic, or natric horizon or fragipan. Requirements:
- > = 5 cm thick
- Albic material between 15 % to 85 %, rest: material like the underlying horizon

- **Kandic horizon**: It is composed of low activity clays, which are accumulated at its upper boundary. Clay skins mayor may not be present It is considered that clay translocation is involved in the process of kandic formation, however, clay skills may be subsequently disrupted or destroyed by physical and chemical weathering, or they may have formed in situ. Requirements:
- Within a distance of < 15 cm at its upper boundary the clay content
- increases by > 1.2 times
- Abrupt or clear textural boundary to the upper horizon
- A pH 7: low-activity days with CEC of < = I6 cmol/kg and ECEC (effective
- CEC) of < = 12 cmol/kg.
- **Natric horizon:** It is a subsurface horizons with accumulations of clay minerals and sodium. Requirements:
- Same as argillic horizon
- Prismatic or columnar structure
- > 15 % of the CEC is saturated with Na^{+}, or:
- More exchangeable Na^{+} plus Mg^{2+} than Ca^{2+}
- **Oxic horizon:** Requirements:
- > = 30 cm thick
- Texture: sandy loam or finer
- At pH 7: CEC of < = I6 cmol/kg and ECEC of' < = 12 cmol/kg (i.e., a high content or 1:1 type clay minerals).
- Clay content is more gradual than required by the kandic horizon
- < 10 % weatherable minerals in the sand
- < 5 % weatherable minerals by volume rock structure (i.e., indicative of a very strongly weathered material).
- **Petrocalcic horizon:** It is an indurated calcic horizon. Requirements:
- At least 1/2 of a dry fragment breaks down when immersed in acid but does not break down when immersed in water.
- **Petrogypsic horizon:** This is a strongly cemented gypsic horizon. Dry fragments will not slake in H_2O.
- **Placic horizon:** This is a dark reddish brown to black pan or iron and/or manganese. Requirements:
- 2 – 10 cm thick
- It has to lie within 50 cm of the soil surface
- Boundary: wavy
- Slowly permeable
- **Salic horizon:** This is all subsurface horizon accumulated by secondary soluble salts. Requirements:
- > = 15 cm thick

- Enrichment of secondary soluble salts such (hat electrical conductivity exceeds 30 dS/m more than 90 days each year.
- **Sombric horizon:** Formed by illuviation or humus (dark brown to black color) but not of aluminium or sodium. Requirements:
- At pH 7: base saturation < 50 %
- Not under an albic horizon
- Free-draining horizon
- **Spodic horizon:** This horizon has an illuvial accumulation of sequioxides and/or organic matter. There are many specific limitations dealing with aluminum, iron, and organic matter content, and clay ratios, depending on whether the overlying horizon is virgin or cultivated.
- Sulfuric horizon: this is a very acid mineral or organic soil horizon.
- Requirements:
- pH < 3.5
- Mottles are present (yellow colour: jarosite).

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. How do you identify the following diagnostic subsurface horizons:
   a. Agric horizon b. Albic horizon
   c. Argillic horizon
   d. Kandic horizon
   e. Fragipan horizon f. Duripan horizon.

PRACTICAL 6

IDENTIFYING HORIZON BOUNDARIES

CONTENTS

1.0 INTRODUCTION

The boundary between the horizons can be described considering the distinctness and topography. **Distinctness** refers to the degree of contrast between two adjoining horizons and the thickness of the transition between them. **Topography** refers to the shape or degree of irregularity of the boundary. In Figs. 6.1 – 6.4 examples for several boundaries ale shown.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain different horizon boundaries
- discuss how to identify them in a profile pit during field soil site classification.

3.0 PROCEDURE

Record **Distinctness** and **Topography** of horizon boundaries, Distinctness is the vertical distance through which the bottom of one horizon grades (transitions) into another. Topography is the lateral undulation and continuity of the boundary between horizons. A complete example is clear, wavy, or *C,W.*

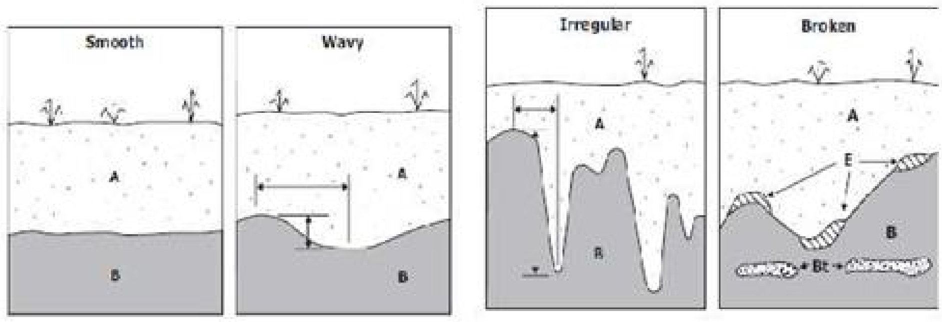


Fig. 6.1 Fig. 6.2 Fig. 6.3 Fig. 6.4

Fig. 6.1 – 6.4: Boundaries between Soil Horizons

Table 6.1: Classification of Horizon Boundaries

Distinctness	**Abbreviation**	**cm**
Abrupt	A	< 2
Clear	C	2 – 5
Gradual	G	5 – 15
Diffuse	D	> 15

Table 6.2: Topography—Cross-sectional shape of the contact between horizons

Topography	**Abbreviation**	**Description**
Smooth	S	Nearly a plane
Wavy	W	Waves wider than deep
Irregular	I	Depth greater than width
Broken	B	Discontinuous

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.

2 The facilitator/teacher should teach in a simple way for easy understanding by the students.

3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Using a profile pit, classify the horizon boundary based on its distinctness.
2. Using a profile pit classify the horizon boundary based on its Topography.

PRACTICAL 7

SOIL COLOUR

CONTENTS

1.0 INTRODUCTION

Colour reflects an integration of chemical, biological and physical transformations and translocations that have occurred within a soil. In general, colour of surface horizons reflects a strong imprint of biological processes, notably those influenced by the ecological origin of soil organic matter (SOM). Soil organic matter imparts a dark brown to black colour to the soil. Generally, the higher the organic, matter content of the soil, the darker the soil. A bright-light colour can be related to an eluvial horizon, where sequioxides, carbonates and/or clay minerals have been leached out.

Subsoil colour reflects more strongly in most soils the imprint of physico- chemical processes. In particular, the redox status of Fe and to a lesser extent Mn, strongly influence the wide variation found in subsoil colour. Soil colour can provide information about subsoil drainage and the soil moisture conditions of soils. In more poorly drained soils (anaerobic conditions) iron compounds arc reduced and the neutral gray colours of Fe^{2+} or bluish- green colours of iron sulfides, iron carbonates, or iron phosphates are visible. A black colour in the subsoil can be related to all accumulation of manganese. In arid and semi-arid environments, the influence of soluble salts (carbon ales, sulfates, chlorides etc.) may impart a strong influence on soil colour. For example, in arid or sub-humid regions, surface soils may be white due to evaporation of water and soluble salts.

Colours associated with minerals inherited from parent materials may also influence colour in horizons that have not been extensively weathered. For example, light gray or nearly while colours is sometimes inherited from parent material, such as marl or quartz. Parent material, such as basalt, call imprints a black colour to the subsoil horizons.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain how soil colours are developed
- discuss how munsell colour chart can be used to classify soil colours using a profile pit.

Table 7.1: Soil Colours Associated with Soil Attributes

3.0 PROCEDURE

Soil colour is usually registered by comparison of a standard colour chart (Munsell Book or Colours). The Munsell notations distinguish three characteristics of the colour, Hue, value, and chroma:

Soil Colour	Soil Attribute	Environmental Conditions
Brown to black (surface horizon)	Accumulation of Organic matter (OM), humus	low temperature, high annual precipitation amounts, soils high in soil moisture, and /or litter from coniferous trees favour an accumulation of OM
Black (subsurface horizon)	Accumulation of manganese Parent material (e.g. basalt)	
Bright-light	Eluvial horizon (E horizon)	In environments where precipitation > evapotranspiration there is leaching of sequioxides, carbonates, and silicate clays. The eluviated horizons consist
Yellow to reddish	Fe^{3+} (oxidized	Well-aerated soils
Gray, bluish-green	Fe^{2+} (reduces iron)	Poorly d rained soils (e.g. subsurface layer with a high bulk density causes water logging, or a

i. **Hue:** It is the dominant spectral colour, i.e., whether the hue is pure colour

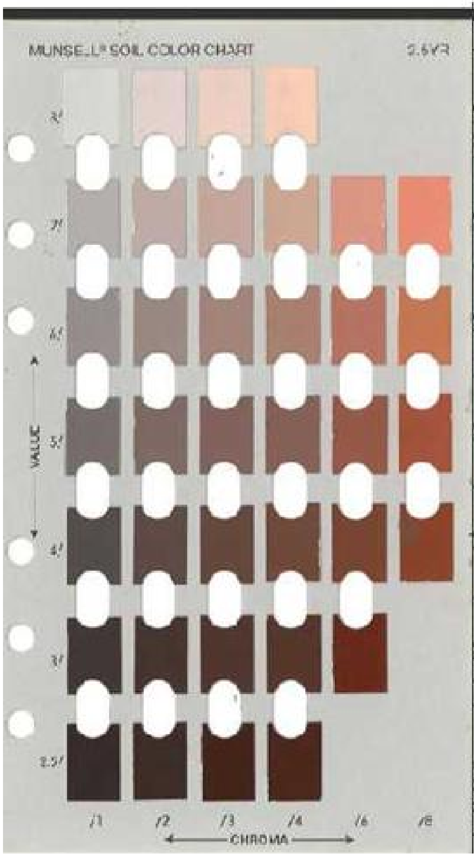
ii. such as yellow, red, green, or a mixture of pure colours.

iii. **Value:** It describes the degree of lightness or brightness of the hue reflected in the property or the gray colour that is being added to the hue.

iv. **Chroma:** It is the amount of a particular hue added to a gray or the

v. relative purity of the hue.

		very fine textured soil where permeability is very low), anaerobic environmental conditions.
White to gray	Accumulation of salts	In arid or sub-humid environments where the evapotranspiration > precipitation there is an upward movement of water and soluble salts in the soil.
White to gray	Parent material:	



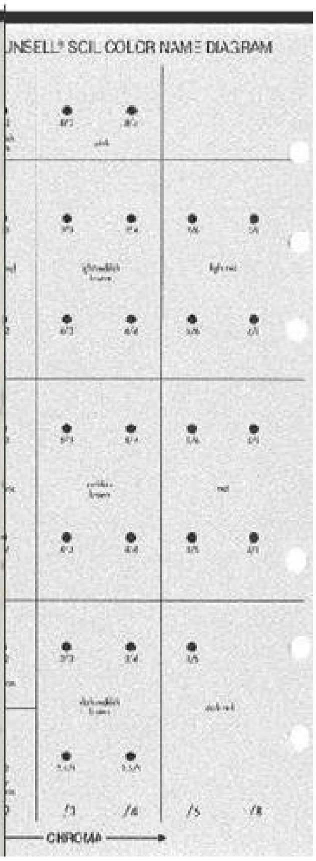


Fig. 7.1: Munsell Soil Colour Chart Fig. 7.2: Chart Interpretation

The soil colours arc given in the order: hue, value, and chroma (Fig. 7.1). For example, 2.5YR 4/2 describes the hue 2.5YR, dark-grayish brown with a value 4 and a chroma of 2. It should be stressed that soil colour is dependent on soil moisture, hence if soil colour is recorded also the soil moisture conditions have to be described (e.g. soil colour dry, soil colour wet). In the upper Midwest and other humid areas, colours are conventionally recorded moist. This convention may differ in other climatic regimes.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTION

1. With the aid of the munsell colour chart and its interpretation in fig.

7.1 and fig. 7.2 respectively, state the colours of the different horizons of a standard profile pit
.

PRACTICAL 8

MOTTLING OR REDOXIMORPHIC FEATURES

CONTENTS

1.0 INTRODUCTION

The many soils have a dominant soil colour. Other soils, where soil forming factors vary seasonally (e.g. wet in winter, dry in summer) lend to exhibit a mixture of two or more colours. When several colours are present the term **mottling or redoximorphic features (RMF)** is used. In such a case, several soil colours have to be recorded, where the dominant colour is first, following by a description of the abundance, size, and contrast of the other colours in the mottled pattern. Mottling//RMFs are described by three characteristics: contrast, abundance, and size of area of each colour.

2.0 OBJECTIVE

By the end of this unit, you will be able to:

- explain mottling and how it develops in the soil.

3.0 PROCEDURE

Redoximorphic features are colour pattern in a soil due to loss (depletion) or gain (concentration) of pigment compared to the matrix colour. H is formed by oxidation I reduction of Fe and/or Mn coupled with their removal and translocation or a soil matrix colour controlled by the presence or Fe^{2+}. RMFs are described separately from other mottles or concentrations! Based on the Field Book for Describing and Sampling Soils (Schoeneberger *et al*., 2002) RMFs are described in terms of kind, colour and contrast, quantity, size, shape, location, composition and hardness, and boundary. RMFs occur in the soil matrix, all or beneath the surface of peds, and as filled pores, linings of pores, or beneath the surface of pores.

Mottles are areas of colour that differ from the matrix colour. These colours are commonly lithochromic or lithomorphic attributes retained from the geologic source rather than from pedogenesis. Mottles exclude RMFs and peel and void surface features (e.g. clay films). Based on the Field Book for Describing and Sampling Soils (Schoeneberger *el al.,* 2002) mottles are described in terms of quantity, size, colour and contrast, moisture state, and shape. Example: Few, medium, distinct, reddish yellow (7.5YR 7/8), irregular mottles.

However, a variety of other features in a horizon may have colours different from the matrix, such as infillings of animal burrows (krotovinas), clay coatings (argillans) and precipitates of calcium carbonate. In all instances where specific soil features are described, the shape and spatial relationships of the feature (i.e.., where is it located, on a ped face, in the matrix ...) to adjacent features should be described in addition to its colour, abundance, size and contrast.

This is done by observation and recording of abundance, size and contract of mottles in a profile pit.

Table 7.2: RMFs/Mottles in Soils are described in term of Abundance, Size, and Contrast

Abundance	**Abbreviation**	**% of the Exposed Surface**
Few	F	< 2
Common	C	2 – 20
Many	M	20 – 40
Very many	V	> 40

Size	**Abbreviation**	**Diameter (mm)**
Fine	1	< 5 mm
Medium	2	5 – 15 mm

Contrast	Abbreviation	Visibility
Faint	F	Difficult to see, hue, and chroma of matrix and
Distinct	D	Readily seen, matrix and mottles vary 1 – 2 hues
Prominent	P	Conspicuous, matrix and mottles vary several units in hue, value, and chroma

5.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher;

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

PRACTICAL QUESTIONS

1. Using a profile pit classify soil mottles into, abundance, size and contrast.
2. How does the redoximophic properties of the investigated profile pit develop?

6.0 REFERENCE/FURTHER READING

Schoeneberger, P. J. Wysocki, D. A, Benham, E.C. & Broderson, W.D. **(**2002). *Field Book for Describing and Sampling Soils*. Lincoln, USA: National Soil Survey Center, Natural Resources Conservation Service, USDA.

PRACTICAL 9

SOIL TEXTURE

CONTENTS

1.0 INTRODUCTION

Texture refers to the amount of sand, silt, and clay in a soil sample. The distribution of particle sizes determines the soil texture, which can be assessed in the field or by a particle-size analysis in the laboratory.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- explain soil texture
- d i s c u s s how it is determined in the field using a soil profile pit.

3.0 PROCEDURE

A field analysis is carried out in the following way: a small soil sample is taken, water is added to the sample, it is kneaded between the fingers and thumb until the aggregates are broken down. The guidelines to determine the particle class are as following:

i. **Sand:** Sand particles are large enough to grate against each other and they can be detected by sight. Sand shows no stickiness or plasticity when wet.
ii. **Silt:** Grains cannot be detected by feel, but their presence makes the
iii. soil feel smooth and soapy and only very slightly sticky.
iv. **Clay:** A characteristic of clay is the stickiness. If the soil sample can he rolled easily and the sample is sticky and plastic when wet (or hard and cloddy when dry) it indicates a high clay content. Note that a high organic matter content tends to smoothen the soil and can influence the feeling for clay.

Table 9.1: Soil Texture Classes

Soil Texture	**Abbreviation**
Gravel	G
Very Coarse sand	Vcos
Coarse sand	Cos
Sand	S
Fine sand	Fs
Very fine sand	Vfs
Loamy coarse sand	Lcos
Loamy sand	Ls
Loamy fine sand	Lfs
Sandy loam	Sl
Fine sandy loam	Fsl
Very fine sandy loam	Vfsl
Gravelly sandy loam	Gsl
Loam	L
Gravelly loam	Gl
Stony loam	Stl
Silt	Si
Silt loam	Sil
Clay loam	Cl
Silty clay loam	Sicl
Sandy clay loam	Scl
Stony clay loam	Stcl
Silty clay	Sic
Clay	c

A variety of systems are used to define the size ranges of particles, where the ranges of sand, silt and clay that define a particle class differs among countries. In the U.S. the soil texture is classified based on the U.S.D.A. system, which is used in this course. The classification or particle sizes are the following (units: mm):

◄xxclay: < 0.002xx►

xxxx ◄xxsilt: 0.002 – 0.05xx► xxxxxxxx◄xxfine sand: 0.05 – 0.1xx► xxxxxxxxxxxxx◄xxmedium sand: 0.1 – 0.5xx► xxxxxxxxxxxxxxxxxxxx◄xxcoarse sand: 0.5 – 1.0xx►x x xxxxxxxxxxxxxxxxxxxxxxxx◄xxvery coarse sand: 1.0 – 2.0xx►x xxxxxxxxxxxxxxxxxxxxxxxxxxxx◄xxgravel: 2.0 – 762.0xx► xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx ◄xxcobbles: > 762.0xx►

Soil texture in the field is determined using a texture triangle (Fig. 9.1). For example, a particle size distribution of 33 % clay, 33 % silt, and 33 %
sand would result in the soil texture class ‘clay loam’.

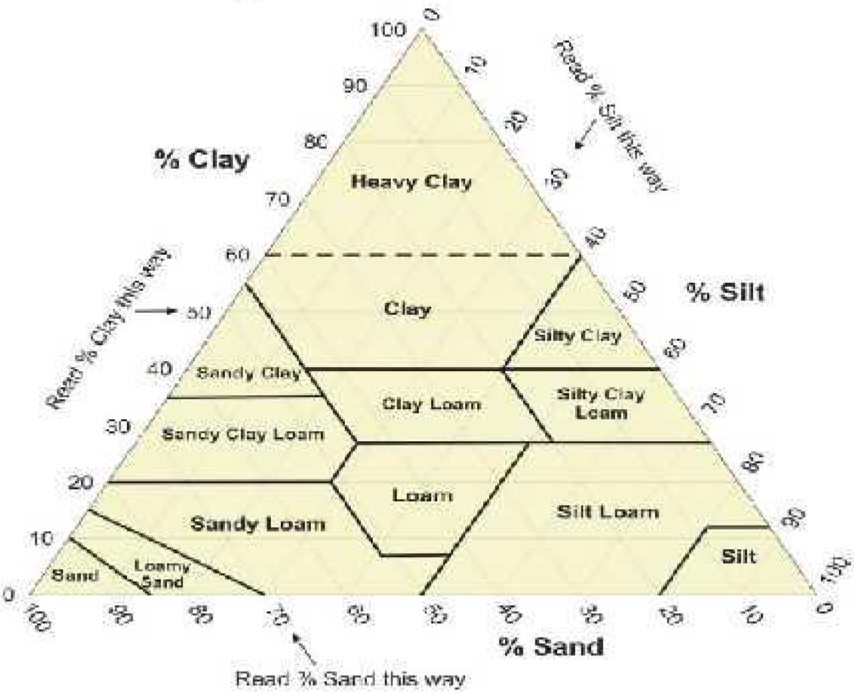


Fig. 9.l: Triangular Diagram of Soil Textural Classes (USDA Triangle)

Particles greater than 2 mm are removed from a textural soil classification. The presence of larger particles is recognized by the use of modifiers added to the textural class (e.g. gravelly, cobbly, stony) (Table 9.2 and 9.5.1.3).

Table 9.2: Terms for Rock Fragments

Shape and Size (mm)	**Adjective**
Spherical and Cubelike: 2 – 75 2 – 5 5 – 20 20 – 75 75 – 250 250 – 600	xxx Gravelly Fine gravelly Medium gravelly Coarse gravelly Cobbly Stony

> 600	Bouldery
Flat: 2 – 150 150 – 380 380 – 600 > 600	Channery Flaggy Stony Bouldery

Table 9.3: Modifier for Rock Fragments

Rock Fragments by Volume (%)	**Adjectival Modifier**
< 15	No modifier
15 – 30	Gravelly loam
30 – 60	Very flaggy loam
> 60	Extremely bouldery loam

The distinction between a mineral and an organic horizon is by the organic carbon content. Layers which contain > 20 % organic carbon and are not water saturated for periods more than a few days are classed as organic soil material. If a layer is saturated for a longer period, it is considered to be organic soil material if it has:

- > = 12 % organic carbon and no clay, or
- > = 18 % organic carbon and > = 60 % clay, or
- 12 – 18 % organic carbon and 0 – 60 % clay.

Significance of Soil Texture

The fine and medium-textured soils (e.g. clay loams, silly clay loams, sandy silt loams) are favourable from an agricultural viewpoint because of their high available retention of water and exchangeable nutrients. In fine pores the water is strongly adsorbed in pores but not available for plants, i.e. cohesion and adhesion water occupy the micropore space and they are retained ill soil by' forces that exceed gravity. In medium-sized pores the available water content is high, whereas in macropores water is more weakly held and percolation is high (gravitational water). In silty soils the distribution of macropores, medium-sized, and fine pores is optimal relating to available water content.

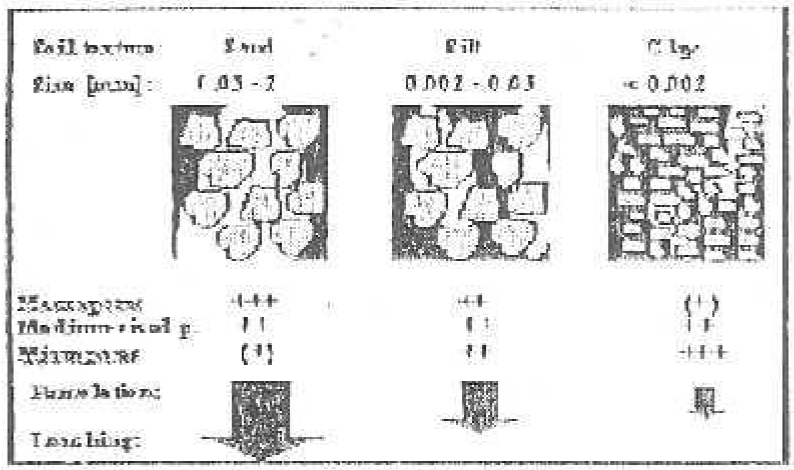


Fig. 9.2: Relationship between Soil Texture and Pore Size

Table 9.4: Pore size distribution in soils different in Texture (Scheffer *et al.*, 1989)

Soil Different in Texture	**Pore Volume (%)**	**Macropores (%)**	**Medium-Size Pores (%)**	**Mivropores (%)**
Sandy Soils	46 (+/- 10)	30 (+/- 10)	7 (+/- 5)	5 (+/- 3)
Silty Soils	47 (+/- 9)	15 (+/- 10)	15 (+/- 7)	15 (+/- 5)
Clayey Soils	50 (+/- 15)	8 (+/- 5)	10 (+/- 5)	35 (+/- 10)
Organic Soils	85 (+/- 10)	25 (+/- 10)	40 (+/- 10)	25 (+/- 10)

In general, coarse-textured soils permit rapid infiltration because of the predominance of large pores, while the infiltration rates of finer-textured soils is smaller because of the predominance of micropores. Other factors, like the compaction of the soil, management practices, vegetation, saturation of the soil have also a significant impact on infiltration and have to be considered.

Soil texture has an impact on soil temperature. Fine-textured soils hold more water than coarse-textured. soils, which considering the differences in the specific heat capacity results ill a slow response of warming up of fine-textured soils compared to coarse-textured soils.

Another issue to address is the effect that with decreasing particle size the surface area increases. Many important chemical and biological properties of soil particles are functions of particle size and hence surface area. For example, the adsorption of cations (nutrients) or the microbial activity is dependent on surface area.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher;

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Using a profile pit determine the sand, silt and clay fraction in the soil
2. How does soil texture affects pore spaces in the soil

PRACTICAL 10

SOIL STRUCTURE

CONTENTS

1.0 INTRODUCTION

Structure refers to the arrangement of soil particles. Soil structure is the product of processes that aggregate, cement, compact or unconsolidated soil material. In essence, soil structure is a physical condition that is distinct from that of the initial material from which it formed, and can be related to processes of soil formation. The peds are separated from the adjoining peds by surfaces of weakness.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss the grades, forms and sizes of structure
- classify soil structure using a profile pit in the field.

3.0 PROCEDURE

To describe structure in a soil profile it is best to examine the profile standing some metres apart to recognize larger structural units (e.g. prisms). The next step is to study the structure by removing soil material for more detailed inspection. It should be stressed that soil moisture affects the expression of soil structure. The classification of soil structure considers the grade, form, and size of particles.

i. The grade describes the distinctiveness of the peds (differential between cohesion within peds and adhesion between peds). It relates to the degree of aggregation or the development of soil structure. In the field a classification of grade is based on a finger test (durability of peds) or a crushing of a soil sample.
ii. The form is classified on the basis of the shape of peds, such as spheroidal, platy, blocky, or prismatic. A granular or

crumb structure is often found in A horizons, a platy structure in E horizons, and a blocky, prismatic or columnar structure in Bt horizons. Massive or single-grain structure occurs in very young soils, which are in an initial stage of soil development. Another example where massive or single-grain structure can be identified is on reconstruction sites. There may two or more structural arrangements occur in a given profile. This may be in the form of progressive change in size/type of structural units with depth (e.g. A horizons that exhibit a progressive increase in size of granular peds that grade into sub-angular blocks with increasing depth) or occurrence of larger structural entities (e.g. prisms) that are internally composed of smaller structural units (e.g. blocky peds). In such a case all discernible structures should be recorded (i.e. more rather than less detail).

iii. The sizes of the particles have to be recorded as well, which is dependent on the form of the peds.

Table 10.1: Classification of Soil Structure considering Grade, Size, and Form of Particles

Grade	**Abbreviation**	**Description**
Structureless	0	No observable aggregation or no orderly
Weak	1	Poorly formed indistinct peds
Moderate	2	Well-formed distinct peds, moderately durable and evident, but not distinct in undisturbed soil
Strong	3	Durable peds that are quite evident in undisplaced soil, adhere weakly to one another, withstand displacement, and become separated when soil is disturbed.
Form	**Abbreviation**	**Description**

Granular	Gr	Relatively nonporous, spheroidal peds, not
Crumb	Cr	Relatively porous, spheroidal peds, not fitted
Platy	Pl	Peds are plate-like. The particles are arranged about a horizontal plane with limited
Blocky	Bk	Block-like peds bounded by other peds whose sharp angular faces form the cast for the ped. The peds often break into smaller
Angular Blocky	Abk	Block-like peds bounded by other peds whose
Sub-angular Blocky	Sbk	Block-like peds bounded by other peds whose rounded subangular faces form the cast for the ped
Prismatic	Pr	Column-like peds without rounded caps. Other prismatic caps form the cast for the ped. Some prismatic peds break into smaller blocky peds. In these peds the horizontal development is limited when compared with the vertical
Columnar	Cpr	Column-like peds with rounded caps bounded laterally by other peds that form the cast for the peds. In these peds the horizontal development is limited when compared with the vertical.
Single grain	Sg	Particles show little or no tendency to adhere to other particles. Often associated with very coarse particles.
Massive	M	A massive structure show little or no tendency to break apart under light pressure into smaller units. Often associated with very fine-textured soils.

Size	Abbreviation
Very fine	vf
Fine	f
Medium	m
Coarse	c
Very Coarse	vc

Size	Angular and Subangular Blocky Structure (mm) diameter	Granular and Crumb Structure (mm) diameter	Platy Structure (mm) diameter	Prismatic and Columnar Structure (mm) diameter
Very fine	< 5	< 1	< 1 (Very thin)	< 10
Fine	5 – 10	1 – 2	1 – 2 (Thin)	10 – 20
Medium	10 – 20	2 – 5	2 – 5	20 – 50
Coarse	20 – 50	5 – 10	5 – 10 (Thick)	50 – 100
Very Coarse	> 50	> 10	> 10 (Very thick)	> 100

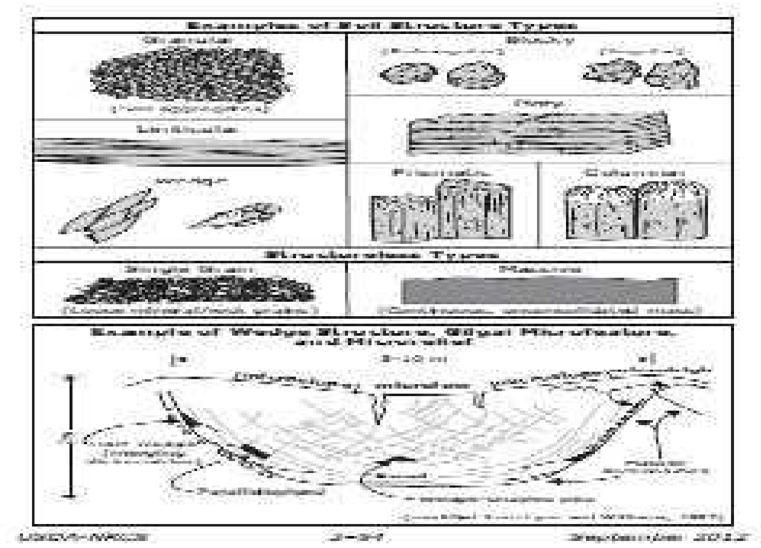


Fig. 10.1: Soil Structures

National Soil Survey Centre Natural

Resources Conservation Service (2012)

The three characteristics of soil structure are conventionally written in the order: grade, size and shape. For example, weak fine sub-angular blocky structure.

The distribution of different particle sizes in a soil influence the distribution of pores, which can be characterized by their abundance, size and shape.

Table 10.2: Abundance, Size, and Shape of Pores

Abundance	**Per Unit Area**
Few	< 1
Common	1 – 5
Many	> 5
Size	**Diameter (mm)**
Very fine	< 0.5
Fine	0.5 – 2.0
Medium	2.0 – 5.0
Coarse	> 5.0
Shape	
Vesicular approx, spherical or elliptical	
Tubular approx. cylindrical or elongated	
Irregularly shaped	

Significance of Soil Structure

Soil formation starts with an unstructured condition, i.e., the structure is single-grained or massive. Soil development also means development of soil structure, which describes the formation of peds and aggregates. Soil structure forms due to the action of forces (hat push soil particles together. Subsurface structure lends lo be composed of larger structural units than the surface structure. Subsoil structure also tends to have the binding agents on ped surfaces rather than mixed throughout the ped.

Climatically-driven physical processes that result in changes in the amount, distribution and phase (solid, liquid, and vapour) of water exert a major influence on formation of soil structure. Phase changes (shrinking-swelling, freezing-thawing) result in volume changes in the soil, which over time produces distinct aggregations of soil materials.

Physico-chemical processes (e.g., freeze-thaw, wet-dry, clay translocation, formation/removal of pedogenic weathering products) influence soil structure formation throughout the profile. However, the nature and intensity of these processes varies with depth below the ground surface. The structure and hydrological function of plant communities, texture, mineralogy, surface manipulation and topography all serve to modify local climatic effects through their influence on infiltration, storage and evapotranspiration of water.

Biological processes exert a particularly strong influence on formation of structure in surface horizons. The incorporation of soil organic matter is usually largest in surface horizons. Soil organic matter serves as an agent for building soil aggregates, particularly the polysaccharides appear to be responsible for the formation of peds. Plant roots exert compact stresses on surrounding soil material, which promotes structure formation. Soil-dwelling animals (e.g., earth worms, gophers) also exert compact forces, and in some cases (e.g., earth worms) further contribute to structure formation via ingestion/excretion of soil material that includes incorporated organic secretions.

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher;

1 the facilitator/teacher should ensure students take part in all demonstrations/practical.
2 the facilitator/teacher should teach in a simple way for easy understanding by the students.
3 adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Carry out the classification of structure using a profile pit
2. Make a diagram of the different soil structures as observed in the profile pit

6.0 REFERENCE/FURTHER READING

National Soil Survey Centre Natural Resources Conservation Service (2012) *Field Book for Describing and Sampling Soils*. U.S. Department of Agriculture

PRACTICAL 11

CONSISTENCE

CONTENTS

1.0 INTRODUCTION

Consistence refers to the cohesion among soil particles and adhesion of soil to other substances or the resistance of the soil to deformation. Whereas soil structure deals with the arrangement and form of peds, consistence deals with the strength and nature of the forces between particles.

2.0 OBJECTIVES

By the end of this unit, you will be able to:

- discuss the concept of soil consistence
- determine consistence in the field.

3.0 PROCEDURE

Consistence is described for three moisture levels: wet, moist, and dry. The stickiness describes the quality of adhesion to other objects and the plasticity the capability of being molded by hands. Wet consistence is when the moisture content is at or slightly more than field capacity. Moist consistence is soil moisture content between field capacity and the permanent wilting point. When recording consistence, it is important to record the moisture status as well. Cementation is also considered when consistence is described in the field. Cementing agents are calcium carbonate, silica, oxides or iron and aluminium.

Table 11.1: Classification of Consistence (Buol *et al.,* 1997)

Moisture Status	Consistence	Abbreviation	Description
Wet	Non-sticky	Wso	Almost no natural adhesion of
	Slightly Sticky	Wss	Soil material adheres to only
	Sticky	Ws	Soil material adheres to both
	Very Sticky	Wvs	Soil material strongly adheres
	Non-plastic	Wpo	No wire is formable by rolling
	Slightly Plastic	Wps	Only short (< 1cm) wires are formed by rolling material between the hands
	Plastic	Wp	Long wires (> 1cm) can be formed and moderate pressure is needed to deform a block of the molded material
	Very Plastic	Wvp	Much pressure is needed to deform a block of the molded material
Moist	Loose	Ml	Soil Material is non-
	Very Friable	Mvfr	Aggregates crush easily
	Friable	Mfr	Gentle pressure is required to
	Firm	Mfi	Moderate pressure is
	Very Firm	Mvfi	Strong pressure is required to
	Extremely Firm	mefi	Aggregates cannot be broken
Dry	Loose	Dl	
	Soft	Ds	
	Slightly Hard	Dsh	

	Hard	Dh
	Very Hard	Dvh
	Extremely Hard	Deh
Cementation	Weakly cemented	Cw
	Strongly cemented	Cs
	Indurated	Ci

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The acilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Determine the consistence of different soil horizons at different moisture levels.
2. Differentiate the soil behaviour at the different moisture levels.

6.0 REFERENCE/FURTHER READING

Buol, S.W., Hole, F.D., McCracken, R.J., & Southard, R.J. (1997). *Soil Genesis and Classification*. Iowa State University Press.

PRACTICAL 12

ROOTS

CONTENTS

1.0 INTRODUCTION

Plant roots give evidence of the plant root activity and the penetration. For example, it is important to record if roots only penetrate through cracks, are retarded by waterlogged layers or cemented layers. Other reasons for limited root penetration can be soil compaction or the absence of nutrients.

2.0 OBJECTIVES

By the end of this unit, you should be able to discuss how the presence of roots in the soil is estimated and calculated.

3.0 PROCEDURES

If there is no obstacle to root growth in the soil the roots may he distributed evenly in a soil. It is important to record the quantity and diameter of roots.

Table 12.1: Classification of Roots

Root Quantity Classes	**Per Unit Area**
Very few	< 0.2
Moderately few	0.2 to 1
Few	< 1
Common	1 to < 5
Many	> = 5

Size Classes of Roots	**Diameter in mm**
Very fine	< 1

Fine	1 – 2
Medium	2 – 5
Coarse	5 – 10
Very Coarse	> 10

4.0 CONCLUSION

The following conclusion should serve as a guide to the facilitator/teacher:

1 The facilitator/teacher should ensure students take part in all demonstrations/practical.
2 The facilitator/teacher should teach in a simple way for easy understanding by the students.
3 Adjustment can be made where necessary.

5.0 PRACTICAL QUESTIONS

1. Determine the quantity of roots in a square area within a horizon of a profile pit.
2. Determine the classes of roots in a horizon of a profile pit.