AGS 2110- FUNDAMENTALS OF SOIL SCIENCE

DETAILED COURSE OUTLINE by Victor Shitumbanuma

Introduction

Definition and concepts of Soil

History of Soil Science

Relation of Soil Science to other Sciences

Applications of Soil Science

Role of Soil Science in Food Production and Management of the Environment

Materials of the Earths

Composition of the earth

Crust, Mantle, and Core

Elemental Composition Earth's Crust

Rocks and Minerals definitions

Minerals

Chemical Classification of minerals- silicates, oxides, hydroxides, hydrous oxides, carbonates, sulphates, sulphides, phosphates, halides, native elements

Properties used to identify minerals specimens in the field

Colour, Streak, Lustre, Cleavage, Fracture, Hardness, specific gravity, reaction with acids

Rocks

Classification based on mode of formation

Definitions of Igneous, metamorphic, and sedimentary

Igneous rocks,

Formation, classification, texture- fine grained, coarse grained, porphyritic,

Examples of igneous rocks mineralogy

Metamorphic rocks

Contact and Regional metamorphism

Classification of metamorphic rocks

Sedimentary Rocks

Formation of sedimentary rocks

Classification of Sedimentary Rocks

Clastic rocks, Non clastic Rocks (Chemical and Biogenic rocks)

Rock cycle

Weathering

Definitions

Physical and Chemical Weathering

Physical weathering process, unloading, or exfoliation, frost wedging,

Chemical weathering: hydration-dehydration, simple solution, hydrolysis, carbonation, oxidation-reduction

Formation of Soils

Factors of soil formation

Soil parent materials (Organic and Mineral Soils)

Formation of soil horizons

Soil profile

Definition of Soil versus solum

Soil forming processes, - additions, losses, transformations, translocation

Examples of specific soil forming process – e.g. Communization, littering, leaching, Humification, rubification or ferrugination, eluviations, illuviation, podzolization, gleyzation, desilication, ferralitization etc.

Relationship between soil forming processes and specific soil horizons, e.g., Eluvation and formation of albic horizon, illuvation and formation of argillic horizon, podzolization and formation of spodic horizons, ferralitization and oxic horizons. Brief introduction to classification of soils.

Major soil horizons

Definitions and properties of: O-horizon, H-horizons, A-horizon, B-horizon, C –horizons, E- horizon, R-horizon

Soil Physical Properties important in Field Description of Soils

Soil Colour- Munsell Colour notation, Hue-Value- Chroma

Soil Structure

Definition of structure of aggregated soils

Type, Class and Grade, (Platy, Crumb, Granular, Angular block, Sub angular blocky, Prismatic, columnar)

Structure on non- aggregated soils, (Single grained, massive)

Soil consistency,

Definitions by moisture status (dry, moist, and wet),

Plasticity, stickiness

Aggregation and Aggregate stability

Determination of aggregate stability

Aggregate Instability Index (AAI) and its interpretation

Soil texture, definition, and determination by feel method.

Particles Size Analysis

Classification of soil particle, by size, clay, silt, sand, gravel, (USDA versus International System)

Methods of determining particle size distribution

Mechanical methods

Stokes equation

Determination of particle size distribution by hydrometer method

Determination of particle size distribution by pipette method

Determination of textural class of soil using the USDA Textural Triangle,

Major textural grouping of soils and relationship with physical and chemical properties of soils

Mass -Volume Relationship of Soils (Measurable Physical properties of Soils)

Density of Soils

Particle density

Dry bulk density

Wet bulk density or total density of soils

Dry specific volume

Fractional porosity

Air filled porosity

Degree of saturation

Soil water content

Gravimetric

Volumetric

Equivalent depth

Conversion of Gravimetric to Volumetric moisture contents

Soil water Potential

Definition of soil water potential
Components of soil water potential
Matric, Pressure, Osmotic, Gravitational
Measurements of soil water potential
Matric potential (pressure plate apparatus)
Relationship between matric potential and radius of pores filled with water
Relative humidity and soil water potential
Definition critical moisture contents (Field capacity, Permanent Wilting point)
Definition of soil moisture status (Oven dry, air dry, moist, wet, saturated)
Measurement of combined osmotic and matric (pychrometric)
Flow of water in soils (Saturated and unsaturated conditions)
Soil moisture characteristic curves
Determination of hydraulic head (H)
Water flow undersaturated conditions (Darcy's Law)

Soil Aeration *(The gaseous phase*)

Importance of aeration in soils for living organisms
Composition of soil air
Factors affecting aeration
Movement of air in soils
Mass flow and diffusion
Effects of poor aeration on plant growth (effects)
Wetlands and organic soils

Soil Chemical Conditions

The solid phase
Structure of silicate minerals
Nesosilicates
Sorosilicates
Cyclosilicates
Inosilicates
Phyllosilicates
Tectosilicates
Structure of layer silicate minerals
1: 1 layer silicates
2: 1 layer silicates (talc-pyrophyllite, smectite, vermiculites, micas, chlorites)
Relationship between structure, CEC,
Sesquixodes- Fe- oxides, Mn-oxides Al-oxides, Ti-oxides
Soil organic matter
Properties and characteristic of soils organic matter
Fractionation of humus
Sources of charge on soils colloids
Permanent versus variable charge
Behaviour of colloids in suspension
Factors affecting diffuse double layer thickness
Valency of counter ions
Charge on colloids

Concentration of bulk solution (EC)
Hydrated radius of counter ions
Temperature of system
Dielectric constant of system
Flocculation and dispersion
Aggregate stability in relation to colloidal behaviour
Classification of salt affected soils and relationship with aggregate stability
Saline soils, sodic soils, etc.

Cation Exchange Capacity (CEC)

Methods of determining CEC
Effective CEC
CEC sum of cations
CEC ammonium acetate
Base saturation
Aluminium saturation
Exchangeable sodium percentage

The Soil Solution *(Liquid phase of the soil)*

Definition of Soil solution and major constituents (anions and cations)
pH scale
Acidity definition
Active acidity
Exchangeable acidity
Non exchangeable acidity
Causes of acidity
Effects of acidity on soils as media for plant growth
Alkalinity- causes and effects
Interpretation of pH values for agronomic purposes
Sodicity- causes and effects of soils
Salinity- causes and effects on soils

Amelioration of Adverse soil chemical Conditions

Liming materials
Definition
Determination of Neutralizing Values
Approaches to neutralizing soil acidity:
Reducing levels of Aluminium saturation
Neutralizing exchangeable acidity
Raising soil pH to desired level
Calculation of lime requirements

Controlling Sodicity

Use of gypsum, $CaCl_2$
Application of acid or sulphur to calcareous sodic soils

Controlling Alkalinity

Use of acid, aluminum sulphate, elemental sulphur and other acidifying materials

Controlling Salinity

Determination of leaching requirements

Soil Biology
Definition of soil organic matter
Living and non living components of soil organic matter
Soil biomass
Major Microorganisms found in soils
Classification of soil organisms found in soils according to kingdoms
Source of carbon, source of energy, mode of respiration
Environmental conditions affecting microbial survival
Temperature, pH, moisture, oxygen requirements, substrates
Common microbes in soils
Bacteria- classification, environmental adaptation, major function in soils
Actinomycetes- classification, environmental adaptation, major function in soils
Fungi classification, environmental adaptation, major function in soils
Protozoa- classification, environmental adaptation, major function in soils
Algae -classification, environmental adaptation, major function in soils
Carbon transformations and soils organic matter formation
Factors affecting OM decomposition, C:N ratios C: S, C: P
Nitrogen cycle
Carbon cycle,

Soil Fertility and Plant Nutrition

Essential elements for plants
Macronutrient sand micronutrients (definitions)
Bioavailable forms of plant nutrients
Requirements of soil for supply of plant growth
Definition of chemical fertility of soils
Means of nutrients transfer from soil to plant roots
Mass flow, diffusion, root interception

Fertilizers
Definition. Chemical versus Organic fertilizers
Classification of nutrients in fertilizer terminology
Primary, Secondary, and micronutrients
Classification of fertilizers based on number of primary nutrient (Compound versus Straight)
Fertilizer grades, guarantee and nutrient expressions
Fertilizer applications methods
Broadcasting, banding, fertigation, foliar application
Calculation of fertilizer requirements based on soil nutrient status and crop nutrient requirements.

Soil Classification
Principles of Classification
USDA Soil taxonomy
Structure of Soil Taxonomy
Order, Suborder, Great Group, Subgroup, Family
Major diagnostic surface and subsurface horizons,
Moisture regimes
Major Orders in Soil taxonomy
Occurrence and distribution of Soils in Zambia
Challenges to management of major Zambian soils