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Licensure Examination in Agriculture Reviewer

(Lecture Manual and Review Questions)

SOIL SCIENCE

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SOIL SCIENCE

I. CONCEPT OF SOIL

- **Soil**
  - a mixture of organic and inorganic materials which developed on the earth's surface through weathering processof rocks and minerals and whose properties are conditioned in various degrees by the influence of climate, living organisms, and topography acting on the parent material over a period of time
  - serves as a medium of plant growth (physical support for anchorage of plant roots; water and nutrient supplier)
  - considered a non-renewable resource because it takes about a hundred years for natural processes to form an inch of soil
  - a natural body with dimensions of thickness and width with indistinct horizontal boundaries enabling it to blend with other soils and vertical boundaries of the air above it and the unweathered rocks below it

- **Soil surface**
  - this term is based on the upper limit of soil which is the boundary between soil and either air, shallow water, live plants, or plant materials that have not begun to decompose

- **Soil individual**

i. Pedon
  - a hexagonal column of soil measuring from 1 to 10 m^2 in top surface area
  - the basic sampling unit used in soil surveys

ii. Polypedon
  - an essential soil individual, comprising an identifiable series of soils in an area
  - made up of multiple pedons and has distinctive characteristics that differentiate it from surrounding polypedons

- **Approaches in the study of soil**

i. Pedological approach
  - (Greek: *pedon*, soil or earth) the study of soils with principal interest on characterization and differentiation of their properties and with only minor emphasis on their practical use
  - Ex. Study of soils for their taxonomic classification; soil as a natural body

ii. Edaphological approach

- (Greek: *edaphos*, soil or ground) the study of soils with emphasis on their practical use, particularly the relationship of soil properties to plant growth
- Ex. Study of soil fertility; Variability of soil productivity; Methods of conserving and improving productivity

- **Fields of study in Soil Science**

i. ***Soil Fertility***: quality of a soil to provide optimum level of nutrients for plant growth
ii. ***Soil Physics***: characteristics, processes, or reactions of a soil caused by physical forces
iii. ***Soil Chemistry***:interactions of solid, liquid, and gaseous phases or components of soil
iv. ***Soil Microbiology***:soil biochemical reaction carried out primarily by microorganisms
v. ***Soil Conservation and Management***: protection of soil against physical loss by erosion or chemical deterioration; totality of all tillage operations, cropping practices, fertilization, liming etc. conducted on a soil for crop production
vi. ***Soil Survey and Classification***: deals with the structural characteristics, mode of origin, and systematic arrangement of soils
vii. ***Soil mineralogy*** : structural chemistry of the solid components of soil
viii. ***Land use***: deals with the allocation of lands for general or broad purposes such as agriculture, forestry, settlement and military reservations

- **Different components of soil-** the proportion of the different components varies in properties among soils

i. Soil solids

- ***Mineral matter***, 45%
  - comes from the weathering of rocks and minerals
  - composed of sand, silt, and clay particles vary among soils
  - major source of all nutrient elements (except nitrogen, carbon, and oxygen) needed for plant growth

- ***Organic matter***, 5%
  - derived from the decayed and decaying remains of plants and animals intimately mixed with the mineral matter
  - the chief natural source of nitrogen; indicative of the nitrogen status of the soil
  - also contributes phosphorus, sulfur, and micronutrients but in smaller amounts compared to mineral sources
  - enables the soil to store cations
  - promotes the formation and stabilization of aggregates, giving the soil greater permeability and porosity
  - *Organic soils* contain more than 20% organic matter; most soils contain less than 20% organic matter, thus classified as *mineral soils*

ii. Pore spaces

- ***Air***, 20-30%

- occupies the pore spaces of the soil
- composed largely of elemental nitrogen (78%), oxygen (20%), carbon dioxide (0.5%), and traces of other gases
- provides oxygen for respiration of plant roots
- For dryland or upland crops, it is ideal that at least half of the pore spaces be occupied by air.
- There must be enough aeration at the root zone for easy exchange of CO_2 and O_2 between the soil pores and the aboveground atmosphere so that CO_2 would not build up to high levels which can be toxic to plant roots.
- The CO_2 in soil air is typically higher in concentration than that aboveground because of the accumulation from CO_2 evolution from organic matter decomposition, plant root respiration, and reaction products of carbonate materials.

∞ ***Water*** 20-30%
- also occupies the pore spaces of the soil
- contains dissolved gases and salts or compounds as well as dissociated ions of various nutrient elements
- carries the nutrients to the proximity of roots where they can be absorbed
- also serves as a weathering agent of minerals to constantly renew the nutrient supply in the soil
- needed by the plant in large amounts for their metabolic functions
- In paddy soils such as in lowland rice fields, the pore spaces are nearly filled with water.
- The dissolved CO_2 in soil water forms carbonic acid which is a solvent that can release nutrients from minerals.

II. WEATHERING AND SOIL FORMATION

- **Rocks** : aggregates of minerals
- **Petrology**: study of rocks
- **3 General classification of rocks**

i. Igneous rocks
∞ original rocks formed from the solidification of molten magma at temperatures of 900 °C to 1600 °C within or outside the earth's crust
∞ The most common soil-forming igneous rocks are granite, diorite, gabbro, ryolite, andesite, basalt, and obsidian
∞ Granite and diorite are lighter in color due to the high proportion of light-colored minerals such as feldspar and muscovite.
∞ Gabbro is dark in color due to the predominance of dark-colored minerals such as biotite, hornblende, and augite.
∞ Granite is acidic while basalt is basic.
∞ Basalt and andesite are among the dominant soil-forming rocks in the Philippines. Examples are the soil series of Adtuyon, Antipolo, Guimbalaon, and Jasaan

ii. Sedimentary rocks

- ∞ formed from other existing rocks through fragmentation, transport (by water) and recementation
- ∞ concentrated near the crust's surface, thus exert a dominant effect on many soils of the world
- ∞ The most important soil-forming sedimentary rocks are limestone, dolomite, sandstone, and shale.
- ∞ Limestone is made up chiefly of the carbonate mineral, calcite or $CaCO_3$.
- ∞ Dolomite is also a carbonated material composed of calcium magnesium carbonate $CaMg(CO_3)_2$.
- ∞ Sandstone is composed of cemented sand grains.
- ∞ Shale is made up of fine particles of clay which become consolidated after deposition in bodies of water.
- ∞ Soils derived from shale/ sandstone are soil series of Alaminos, Bantay, Bauang, Lugo and Ubay.
- ∞ Soils derived from limestone are soil series of Faraon, Bolinao, Binangonan, and Alimodian which are the soils in Cebu and Bohol.

iii. Metamorphic rocks

- ∞ formed from other existing rocks through the processes or remelting and recrystallization under very high temperature and pressure
- ∞ The most typical soil-forming metamorphic rocks are gneiss, schist, quartzite, slate, and marble.
- ∞ Marble is the metamorphic form of limestone.

♦ **2 Modes of rock formation**

i. Extrusive (volcanic) formation

- ∞ happens when the magma is ejected out of the earth's crust through volcanic eruption and solidifies on the surface
- ∞ There is abrupt cooling of the magma and less time for crystal growth.
- ∞ The rock formed is fine-grained. Ex. basalt

ii. Intrusive (plutonic) formation

- ∞ happens when magma solidifies within the earth's crust
- ∞ There is more time for crystal growth of the magma because of slow cooling due to high temperature.
- ∞ The rock formed is coarse-grained. Ex. Granite

♦ **8 Most abundant elements in the earth's crust**

i. Oxygen (46.6%)
ii. Silicon (27.7%
iii. Aluminum (8.13 %)
iv. Iron (5.0%)
v. Magnesium (2.09%)
vi. Calcium (3.63%)
vii. Sodium (2.83%)
viii. Potassium (8.13%)

♦ **Mineral**

- ∞ a naturally occurring inorganic substance with more or less definite chemical composition and specific physical properties
- ∞ serves as building block of rocks

♦ **Mineralogy** : study of minerals and their properties

- **2 General classifications of minerals**

i. Primary minerals

- persist in the soil in their original state due to high resistance to decomposition
- chief sources of the sand and silt fractions of soils
- Some of the most important primary minerals
  - Quartz, SiO_2 (microline): a predominanty Quartz parent material is expected to give rise to sandy soils; does not contribute to soil fertility because of its main composition of SiO_2
  - Orthoclase, K $AlSi_3O_8$ (anorthite) : contributes K upon weathering
  - Sodium-plagioclase, Na $AlSi_3O_8$ (albite) : contributes Na upon weathering
  - Calcium-plagioclase,Ca $Al_2Si_2O_8$: contributes Calcium upon weathering
  - Muscovite, K $Al_3Si_3O_{10}$ $(OH)_2$ (white mica)
  - Biotite (black mica)
  - Hornblende
  - Augite
  - Apatite

ii. Secondary minerals

- arise from the chemical breakdown of the least resistant primary minerals
- contributes the clay fraction to the soil
- The more commonly occurring secondary minerals are:
  - Calcite
  - Dolomite
  - Gypsum
  - Limonite
  - Hematite
  - Gibbsite
  - Kaolinite
  - Montmorillonite
  - Illite

- **2 Types of weathering of rocks and minerals**

i. Physical weathering

- breaking up or rocks and minerals into smaller pieces without any drastic alteration of their chemical composition
- Example: *Unloading* which refers to the imperceptible movement of rock formation towards the earth's surface resulting in cracking or rocks.
- Example: A freezing water in narrow cracks in the rocks can cause physical disintegration due to expansion and contraction in response to the alternate cooling and heating.

ii. Chemical weathering

- involves change in the chemical structure and composition of rocks and minerals which results into simpler products
- The processes involved are
  - *Hydrolysis* : the reaction of water with the mineral resulting in the destruction of the original chemical structure and the formation of an acid and base

Ex. Potassium feldspar reacted with water to form silicic acid and potassium hydroxide (base)

- *Hydration*: also involves the reaction of water with the mineral but not leading to the destruction of the chemical structure; The result is a rigid attachment or association with a water molecule.
  Ex. The transformation of hematite to limonite
- *Oxidation*: changes the iron in the mineral from ferrous (reduced) to ferric (oxidized) form; the reduction in size and increase in valency of Fe results in the weakening and instability of the mineral's structure
  Ex. Ferrous oxide to hematite
- *Carbonation*: the reaction of carbonic acid (H_2CO_3) with a mineral to produce a more soluble product
  Ex. The transformation of calcite to calcium bicarbonate
- *Solution*: the dissolution of minerals through the solvent action of H_2CO_3 or H^+ ions which results into the separation or dissociation of component cations
  Ex. Silica is dissolved from minerals and washed off from the soils.

- **Stages of soil formation**: Rocks and its component minerals undergo weathering resulting into the partially broken parent material. Further weathering allows development of soil horizons.
  - ***i.*** Physical weathering: reducing the size of the parent material (rocks and minerals) particles
  - ***ii.*** Rearranging the mineral particles
  - ***iii.*** Adding of organic matter
  - ***iv.*** Chemical weathering: changing the composition and structure of minerals including clay formation
  - ***v.*** Formation of soil horizons

- **5 factors of soil formation (CLORPT)**

1. Climate: affects the amount of leaching that takes place in the soil and the speed with which soil horizons develop

- ***Temperature***
  - As the mean annual temperature increases, the weathering of rocks and minerals in the soil will be faster.
  - For every 10 °C rise in temperature, the rate of biochemical reactions doubles.
  - Tropical soils will weather faster because of faster chemical reactions which can occur throughout the year.

- ***Rainfall***
  - Areas with more rainfall will have greater weathering (hydration and hydrolysis) and greater leaching.
  - Leaching occurs when water moves through the soil and removes the soluble constituents.
  - Soluble silica and bases are leached out to give rise to soils high in kaolinite and sesquioxides.
  - Water is an agent of erosion and deposition of soil materials.

- At optimum levels, water facilitates decomposition of organic matter.
- Cool and wet areas will have more leaching than hot and wet areas.
- In areas with low rainfall, silica and basic cations like Ca, Mg, Na and K accumulate and form monmorillonitic soils.
- Hot and dry areas have slower soil formation resulting to a shallow solum.

2. Living organism

- affects soil formation through their effect on the amount and kind of organic material decomposed and accumulated
- Vegetation affects the thickness and color of the surface horizons.
- *Bioturbation*: the mixing of the soil by organisms
- Soils of forested areas (dipterocarps) have thin surface horizon, leached, light colored zone below the surface and an accumulation zone that is often brown or red in color.
- Soils of grassland areas have thick, black surface horizon.

3. Relief or Topography

- The shape or contour of the land surface affects the movement and accumulation of water which can modify the effect of the climate factor.
- Steep slopes: less water to soak the soil but more runoff to erode the surface thus preventing the formation of a thicker soil profile
- Flat lowlands: develop thicker solum due to accumulation of moisture and deposition of soil materials from the uplands
- Soils at the summit and shoulder will develop horizons the fastest.
- Soils on the backslope will develop slower.
- Soils at the footslope will collect sediments from the upslope.

4. Parent material

- the partly weathered mineral or organic debris from which true soil (solum) is formed
- the starting point of soil formation at zero time of formation
- 2 general classification of parent material
  - *sedentary or residual*: those that develop in place and formed from the rock below where it is found
  - *transported*: those which are transported by various agents and deposited in other sites where they form the soil. The different types based on the agent and manner of transport are the following:
    - *Alluvium*: accumulated from running water i.e. rivers and streams; Ex. Soils surrounding the Cagayan river; the central plains of Luzon
    - *Lacustrine*: materials that are accumulated in former lakewaters
    - *Marine*: materials that are accumulated in former oceans
    - *Glacial till or moraine*: those that are carried and deposited by moving glaciers
    - *Aeolian* : those that are carried and deposited by the wind; Ex. Sand

dunes; extensive soils around Taal volcano developed from volcanic ash

- *Volcanic tuff:* a stratified rock hardened (lithified) from deposited fine dust or ash emitted on a volcanic eruption; Soil series of Lipa, Guadalupe, Ibaan, Magallanes, Tagaytay, Novaliches, and Taal are formed from volcanic tuff parent material.
- *Collovium* : those transported and deposited by gravity

5.Time

- ∞ (age of soil) the length of time in years since the land surface became stable ; depends on how much development the soil has undergone
- ∞ A young soil has minimal soil development and few horizons.
- ∞ Alluvial soil is generally a young soil because of the constant deposition which renews the parent material.
- ∞ The older the soil, the less it reflects the properties of the parent material.
- ∞ As development proceeds, more of the soluble components particularly the bases are leached out.
- ∞ Old soils have thick solum but are generally acidic and low in fertility.

♦ **Soil profile** : a vertical cross section of the soil exposing all of its horizons

♦ **Soil horizon** : a layer of soil or soil material approximately parallel to the land surface and differing from adjacent horizons in physical, chemical and biological properties

♦ **Horizon differentiation** : process wherein each horizon acquires distinctly different properties from the others due to various mechanisms of addition, losses, translocation and transformation

♦ **Mechanisms of Addition and Transformation**

i. Enrichment : general term for the addition of any material to the soil body

ii. Melanization : admixing of organic matter to the mineral matter which darkens the soil

iii. Cumulization: addition of mineral matter trough wind and water to the soil body

♦ **Mechanisms of translocation**

i. Illuviation : general term for the movement of soil material from one part of the soil to another resulting in the formation of argillic (clayey) layers

ii. Calcification: the transfer and accumulation of calcium carbonate in particular soil horizon

iii. Decalcification: removal of calcium carbonate from the soil horizon

iv. Salinization : accumulation of soluble salts of sulfates and chlorides of calcium, magnesium, sodium and potassium in certain horizons; Opposite: Desalinization

v. ***Alkalinization*** (solonization) : accumulation of sodium ions; Opposite: Dealkalnization (solodization)
vi. ***Podzolization*** (Silication) : the translocation of aluminium and iron and/or organic matter thus, concentrating the silica in the leached layer
vii. ***Laterization*** (Desilication) : the transfer of silica from the solum, thus concentrating the aluminium and iron oxides and sesquioxides in the leached layer
viii. ***Leucinization*** : paling or loss of dark colorof the soil due to the removal of organic matter from the solum
ix. ***Lessivage*** : specific term for the movement of fine mineral particles from the top soil resulting in the enrichment of clay on the lower horizon

- **Solum** : A and B, zone of pedogenic activity; considered as the true soil because these are the layers reached and used by the roots as source of water and nutrient

- **Pedoturbation** : the biological (by soil organisms) and physical (freezing, thawing, wetting, drying) mixing of soil materials resulting into the homogenization of the solum
- **Regolith** : all loose materials above the bedrock (A,B, and C horizons)

- **Naming soil horizons**
  i. One capital letter is used to designate master horizons (A,B,C)
  ii. Two are used for transitional horizons (AB,BC)
  iii. Lowercase subscripts are used to subdivide master and transitional horizons (Bt,Ap) and to designate important horizon properties
  iv. Descriptive soil profile symbols
    O: Horizon dominated by organic matter
    A: Organic-rich, mineral horizon at or adjacent to the surface
    E: Mineral horizon of maximum eluviation
    B:Mineral horizon of maximum illuviation and formed beneath an O,A, or E
    C: Weathered parent material
    R: underlying consolidated bedrock

Surface Horizons: mainly influenced by the addition of organic matter
  O: surface litter – Oi, Oe, Oa
  A: topsoil - Ap
  AB: transition horizon
Subsurface horizons: developed due to the translocation, transformation and losses
  E (zone of leaching) – B (subsoil) – Bt, Bw, Bk
  C horizon: weathered parent material; outside the zone of soil development; little altered by soil forming processes
  R horizon:bedrock; impenetrable layer

III. PHYSICAL PROPERTIES OF THESOIL

- **Soil Texture**
  - the relative proportion of the various size fractions: sand, silt and clay in the soil
  - a relatively stable property of the soil
  - No amount of organic matter added can alter soil texture since it is determined by proportions of the inorganic components sand, silt and clay.

- When flooding deposits huge amounts of any of these fractions in an area, then that is the case when soil texture can change/
- Soil texture can also change when volcanic eruption deposits huge amount of sand-sized particles in an area.
- Generally, coarse-textured soils are less fertile because they contain many primary minerals such as plagioclase feldspars, quartz, and magnetite with low bases and do not release many nutrients important to plants. They are also easily leached.
- Upland crops are more suitably grown in coarse to medium-textured soils, particularly the tuber crops where the tubers can more easily develop.
- Fine to medium- textured soils are more suitable for growing paddy rice because water can be impounded longer than in sandy soils.
- The sand and silt fractions provide for the framework for the soil because of their bigger particle sizes
- Large spaces in between sand and silt particles facilitate air and water movement, so coarse-textured soils are better drained.
- Clayey soils are generally more fertile but tend to be plastic and sticky when wet.
- Clayey soils have greater water holding capacity because of greater total volume of pore spaces.
- Water moves slowly in clayey soils but farther in the long run because the water channels are mostly through capillary pores.
- References for soil separates diameter: (USDA) United States Department of Agriculture and (ISSA) International Soil Science Society

- **Soil separates and their characteristics**
  - Sand particles are the largest fractions and are more or less rounded.
  - Particles of sandy soils are more loosely cemented so they are easier tilled even when wet or dry.
  - Relationship between particle size and surface area:
    - The smaller the particle size, the greater is the total surface area of a given mass of soil.
    - Clayey soils have greater surface area than sandy soils.

Table 1. Properties of the different soil separates.

Soil separate	Diameter (mm) range (USDA)	Diameter (mm) range (ISSA)	Characteristic "feel"	Mineral sources	Shape
Sand	2 – 0.05	2 – 0.02	Coarse, gritty	Mostly primary minerals (quartz and feldspars)	Cubic to spherical

Silt	0.05 – 0.002	0.02 – 0.002	Smooth, powdery	Mostly primary minerals (quartz and feldspars)	Cubic to spherical
clay	<0.002	<0.002	Sticky and plastic when moist	Mostly secondary "clay" minerals having high specific surface area	Plate-like, flake-like, some are tubular

Easy to till ("light" soil)	Difficult to till ("heavy" soil)
Non sticky and non plastic when wet	Very sticky and plastic when wet
Low nutrient holding capacity (less fertile)	high nutrient holding capacity (more fertile)

- **Textural Triangle**: shows the percentage of sand, silt and clay at various textural classes. To find the textural class of soil in the Textural Triangle given their respective percentages f soil separates, simply find the intersection point where the soil separates meet.

Table 2. Comparison between sand and clay separates.

Sands	**Clays**
Low total porosity (more macropores)	High total porosity (more micropores)
Low water holding capacity (droughty)	High water holding capacity
Very good aeration	Poor aeration and drainage

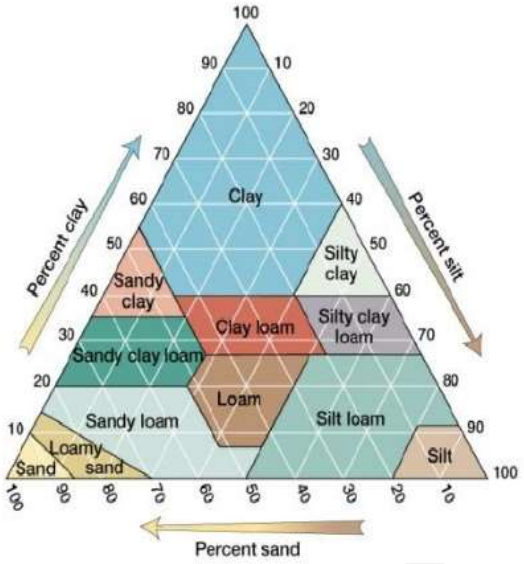


Figure 1. The Textural Triangle
Lifted from http://www.public.iastate.edu/~arossi/texture%20triangle.jpg

- **The 12 Textural Classes**
  - The first three classes are classified roughly as coarse-textured soils
  - Loam to silty clay loam are medium-textured soils
  - Sandy clay to clay are fine-textured soils
  - Loam is the ideal texture for growing most crops because this class has nearly equal proportions of desirable properties attributed to sand, silt and clay

Table 3. The 12 Textural Classes.

Textural Group	Textural Class
1. Sands	1. Sand (S) (85% sand or more)
	2. Loamy sand (LS) (75-85% sand)
2. Loams	3. Sandy loam (SL) (43 – 52% sand)
	4. Loam (L) (less than 52% sand, 7-27% clay, 28 – 50% silt)
	5. Silt loam (SiL) (less than 50% silt)
	6. Silt (Si)
	7. Sandy clay loam (SCL)
	8. Silty clay loam (SiCL)
	9.Clay loam (CL)
3. Clays	10. Sandy clay (SC)
	11. Silty Clay (SiC)
	12. Clay (C) (40% clay and more, less than 45% sand, less than 40% silt)

- **Soil texture determination**

i. Feel method

- rapid method which can be used in the field without the use of any elaborate instruments
- qualitative method and can only approximate the soil texture
- rubbing moist soil between the fingers and estimating the characteristic "feel" of the dominant soil separate in the soil
- The word texture refers to the sensation when one rubs the material with the finger.
  - Sandy soils will feel gritty and rough.
  - Silty soils are smooth and powdery.
  - Clayey soils are plastic sticky.

ii. Roll method

- The moist sample is kneaded into a rod and the texture is approximated by the ability to form rods or of the rods to remain intact when bent into a loop.
- Sandy soils do not form rods.
- Medium textured soils such as loam and silt loam form rods but which break easily when a loop is formed.
- Clayey soils such as silty clay, sandy clay, and clay form a continuous rod and which can be moldedinto a ring without cracking or breaking.

iii. Mechanical analysis (Hydrometer method and Pipette method)

- uses the principle expressed by Stoke's Law of sedimentation which states that the settling velocity of soil particles in an aqueous medium is directly proportional to the square of their diameter multiplied by a constant
- In equation, $V=KD^2$
  where V = settling velocity
  K = constant to correct for variations in temperature and viscosity of the soil suspension
  D = diameter of the particles, mm
- The bigger the particle, the faster is the settling velocity.
- In a soil suspension where the soil separates (sand, silt, and clay) were dispersed, sand will settle first (after about 4 minutes) followed by silt, and lastly by clay particles (about 7 hours).
- Hydrometer Method:
  - Destroying the organic matter to remove the cementing material of the soil separates
  - Dispersing the soil vigorously with sodium hexametaphosphate
  - The suspension is made up to one liter in a Buoyoucous jar
  - A hydrometer is floated at specific time intervals

- **Soil structure**

- refers to the clustering of the soil particles into characteristic aggregates of various sizes, shapes and stability
- the shape that the soil takes based on its physical and chemical properties
- an unstable property
- The nature of soil structure does not depend on the relative proportion of sand silt and clay because it deteriorates with poor soil and crop management.
- Soil structure is affected by the kind and amount of cementing materials, the position of the soil in the profile, and by the management the soil has been subjected to.
  - The greater the amount of cementing materials, the greater the aggregation and stability of soil structure.
  - The major cementing agents in soil structure formation are colloidal clay, oxides of iron and aluminium (sesquioxides) and organic matter.
  - Humus binds particles together by virtue of its gel-like property.
  - Decomposing organic matter produce by-products of microbial metabolism which act as cementing substances.
  - Fungi and streptomycetes produce mucilaginous substances that bind soil particles together.
  - Calcium-rich (calcareous) soils are generally well granulated while sodium –rich (sodic) soils are highly dispersed
- Structureless conditions
  - Little or no aggregation; the particles occur as single grains e.g. in sandy soils
  - Compacted soils: the soil particles are bound together in large mass e.g. paddy soils
- The best soil structure for good plant growth is the granular specifically, crumb structure because it has good distribution of large and small pores.
- Laying mulch on the soil surface prevents destruction of the soil aggregates by raindrops as well as provides organic matter that can later be plowed under.
- Infiltration is fastest where soil structure is granular or single-grained, moderate for prismatic or blocky and slow for massive and platy.
- Sustainable soil management depends on how we manage good soil structure

- **Structural classes based on the shapes of the aggregates**

i. ***Prismatic structure*** : pillar-like with level tops
ii. ***Columnar structure*** : pillar-like with rounded tops; like prismatic structure, commonly occur in subsoils and in soils of arid and semi-arid regions
iii. ***Blocky structure*** : cube-like and has more or less sharp edges and the rectangular faces are distinct
iv. ***Sub-angular blocky structure*** : has edges which are more or less rounded; like the blocky structure, typical in clayey subsoils particularly in humid regions
v. ***Platy structure***: has disc-like aggregates; commonly found in virgin soils and subsoils; generally make the soil poorly drained

vi. Spheroidal structure: rounded aggregates which are more porous; characteristic of surface soils especially those high in organic matter content

- Granular / Crumb : resembles cookie crumbs; commonly found in surface horizons where roots have been growing

Table 4. Comparison between soils with good and poor soil structure.

Poor soil structure	Good soil structure
Massive or compacted soil	Well-aggregated crumb
Dominantly micropores	Balanced macro and micropores
Poor drainage Poor aeration Poor root growth	Micropores for water storage Macropores for drainage, aeration and root growth
Hard to till	Easy to till
Low porosity	High total porosity
High bulk density	Low bulk density

- **Soil pore spaces**
  - fraction of the soil volume occupied by air and water
  - The micropores (small-sized pores) are formed within the aggregate; they store water.
  - The macropores (large-sized pores) are formed in between aggregates; they drain excess water, provide aeration and root proliferation.
  - As a medium for plant growth, a soil should have good proportion of the micropores and macropores.

- **Bulk density**
  - the mass (dry weight) per unit volume of soil
  - Mathematically,

    B.D. = W_s / V_t

    where: B.D. =bulk density in g/cm^3

    W_s = oven-dried weight of soil in g

    V_t = total volume of soil clod in cm^3 (includes solids and pore spaces)
  - a measure of degree of compaction of the soil and an indicator of porosity
  - The more compacted the soil, the greater is the bulk density value and the less porous it is.
  - The range of bulk density values for sand and sandy loam soils is 1.20 to 1.80 g/cm^3.
  - The range of bulk density values for clay, clay loam and silt loam is 1.0 to 1.60 g/cm^3.

Table 5. Interpretation of some bulk density values.

B.D. values	Interpretation
1.0 to 1.3 g/cm^3	Normal soil
> 1.3 g/cm^3	Compacted soil, poor soil structure
< 1.0 g/cm^3	Very loose soil

- **Factors affecting bulk density**

i. Soil texture

- ∞ The coarser the texture, the higher the bulk density and vice- versa.
- ∞ Sandy soils have higher bulk density because the particles tend to lie closer together; they are more closely packed
- ∞ Fine-textured soils such as silt loam, clay loam, and clay are generally well aggregated with large pores between aggregates giving low bulk density values.

ii. OM content: Higher OM, lower B.D.

iii. Cultivation

- ∞ If cultivation results in compaction, B.D. is higher.
- ∞ If cultivation results in loosening of soil, B.D. is lower.

iv. Depth in the Profile

- ∞ B.D. generally is higher with depth due to compaction brought about by the weight of overlying layers
- ∞ Soils in the deeper horizons have higher bulk density due to their lower organic matter content, less aggregation, less root penetration.

- **Particle density**
  - ∞ mass (dry weight) per unit volume of soil excluding the pore spaces within that soil volume
  - ∞ In equation,
    P.D. = Ws /Vs
    where: P.D. = Particle density in g/cm^3
    Ws = oven-dried weight of soil in g
    Vs = volume of soil solids in cm^3
  - ∞ Values of P.D. have a narrower range of 2.50 to 2.75 g/cm^3; Mean P.D. = 2.65 g/cm^3
  - ∞ P.D. of a given soil is constant thus unaffected by fineness of the particles nor by the arrangement of soil colloids
  - ∞ P.D. may indicate the mineral ancestry of the soil
  - ∞ High P.D. (>2.70 g/cm^3) may indicate soils derived from heavy (iron-bearing) minerals (magnetite, hornblende, zircon)
  - ∞ Low P.D. (<2.50 g/cm^3) may indicate soils have high organic matter
  - ∞ Since organic matter is generally higher in topsoils than in subsoils, surface soils usually have lower particle density.
  - ∞ P.D. of organic matter is 1.20 to 1.50 g/cm^3

- **Porosity**

- ∞ Porosity signifies the extent of pore space expressed as percentage of the bulk volume of the soil.
- ∞ In equation,
  % Pore spaces = {1- (B.D. / P.D.)} x 100
- ∞ The higher the bulk density of the soil, the lower is its porosity.
- ∞ As the bulk density approaches the value of the particle density, the percentage porosity approaches zero.
- ∞ If we can compact the soil to the extent that no pore space is left, B.D. will be equal to P.D.

♦ **Aeration Porosity**
- ∞ The volume of soil pore spaces left occupied by air after the other pore spaces are filled with moisture
- ∞ For upland/dryland crops, it is ideal that only about half of the total volume of soil pores be filled with water to let the plant roots to "breathe".

♦ **Soil water**
- ∞ constitutes the primary source of water for terrestrial plants
- ∞ carries the ions and the solutes to plant roots where they can be absorbed
- ∞ moves further in fine textured soils than in coarse textured soils
- ∞ Soil moisture that surrounds soil particles is held at varying degrees of tenacity.
- ∞ The farther away the moisture film from the surface of the soil particle, the weaker is the attraction between soil and moisture.
- ∞ Soil moisture is held more tenaciously in fine textured soils because of the proximity of the predominant micropores present.
- ∞ For the benefit of the plant growing on the soil, it is best to maintain the soil moisture content within the rootzone of the plants as close as possible to the upper limit of the available moisture range.

♦ **Soil moisture tension (SMT)**
- ∞ the force by which water is held in the soil
- ∞ the force that must be overcome by plant roots to draw water from the soil
- ∞ expressed in atmospheres (atm) or bars, where 1 atm = 1.01325 bar; 1 bar = 0.9869 atm
- ∞ Tension becomes larger when the amount of water stored or retained is smaller.
- ∞ SMT is low in wet soils and increases as the soil dries up.
- ∞ Soil moisture moves from a zone of low SMT to a zone of high SMT, from wetter to a drier portion of the soil.

♦ **Soil moisture –release curve**
- ∞ A graph showing the relationship between moisture content and moisture tension of the soil, and the characteristic of the soil itself.

♦ **Calculations of Moisture Content (MC)**

i. Gravimetric: MC by weight (MCw)

- ∞ the weight (or mass) of water per unit weight of soil in which it is contained
- ∞ In equation,
  %MCw= [(FW – ODW) / ODW] x 100
  where:
  % MCw = percent moisture content of the soil by weight
  FW = fresh weight of the soil, g
  ODW = oven-dried weight of soil, g
- ∞ easily determined by oven drying the soil at 105 – 110 °C for at least 15 hours to a constant weight

ii. Volumetric: MC by volume (MCv)

- ∞ the volume of water per unit of bulk volume including soil solids plus pore spaces of the soil
- ∞ the conversion from MCw to MCv using the Bulk density of the soil (g/cm^3) is
  %MCv = %MCw x B.D.

iii. Soil water Depth

- ∞ H_{sw} = MCv x H_t
  Where H_t = total depth of soil

♦ **Availability *of water at various moisture conditions***

i. Water at saturation

- ∞ All pore spaces are completely filled with water (maximum water holding capacity)
- ∞ Occurs after a heavy rain and persists for only a short period of time
- ∞ SMT =0; the water in the soil is loosely held by the particles and it easily drips with the action of gravity

ii. Water at Field Capacity (FC)

- ∞ An estimate of the upper limit of the available moisture range
- ∞ SMT = 1/3 bar; occurs when excess water has drained from the large pores after a period of saturation and only the water at the smaller pores is left

iii. Water at Permanent Wilting Point (PWP)

- ∞ an estimate of the lower limit of the available moisture range
- ∞ SMT = 15 bar; the point where the plant begins to wilt permanently because it can no longer draw up the very little moisture due to very high moisture tension

iv. Hygroscopic (water) coefficient

- ∞ the water film at the immediate surface of the soil particle
- ∞ not available for plant use
- ∞ held at a very high SMT of 31 atm

v. Available Water (AW)

- ∞ Computed by getting the difference between FC and PWP ,i.e. AW= FC – PWP

vi. Gravitational water

- ∞ also called drainage water; the water which soon drains out of the macropores
- ∞ the difference between the water at saturation and the water at field capacity

- **Measuring soil moisture status**

i. Gypsum blocks

- small cubes of gypsum connected to wires and buried at specified depths of the soil where water status is to be monitored
- The electrical resistance in a porous material like gypsum changes with the changes in moisture content.
- The block is calibrated so the electrical resistance is converted into moisture content (applicable from 1 to 15 atm SMT).
- It equilibrates with the moisture content in the soil when the block is imbedded in the soil.
- The gypsum block becomes wetter or drier as the water also does.

ii. Tensiometer

- consists of a long tube filled with water and with a porous cup buried in the soil and a mercury gauge above the ground
- Water in the tensiometer equilibrates with that in the soil so that it moves in and out of the cup in response to changes in soil moisture content.
- The changes are read in the attached gauge.

- **Water movement**

i. Upward: Capillary movement of soil water

- *Capillary*: movement of liquid through small channels.
- The forces involved are adhesion of water on the walls of channels, and cohesion which is the mutual attraction of water molecules with each other.
- The smaller the soil pores, the higher is the capillary rise of underground water
- Capillary pores in soil are not continuous but are broken by large pores.

ii. Downward: Infiltration and Percolation

- governed by gravitational forces
- *Infiltration:* the downward entry of water via the soil surface
- *Percolation:* the downward movement of water through the soil; the water moves at a greater depth in the soil profile

- **Soil Consistency**
  - the physical condition of the soil manifesting cohesion and adhesion forces acting within the soil at various moisture contents
  - the workability of the soil at specific moisture contents
  - A soil behaves differently at different soil moisture content. It is hard when it is dry, friable when it is moist, sticky and plastic when it is wet, and viscous (flows like liquid) when super saturated
  - Soil Moisture Consistency Limits or Atterberg Limits can be determined in the laboratory.
  - The manifestations of soil consistency are:
    - *Liquid consistency*:the soil is easily puddled which is attained at paddy rice culture. Puddling destroys aggregation.
    - *Plastic consistency*: the soil is plastic and sticky. It can be good for pottery.

- *Friable consistency*: Soil best for cultivation since it is soft, friable, mellow and soil structure is rejuvenated.
- *Harsh/ hard consistency*: the soil is hard and requires high energy to pull the plow, resulting to cloddy seed bed.

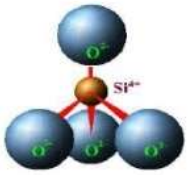
- **Soil color**
  - can be a useful indicator of the soil's identity and therefore its implicit properties
  - Dark-colored soils are generally more fertile since the dark coloring is usually due to abundant humus content or parent materials (containing base-rich ferromagnesian minerals).
  - In general, reddish soils are very old soils which are acidic and low in basic cations.
  - Red yellowish color in subsoils indicates good drainage.
  - Dark bluish or grayish coloration (mottling) indicates poor drainage.

- **Soil colordetermination**
  - *Munsell Color Chart* : the standard color comparison chart used
    - *Hue*: the dominant spectral color
    - *Value*: darkness or lightness of color
    - *Chroma*: gradation of purity of color or the intensity or brightness of a color
  - Example: 7.5 YR 4/6 BROWN
    Hue = 7.5 YR
    Value = 4
    Chroma = 6
  - Soil color of most soils is centered on the Brown color, the most dominant soil color of the lower soil horizon e.g. Brown, Reddish Brown, Yellowish Brown, Dark Brown

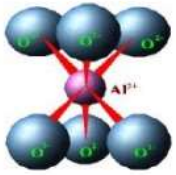
III. CHEMICAL PROPERTIES OF SOILS

- **Chemical nature of soil constituents**
  - Soil is considered to have 3 phases
    1. Solid: organic and inorganic materials; serves as a skeletal framework of soils
    2. Liquid: the soil solution which carries the dissolved nutrients
    3. gas: soil air; composed mainly of N_2, O_2 and CO_2
- **Soil colloids**
  - very small particles of matter (0.2 micron to 1 micron)
  - the seat of various chemical reactions in soils
  - with high surface area per unit amount (specific surface area)
  - chemically reactive because of the electrical charges (positive and negative) on their surface
  - classified into 2 general group: organic colloids and the inorganic/mineral/clay colloids

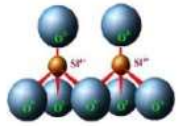
- **Organic colloids**
  - constituted by organic complexes occurring in colloidal form
  - represented by *humus* : a complex, high molecular weight organic product of the biological decomposition of organic residues in the soil
  - Humus is relatively stable to further biological action
  - The main source of negative charges in humus is the dissociation of H^+ from carboxylic and phenolic functional groups at high pH.
  - Humus enables the soil to have greater ability to adsorb and exchange ions.
  - The Basic structure of aluminum silicate clays
    - a tetrahedron which has a silicon atom at the center surrounded by four oxygen atoms at the corners
    - a continuous network of these octahedron has aluminum, magnesium and other cations at the center surrounded by hydroxils at the six corners
    - A layer of these octahedron make up the aluminum sheet



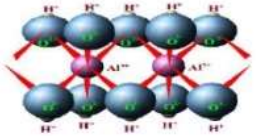
silica tetrahedron



alumina octahedron



silica sheet



octahedral sheet

- **Inorganic colloids** (categories based on structure and chemical composition)

i. Crystalline Silicate clays

  - composed of sheet-structured alluminosilicates of various types depending on the ratio of silica sheet to alumina sheet in the crystal structure
  - Examples are
    - 1:1 non expanding type (kaolinite and halloysite)
    - 2:1 expanding type or smectites (montmorillonite); most chemically reactive due to very high specific surface area
    - 2:1 limited expansion type (vermiculite)
    - 2:1 non expanding type (Illite)
    - 2:2 type (chlorite)
  - Soils dominated by montmorillonite expand when wet and shrink when dry producing large cracks on the surface

ii. Amorphous (non-crystalline) silicate clays

  - represented by allophone and imogolite

- In the Philippines, they are usually associated with relatively young soils derived from volcanic ash and characteristically containing high organic matter.

iii. Amorphous Non-silicate clays

- occur as amorphous hydrous oxides of Iron and Aluminum
- Examples are
  - Hematite
  - Goethite
  - Limonite
  - Boehmite
  - Gibbsite

- **Electrical charges of silicate clays**

i. negative charges

- arise mainly from exposed hydroxyl groups at the broken edges of crystals
- arise when the H^+ of the hydroxyl dissociates especially at high pH or alkaline environment (pH dependent charges, mostly occurring in 1:1 clay types)
- arise from isomorphous (same size) substitutions of ions in the silica or octahedral sheets (mostly occurring in 2:1 clay types)
- can be demonstrated by the positively charged organic dye, gentian violet which loses its color indicating its adsorption by the soil
- enables the soil to store nutrients, specifically the positively charged ions (cations)
- The cations are adsorbed (attracted on surfaces of colloids) and kept from being washed away by water passing water through the soil solum.
- Agriculture important soils are net-negatively charged.

ii. positive charges

- arise from the protonation or addition of H^+ to OH^- groups on the edge of minerals such as sesquioxides, allophone and kaolinite
- arise from the exchange of OH^- groups for other anions
- can be demonstrated by the negatively charged organic dye eosin red which does not lose its color when it reacts with the soil

- **Ion exchange**
  - a reversible process by which ions are exchanged between solid and liquid phases and between solid phases if in close contact with each other; occurs due to the presence of electrical charges in the soil
  - Two Types of Ion Exchange:
    - *Cation Exchange* : the attraction of cations (positively charged ions) on the surface of colloids and exchanged for ions in the soil solution (NH^{4+}, Ca^{2+},Mg^{2+}, Na^+, H^+, K^+)
    - *Anion Exchange* : the attraction of anions (negatively charged ions) on the surface of colloids and exchanged for ions in the soil solution (NO_3^-, PO_4^-, SO_4^-)

- **Concept of milliequivalent and cmol**

- wt of 1 me = atomic weight / (valence x 1000)
- wt of 1 me of K^+= 39 / (1 x 1000) = 0.039 g/me
- wt of 1 me of Ca^{2+}= 40 / (2 x 1000) = 0.02 g/me
- Sample calculations:

Calculate weight (g) of Ca^{2+} needed to replace 1 g of H^+

1 me Ca^{2+} will replace 1 me H^+

1 me Ca^{2+} = 0.02 g; 1 me H^+ = 0.001 g

Using ratio and proportion, $\frac{0.02\ g}{0.001\ g} = \frac{x\ (Ca^{2+})}{1\ g\ H^+}$

x = 20 g Ca^{2+}

Using the concept of cmol

1 cmol = 1/100th of a mole

1 cmol Ca^{2+} = 0.40 g

1 cmol H^+ = 0.01g

½ cmol Ca^{2+} will replace 1 cmol H^+

$\frac{0.02\ g}{0.001\ g} = \frac{x\ (Ca^{2+})}{1\ g\ H^+}$

x = 20 g Ca^{2+}

- **Cation Exchange Capacity (CEC)**
  - the ability of the soil to adsorb and exchange cations with those in the surrounding soil solution as well as with the plant roots
  - the sum of all adsorbed cations per unit amount of soil
  - commonly expressed as milliequivalent per 100 g of soil (me/100g) or $cmol_c$/ kg soil
  - reversible, instantaneous, and stoichiometric process
  - typical values ranges from 10 me/100 g to 30 me/100g
  - increases with increasing amount of clay and organic matter
  - Cations are adsorbed on surfaces of colloids at varying levels depending on their valence, ionic size, hydration size, and concentration of cations.
    - The greater the valence, the stronger the adsorption i.e. Ca^{2+} is more strongly adsorbed than K^+
    - The smaller the ionic size, the higher the ability of the cation to closely approach the colloidal surface
    - The smaller the hydration size of the cation, the stronger is its adsorption capacity
    - The greater the concentration of a particular cation in the solution surrounding the colloids, the more strongly adsorbed is that cation
  - Generally, the adsorption strength is in the order: $(Al^{3+}, H^+) > Ca^{2+} > Mg^{2+} > K^+ > Na^+$
  - In strongly leached soils, the more strongly adsorbed cations will be left in the soil.

- **Simple CEC calculation**
  - Simply add up the me*s* of all the cations adsorbed
  - Example:

A soil analysis showed that it contains the following cations. Compute for the CEC.

Exchangeable cations	me/100g soil
Ca^{2+}	10.0
Mg^{2+}	6.0
K^+	0.5
Na^+	1.5
H^+	5.0

CEC= 10.0 + 6.0 + 0.5 + 1.5 + 5.0 = 23 me/100 g

- **Percent Base Saturation (%BS)**
  - the degree by which the exchange sites in the colloids are occupied by basic cations
  - The basic cations are Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, NH^{4+}, etc.
  - The acidic cations are H^{+} and Al^{3+}
    - Aluminum is acidic because it yields H^{+} upon hydrolysis.
  - %BS is calculated by taking the ratio of the bases with the CEC
  - Sample calculation: A soil analysis showed that it contains the following cations. Compute for the % BS.

Exchangeable cations	me/100g soil
Ca^{2+}	10.0
Mg^{2+}	6.0
K^{+}	0.5
Na^{+}	1.5
H^{+}	5.0
Al^{3+}	4.0

Solution: %BS = {me of bases/ CEC } x 100
%BS = {(10.0 + 6.0 + 0.5 + 1.5)/ 27.0} x 100
= 66.7%

- **Exchangeable Sodium Percentage (ESP)**
  - the degree by which the exchange sites of colloids are occupied by sodium ions
  - computed by taking the ratio of the me of Na+ and that of the CEC
  - Sample calculation: In previous example, CEC = 27 me/100g soil while Na^{+} = 1.5 me/100g soil

ESP = (me Na^{+}/ CEC) x 100
ESP = (1.5/27) x 100 = 5.6%

  - The soil becomes highly dispersed with high ESP values (>15%).
  - High ESP is undesirable because it leads to poor aeration and drainage or permeability to water.

- **Soil pH**
  - the degree of acidity or alkalinity (basicity) of the soil
  - also referred to as soil reaction
  - determined by the relative abundance of H^{+} and OH- ions
  - can also be expressed as pH = - log [H^{+}] or the negative logarithm of hydrogen ion concentration
  - The lower the pH value, the higher is the H^{+} concentration and the lower is the OH^{-} concentration.
  - can be determined easily and quickly either using the pH meter or organic dyes
  - an indicator of soil fertility problem

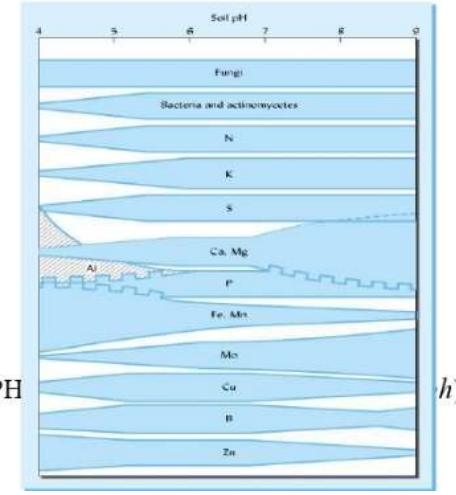
- **Soil pH and nutrient availability**
  - The most favourable pH for growing most agricultural plants is between pH 6 and pH 7 because at the availability of the nutrients and activities of beneficial microorganisms are at maximum at his range.
  - The range of pH in the Philippines is from pH 5.5 to ph 6.5.
  - When the pH is too low (< 5.0, strongly acidic)
    - nutrients particularly Ca, Mg, K, P, Mo, N become less available to plants

- N release may also be hindered when the symbiotic nitrogen fixation and nitrification are inhibited
- Fe, Al, and Mn become more soluble to the point of toxicity
- P becomes complexed into insoluble forms with Fe and Al
- P can also be precipitated as insoluble manganese phosphate compounds when the soil is rich in manganese oxides

∞ Soils also become acidic when the bases are leached out and replaced by H^+ ions e.g. old soils in the humid tropics

∞ Soil acidity may also develop from the decomposition of organic matter due to the formation of organic acids like fulvic acid, humic acid and carbonic acid.

∞ When pH is too high (>8.0, strongly alkaline)
- same nutrients become unavailable
- Most micronutrients (except Mo) become unavailable at high pH
- Iron deficiency commonly develops



- P becomes complexed with calcium as precipitates of calcium hydroxyapatite or calcium phosphate dehydrate
- K also competes with the now abundant Ca for plant absorption

Fig 2. Relationships existing in mineral soils between pH and the availability of plant nutrients. The pH value with wider bands indicates that the nutrients are most available for plant use.

♦ **Sources of Acidity**

i. H^+ and Al^{3+} ions (Hydrolysis of Al^{3+} indirectly contributes to soil acidity)

ii. Carbonic acid (H_2CO_3) dissociation:

$$CO_2 + H_20 = H_2CO_3 = 2\ H^+ + CO_3^{2-}$$

iii. Organic Acids from OM decomposition

∞ Fulvic, humic and other inorganic acids are formed during organic matter decomposition

- ∞ Production of CO_2 during organic matter decomposition is responsible for the lowering of pH of calcareous soils in submerged soils

iv. Mineral weathering

v. Acid rain

vi. Heavy cropping removes (crop removal) basic cations and replaced by H^+ ions from roots

vii. Long-term use of acidifying fertilizers (NH_4^+containing fertilizers) due to nitrification process (conversion of NH_4^+ to NO_3^- and release of H^+ in the soil)

- **Pools of acidity**

i. Active acidity

- ∞ acidity due to H^+ ions in soil solution
- ∞ measured when pH is determined in the usual method of mixing equal amounts of soil and water
- ∞ should be in equilibrium with reserve acidity

ii. Reserve acidity

- ∞ acidity due to H^+ and Al^{3+} ions adsorbed on colloid surfaces
- ∞ also measured (in addition to active acidity) when KCl is mixed with the soil instead of water in the pH determination

- **Sources of Alkalinity**

i. Base- forming cations

- ∞ As the basic cations such as Ca, Mg, K and Na saturates the soil's exchange complex, the H^+ ion concentrations in the soil solution will decrease and the concentration of OH^- increases.
- ∞ Alkaline reactions results from the hydrolysis of colloids saturated with basic cations

ii. Carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-)

- **Increasing the pH (Liming)**
  - ∞ involves the application of *lime* : any Ca or Mg bearing compound added to the soil to neutralize the H+ ions
  - ∞ Lime reacts with carbonic acid to form bicarbonates which will dissociate with Ca replacing H+ in the exchange sites
  - ∞ Liming application: small amounts split and incorporated into the soil
  - ∞ usually applied in large amounts (tons/hectare) ahead of planting to allow ample time to react with the soil
  - ∞ its effectivity depends on the lime's fineness (particle size) and relative neutralizing value (RNV) or also calculated as the calcium carbonate equivalent (CCE)
  - ∞ *RNV* : the strength of the lime in correcting soil acidity with reference to calcium carbonate; computed from the ratio of the molecular weight of calcium carbonate and that of the liming material ,

    RNV = (mol wt $CaCO_3$ / mol wt of the liming material) x 100
  - ∞ *Lime requirement*: the amount of liming material needed to raise the pH of one hectare soil (2 x 10^6 kg) up to a desired level under field condition
  - ∞ Too much liming is can be harmful with the reduced availability of Fe, Mn, Cu, Zn, P, and B, and antagonism between Ca, K, and Mg.

- **Common liming materials**
  - these are the oxides, hydroxides and carbonates of lime
    1. *Limestone* : made up chiefly of the minerals calcite $CaCO_3$ with RNV of 100%, or dolomite $CaMg(CO_3)_2$ with RNV of 109%; Limestone deposits are crushed to specified particle size with average purity of 94%

    2. *Burned lime* or quick lime CaO or MgO: made by igniting calcium or magnesium carbonates; about 95% pure; hygroscopic, tends to absorb water from the air; cakes readily even when sealed in bags; CaO RNV of 179%

    3. *slaked lime*: hydroxide of lime made by reacting CaO or MgO with water; about 95% purity; Ca(OH)2 RNV of 136%
  - An RNV of 179% (CaO) means that every kg of CaO is equivalent in neutralizing ability to 1.78 kg of $CaCO_3$.
  - The greater the purity, the greater the neutralizing ability of the lime
  - Calcium sulfate $CaSO_4$ also contains calcium, but it has sulfate which can form sulfuric acid.
  - Gypsum isnot a liming material, as it has very slight effect on pH, but can provide Ca as a nutrient or exchange with Na.

- **Lowering the pH (acidification)**
  - more difficult than raising the pH
  - usually involves addition of large amounts or organic matter into the soil, or by adding ferrous sulfate or sulfur mineral [to transform into sulfuric acid]

- **Buffering capacity**
  - the resistance of the soil to drastic changes in pH
  - The pH of the soil hardly changes because when the H^+ ions in the soil solution are leached out, these are replenished by the H^+ ions in the exchange complex (concept of active and reserve acidity); the replenishment is reversible making liming a continuous practice in order to maintain the desired pH
  - The higher the buffering capacity of the soil, the higher the amount of liming needed to neutralize the acidity.
  - The higher the CEC, the higher the buffering capacity.
  - More lime is needed to raise the pH of acidic clay soils than acidic sandy soils.

- **Acid sulfate soils**
  - also found to occur in the Philippines
  - The acidity is due to the oxidation of sulfur compounds in soils that are rich in sulfur, or are derived from sulfur-bearing minerals
  - There is formation of sulfuric acid.
  - pH value can be as low as 4.0
  - Soil organisms of genus *Thiobacillus* also facilitate the oxidation of sulfur compounds to sulfate

- **Saline soils**
  - soils with toxic amount of soluble salt content

- ∞ soils with electrical conductivity (EC) greater than 4 mmhos/cm
- ∞ occurs in arid areas where there can be evaporation of water reaching the area allows concentration of salts e.g. near sea coasts with sea water intrusion
- ∞ can be reclaimed by repeatedly flooding with fresh water
- ∞ diversion canals must be constructed to prevent entry of salt water

♦ **Sodic soils**
- ∞ soils with excessive amount of soluble sodium (Na content more than 15% of the CEC)
- ∞ highly dispersed and poorly drained
- ∞ can be reclaimed by replacing Na+ in the exchange sites of colloids with Ca^{2+} (sources can be gypsum), and then washing out the Na^{+}; e.g. application of gypsum

♦ **Upland soils**
- ∞ also referred to as dryland soils
- ∞ grown to crops like corn, vegetables, fruit trees, etc.
- ∞ aerobic most of the time
- ∞ the nutrients present in the soil exist in their oxidized state i.e. NO_3^-, $H_2PO_4^-$, SO_4^{2-},SO_4^-, Fe^{3+}, Mn^{4+}, CO_2
- ∞ soil color is brown, yellowish brown, or reddish brown
- ∞ organic matter decomposes with CO_2 as a major product

♦ **Lowland soils**
- ∞ also referred to as paddy soils
- ∞ grown to rice, and other crops requiring water or puddling
- ∞ anaerobic most of the time because of continuous submergence
- ∞ There is a thin oxidized layer above the water surface.
- ∞ The nutrients exist in reduced state NH_4^+, H_2S, Mn^{2+}, Fe^{2+}, CH_4
- ∞ soil color is dark gray or bluish gray
- ∞ organic matter decomposes with the following major products: CH_4 (methane), H_2S (hydrogen sulfide), organic acids, alcohols, and ketones

IV. SOIL ORGANISMS AND ORGANIC MATTER

♦ **Soil organisms**
- ∞ composed of large and small plants and animals
- ∞ The larger organisms (insects, worms, moles, etc.) prepare the organic materials for further degradation by breaking them into smaller pieces
- ∞ The smaller organisms (bacteria, fungi, actinomycetes, algae, nematodes, protozoa) cause biochemical changes in the organic materials
- ∞ Roles:
  - ○ Responsible for biochemical changes

- Agents in the decomposition of plant and animal residues
- Improve soil structure through aggregation

- **Earthworm**
  - eat detritus, soil organic matter and microorganisms found on these materials
  - also facilitates aeration and drainage through the channels they create
  - probably the most significant microorganisms in humid temperate region soils
  - 7000 species worldwide
  - *Lumbricus terrestris* and *Allolobophora caliginosa* are the most common
  - more numerous in fertile and alkaline soils than in infertile and acid soils
  - *Epigeic* : live in the litter layer,
    Ex. Compost worm –*Eisenia foetida*
  - *Endogeic* : live in the top 10-30 cm of soil,
    Ex. Pale-pink-red worm – *Allolobophora caliginosa*
  - *Anecic* : live in vertical burrow up to 1 meter,
    Ex. the introduced Night Crawler – *Lumbricus terrestris*

- **Protozoa**
  - Single-celled animals (20-50 microns in diameter)
  - Aerobic
  - Ingest food through oral openings
  - ingest other soil organisms particularly bacteria and helps released the immobilized nutrients in the bacteria
  - Reproduction : Binary fission; budding
  - Population: $10^3 – 10^5$ Cells/g soil
  - Biomass: ≈ 100 kg/HFS
  - CFU: colony forming unit
  - HFS: hectare furrow slice

- **Bacteria**
  - probably the most important in terms of their effect on soil properties
  - involved in various nitrogen transformation, sulfur oxidation and reduction, and other chemical processes
  - Morphological Grouping
    - Cocci (speherical)
    - Rods (short, long, curved)
    - Spiral (vibrio)
  - Nutritional Grouping
    - Heterotrophic (OM as source of carbon and energy)
    - Autotrophic
    - Photosynthetic (Energy from sunlight; C from CO_2)
    - Chemosynthetic (Energy from oxidation of inorganic compound; C from CO_2)
  - Grouping based on oxygen requirement
    - aerobic
    - anaerobic
    - facultative
  - Grouping based on temperature for optimum activity
    - mesophilic
    - thermophilic
    - psychrophilic
  - Population: 10^6 - 10^9 CFU/g soil
  - Biomass: ≈2,000 kg/HFS

- **Fungi**

- most adaptable and versatile soil organism
- some species can thrive in extreme acidity and alkalinity
- able to decompose the resistant organic compounds such as lignin, cellulose, and gums
- *Mycorrhizae* : an association between fungi and plant roots which help plants in solubilization of P and its absorption
- Complex morphology (multicellular; highly branched)
- Heterotrophic
- Aerobic
- Acid-loving (efficient OM decomposers under acidic conditions)
- Population : $10^4 - 10^5$ CFU/g soil
- Biomass: ≈ 8,000 kg/HFS

- **Actinomycetes**
  - attack and simplify complex organic compounds such as cellulose, chitin, and phospholipids
  - Branched mycelial structures
  - Intermediate between bacteria and fungi
  - Very fine hyphae (< 1 micron diameter)
  - Heterotrophic
  - Aerobic : some microaerophilic
  - Major Antibiotic Producer: Streptomycin, Erythromycin)
  - Acid Sensitive (Critical pH = 5.5)
  - Population: $10^5 - 10^6$ CFU/g soil
  - Biomass: ≈ 4,000 kg/HFS

- **Algae**
  - chlorophyll bearing organisms which thrive mostly in soil surfaces
  - includes blue-green algae, green algae, and diatoms
  - Principally thrives in aquatic environment, loves moist habitat
  - Both single – celled and multicellular species are present in the soil
  - Aerobic
  - Photoautotrophs
  - Blue-Green Algae are capable of N_2 fixation
  - Excellent host for bacteria due to oxygenating capacity
  - Population: $10^3 - 10^5$ CFU/g soil
  - Biomass: ≈ 250 kg/HFS

- **Soil Organic Matter (SOM)**
  - refers to the totality of all carbon-containing compounds in the soil derived from either plants or animals
  - Organic constituents of plants:
    - Cellulose (15 – 60%)
    - Hemicellulose (10 – 30%)
    - Lignin (5 – 30%)
    - Water-soluble fractions: amino sugars, amino acids (5 - 30%)
    - Proteins
    - Fats, oils and waxes
  - accumulation is affected by temperature, soil moisture, vegetation, soil texture, and cropping system
  - SOM is higher in areas of higher effective moisture regime.
  - Sandy soils accumulate less organic matter than clayey soils.

- ∞ More accumulation of organic matter in grassland than in forested land due to faster turnover of vegetative matter and shorter life cycle of grass than of trees
- ∞ Cultivated soils contain an average of 2 to 3% organic matter.
- ∞ Organic matter declines when the soil is cultivated because of the enhanced oxidation and microbial activity brought about by the loosening of the soil.

- **Effects of organic matter to soil properties**

i. Physical

- ∞ enhances soil aggregation and aggregate stability
- ∞ reduces plasticity, cohesion and stickiness of clayey soils
- ∞ increases soil water retention, infiltration rate, water holding capacity and aeration
- ∞ darkens soil
- ∞ reduces bulk density and compaction

ii. Chemical

- ∞ increases CEC of soils
- ∞ increases soil buffering capacity
- ∞ increases nutrient availability through solubilization of minerals by organic acids and by chelation of metal ions
- ∞ reduces Al toxicity by binding the Al ions in non-toxic complexes
- ∞ increases soil native supply of N, P, S, etc
- ∞ adsorbs pollutants such as Pb, Cd and Cu
- ∞ inactivates toxin and pesticides

iii. Biological

- ∞ provides C and energy to soil organisms and thus increases their diversity and activity
- ∞ enhances microbial functions such as N fixation, decomposition, and nutrient transformations

- **SOM decomposition**
  - ∞ Organic materials such as crop residues, animal manures and other carbonaceous and nitrogenous compounds are decomposed by the heterotrophic microflora in the soil.
  - ∞ *Decomposition* is the enzymatic oxidation by soil organisms under aerobic condition with CO_2, heat or energy and water as the major products.
  - ∞ in the process, soil organisms derive carbon and energy for their use
  - ∞ essential nutrients like N,P and S are released for plant absorption
  - ∞ anerobic soil organisms act upon organic materials under flooded conditions or in poorly drained soils
  - ∞ toxic gases and organic acids produced may kill newly transplanted rice seedlings
  - ∞ Microbial Activity Related to SOM decomposition:
    - o Fungi : unaffected by pH level
    - o Bacteria and Actinomycetes: inhibited at pH 5.5

- **Carbon/Nitrogen ratio**

- ∞ The carbon nitrogen ratio of organic materials is a convenient tool for predicting the rate of decomposition and regulating the quantity of mineral nitrogen available to plant.
- ∞ The higher the C/N ratio (usually 30), the slower is the rate of organic matter decomposition because the nitrogen is immobilized by microorganisms. Soil microbes use whatever N is available, approximately 30:1 C/N
- ∞ 20/1 is the optimum C/N ratio of organic materials for faster decomposition; When the C/N ratio narrows (20) mineralization predominates and NO_3^- levels increase.
- ∞ Nitrogen-rich materials such as legumes or blood meal are metabolized very rapidly, and the micro flora responds little to supplemental nitrogen while the addition of ammonium or nitrate to straw or other nitrogen-deficient substrates greatly enhances decomposition.
- ∞ C/N ratio of organic material is determined by analysis of the total C and N

♦ **<u>Microbial transformations of N</u>**

i. Mineralization : conversion of organic N to inorganic N; renders N available for plant use

ii. Immobilization

- ∞ conversion of inorganic N to organic N; renders N unavailable for plant use
- ∞ happens when available N is used by soil microorganisms and assimilated it into their bodies

iii. Nitrification

- ∞ the biological formation of NO_3^- or NO_2 from compounds containing reduced nitrogen
- ∞ The most common initial substrate is NH_4^- and the final product is NO_3^- .
- ∞ Two separate and distinct steps: 1st is initial oxidation of ammonium to nitrite, 2nd is the further oxidation of nitrate.
- ∞ The production of NO_3^- is related to soil and solution pH values.
  - o Optimum pH values may vary from 6.6 to 8.0
  - o Rate decreases below pH 6.0 and become negligible below pH 4.5
- ∞ Micororganisms responsible
  - o *Nitrosomonas*: chemoautotrophic, gram-negative, non spore forming, ellipsoidal or short rods, responsible for the oxidation of NH_4^+ to NO_2^-
  - o *Nitrobacter*: chemoautotrophic, gram–negative, non- spore forming, short rods, further oxidizes nitrite to nitrate.
- ∞ Nitrate can be lost through denitrification and in leaching particularly in sandy soils, under heavy rainfall, or where excessive irrigation. Excess NO_3^- leached from soil often ends up in ground water, lakes, and streams lead to water pollution such as *eutrophication* or the excess growth of plant and algae, and the health problem in infants and animals *methemoglobinemia*.

iv. Denitrification

- ∞ biochemical reduction of nitrate-N to gaseous N by facultative anaerobic soil organisms

- ∞ Denitrificans reduce the NO_3^- to nitrite then to gaseous nitrogen forms, nitrous oxide (NO) and elemental Nitrogen (N_2) that are commonly lost to the atmosphere
- ∞ Denitrification is all aerobic but nitrate is used as the electron acceptor in the absence of O_2.
- ∞ The microorganisms involved: *Pseudomonas, Achromobacter, Bacillus* and *Micrococcus*
- ∞ a major avenue of loss of N in paddy soils and contributes to the low efficiency of applied nitrogen fertilizer
- ∞ NO_3^- in the thin aerobic surface of paddy soils is leached down to the reduced subsoil

v. Ammonification :

- ∞ The process of ammonification is the result of the breakdown of organic matter such as dead animals and plants or waste materials like excrement.
- ∞ This breakdown is accomplished by microorganisms which utilize dead organic material for energy and produce ammonia and related compounds as a byproduct of their metabolisms.

vi. Symbiotic Biological N fixation

- ∞ renders N available to plants
- ∞ occurs in legumes in the presence of rhizobia which are aerobic, gram-negative, non-spore-forming rods which are typically motile with simple nutritional requirement
- ∞ Rhizobia enter and irritates the roothair causing the formation of root nodules
- ∞ the bacteria in root nodules trap atmospheric N which is transformed to NH_3 which will combine to organic compounds to form amino acids and proteins
- ∞ In return, the plant supplies the carbohydrates and energy for bacteria's metabolism
- ∞ When the legumes are plowed into the soil, the fixed N is added into the soil.

vii. Non symbiotic N fixation

- ∞ conversion of atmospheric N amounting to 20 to 100 kg N/ha per year by microorganisms without an associated plant host
- ∞ the organisms include bacteria *(*Azotobacter, Beijerinckia and *Clostridium pasteurianum)* blue-green algae and some fungi species
- ∞ Azotobacters are strict aerobes, mesophiles with an optimum temperature of 30° C, gram-negative, large cocci.
- ∞ Members of genus Clostridium are anaerobes, gram-positive rods, which are found in soils with pH 5.0 and are still capable of growth at pH 9.0.
- ∞ Clostridia proliferate when organic matter is added, and they often are numerous around plant roots.
- ∞ Blue green algae (BGA) are believed to help maintain fertility of lowland rice paddies.
- ∞ Common BGA in the Philippines are *Anabaena uariabilis, Gloetrichianatans, Nostoc commune, Nostoccarneum, Hapalosophon sp., Anabaenopsis spp.* and *Tolypothrix sp.*

♦ **<u>Inorganic P solubilization</u>**

- ∞ Genera of bacteria capable of solubilizing Calcium phosphates

- Pseudomonas
- Mycobacterium
- Bacillus
- Micrococcus

∞ Genera of fungi capable of solubilizing Calcium phosphates
- Penicillium
- Fusarium
- Aspergillus

∞ Microbiological means by which inorganic P is solubilized
- Production of organic acids
- Nitric acid or sulfuric acid production
- Flooding resulting in the reduction of Fe in insoluble ferric phosphates
- Mycorrhizal association (related to organic production); Two general types:
  - *Ectotrophic* : fungus forms a mantle around root exteriors hyphae enters into spaces between plant cells hyphae enters into spaces between plant cells examples (pine, eucalyptus)
  - *Endomycorrhiza* : fungus penetrates the cells of the plants examples (orchids, coffee, fruit trees, rice and corn)

♦ **Microbial transformation of sulfur**

∞ The major sulfur in soil is in the organic fraction with low concentration of sulphate, the form available for plants.

∞ Decomposition of organic S compound
- Microbial assimilation or immobilization of S and their incorporation into microbial cells.
- Oxidation of inorganic compounds such as sulfides, thiosulfates and elemental S.
- Reduction of SO_4^{2-} and other anions to sulfides.

∞ In anaerobic conditions, sulfate availability may be limited in the soil.
- Sulfate-reducing bacteria, predominantly of the genus *Desulfovibrio* and *Desulfotomaculum* use sulfate as the hydrogen acceptor in their energy-yielding metabolism, reducing sulfate to sulfide.

∞ In aerated environments, the combined sulfur is ultimately metabolized to sulfate.
- Members of the genus *Thiobacillus* are capable of oxidizing elemental sulfur to sulfate. They are gram-negative, non-sporulating rods which are predominantly aerobes.
- The oxidation of elemental sulfur leads to the formation of enormous amounts of sulfuric acid which decreases soil pH.

♦ **Iron Precipitation by soil bacteria**

∞ brought about a group of bacteria sometimes termed as the *iron bacteria*

∞ These transformations can be (a) Ferrous Oxidation from Fe^{+2} to Fe^{+3} , (b) Iron Reduction, and (c) Iron precipitation from organic salt.

♦ **Composts and composting**

∞ *Composting* : process of creating humus-like organic materials by piling, mixing, and storing of organic materials under conditions favourable for aerobic decomposition

∞ *Compost* : finished product of composting and used as soil conditioner or slow-release fertilizer

- ∞ After composting, the C/N ratio of organic materials is reduced to about 14-20:1
- ∞ Pathogenic organisms are destroyed during thermophilic stage (50-75 ºC) but heavy metals (inorganic contaminants) are not destroyed.

- **Cellulose decomposition**
  - ∞ *Cellulos*e : one of the most abundant organic matter in nature
  - ∞ The genera of cellulose decomposing bacteria and fungi are the following:
    - o Strongly cellullotic fungi are represented by species of the genera Aspergillus, Chaetomium, Cuvularia, Fusarium, Memnoniella, Phoma, Thielavia and Trichoderma.
    - o A bacterial genus that contains representatives digesting cellulose includes Bacillus, Cellulomonas, Clostridium, Corynebackterium, Cytophaga, Polyangium, Sporoccytophaga and Vibrio).
      - Bacillus: aerobic, spore-forming, gram-positive rods
      - Cellulomonas : short gram–negative rods that produces yellow, water-insoluble pigments
      - Clostridium: anaerobic, non-motile, gram negative rod, which does not ferment carbohydrates other than cellulose; produces a yellow pigment
      - Cytophaga: aerobic, long, flexuous rod with pointed ends; abundant in soils receiving straw or manure

V. PRINCIPLES AND MANAGEMENT OF SOIL FERTILITY

- **Soil fertility**
  - ∞ the capability of the soil to supply the nutrients in the right amounts and proportions to meet the nutrient requirement of the crop, as affected by soil properties and condition
  - ∞ only among the many factors that makes the soil productive
  - ∞ A fertile soil is not necessarily a productive soil.

- **Soil productivity**
  - ∞ the ability of the soil to support or produce a desired quantity of plant yield
  - ∞ A productive soil is necessarily fertile.

- **Plant Nutrition**
  - ∞ the supply and absorption of chemical elements or compounds required by the plant
  - ∞ Roots absorb mineral nutrients as ions in soil water.
  - ∞ Ions can be readily available to roots or could be "tied up" by other elements or the soil itself.
  - ∞ Many factors influence nutrient uptake for plants.

- **Nutrients** : chemical elements or compounds required by plants for normal growth

- **Metabolic processes** : are mechanisms by which elements are converted to cellular materials or as sources of energy, or to drive reactions

- **The 17 Essential Elements**

1. Carbon (C)
   - major component of plant's organic compounds
2. Hydrogen (H)
   - major component of plant's organic compounds
3. Oxygen (O)
   - major component of plant's organic compounds
4. Nitrogen (N)
   - Constituent of amino acids, proteins and nucleic acids (DNA, RNA)
   - Integral part of chlorophyll molecule
   - Associated with high photosynthetic activity, vigorous vegetative growth, dark green color of leaves and succulence of tissues
5. Phosphorus (P)
   - Energy storage and transfer through ATP – ADP conversion
   - Structural component of nucleic acids, coenzymes, nucleotides, phosphoproteins, phospholipids and sugar phosphates
   - As constituent of ATP, P is involved in metabolic processes such as photosynthesis, respiration, synthesis of proteins, phospholipids, nucleic acids, lipids, cellulose, hemicellulose, lignin, pectin etc
   - Important in seed formation and development of reproductive parts of plants
   - Associated with increased root growth, early maturity particularly grain development
6. Potassium (K)
   - Enzyme activator
   - Regulates osmotic pressure in roots
   - Maintains turgor pressure of guard cells and regulates opening of stomata, thus controlling photosynthesis and transpiration.
   - Needed in ATP synthesis which is used in translocation of sugars from leaves, N uptake and protein synthesis.
   - Strengthens straw of grain crops and prolongs the life of the flag leaf.
   - Increases pest and disease resistance.
7. Calcium (Ca)
   - Enhances NO_3–N uptake and regulates cation uptake
   - Essential for cell elongation and division
   - Calcium pectate in cell wall
8. Magnesium (Mg)
   - Constituent of chlorophyll molecule
   - Structural component in ribosome which are associated with protein synthesis
   - Associated with energy transfer reactions from AP in metabolic processes like photosynthesis, glycolysis, TCA cycle, and respiration
9. Sulfur (S)
   - Needed in synthesis of sulfur-containing amino acids, such as cystine, cysteine and methionine
   - Needed in synthesis of coenzyme A, biotin, thiamin (or vitamin B1) and glutathione
   - Required for synthesis of chlorophyll
   - Occurs in volatile compounds responsible for the characteristic taste and smell of mustard and onion.
   - Enhances oil formation in flax and soybeans

- ∞ Improves quality of forage by narrowing N/S ratio

10. Iron (Fe)
- ∞ Chlorophyll synthesis and in enzymes for electron transfer

11. Copper (Cu)
- ∞ Catalyst for respiration, enzyme constituent

12. Zinc (Zn)
- ∞ In enzyme systems that regulate various metabolic activities

13. Manganese (Mn)
- ∞ Controls several oxidation-reduction systems, formation of O_2 in photosynthesis

14. Boron (B)
- ∞ believed important in sugar translocation and carbohydrate metabolism

15. Molybdenum (Mo)
- ∞ In nitrogenase needed for nitrogen fixation

16. Chlorine (Cl)
- ∞ Activates system for production of O_2 in photosynthesis

17. Nickel (Ni)
- ∞ Component of enzymes urease and hydrogenease; involved in the mobilization of nitrogeneous compounds

18. Cobalt (Co)
- ∞ Essential for symbiotic nitrogen fixation

♦ **Criteria of Essentiality**

i. Perform vital functions in plant metabolism i.e. plants cannot complete their life cycle in its absence or deficiency

ii. Needed as integral part of plant structures and/or participates in one or more metabolic processes in the plant

iii. No other element can substitute for that element if it is absent or deficient. The deficiency can only be corrected by the addition of that element

♦ **Macronutrients** : absorbed by plants in large amounts

1. C = CO_2
2. H = H_2O, H_2
3. O = O_2
4. N = NH_4^+, NO_3^-
5. P = $H_2PO_4^-$, HPO_4^{2-}, PO_4^{2-}
6. K = K^+
7. Ca = Ca^{2+}
8. Mg = Mg^{2+}
9. S = SO_4^{2-}

♦ **Micronutrients** : needed by the plants in relatively low amounts

1. Fe = Fe^{2+}, Fe^{3+}
2. Mn = Mn^{2+}
3. Cu = Cu^{2+}
4. Zn = Zn^{2+}
5. Mo = MoO_4^{2-}
6. B = H_3BO_3, $H_2BO_3^-$
7. Cl = Cl^-
8. Ni = Ni^{2+}, Ni^{3+}
9. Co = Co^{2+}

♦ **Mobile nutrients**: the deficiency can be seen on older leaves

1. N
2. P
3. K
4. Mg
5. Zn

- **Immobile nutrients**: the deficiency can be seen on younger leaves

1. Cu
2. Mn
3. Bo
4. S
5. Ca
6. Fe

- **Mechanisms of nutrient movement**

i. Mass flow

- ∞ nutrients are carried by mass movement of water as water is absorbed the roots
- ∞ the amount of nutrients absorbed depend on the amount of water and the rate of water flow to the roots and the concentration of nutrients in the water
- ∞ believed to be the major avenue by which Ca, Mg, Zn, Cu, B, and Fe are absorbed
- ∞ low amount of nutrients are absorbed when absorption and transpiration of water by the plants is low

ii. Diffusion

- ∞ the movement of ions from a zone of high concentration to a zone of low concentration
- ∞ follows Fick's Law
- ∞ most nutrients particularly P and Ka re supplied to plant by diffusion

iii. Contact exchange (interception)

- ∞ the direct exchange of ions between the toots and soil colloids as roots come in contact with the colloid

- **Carrier theory of nutrient uptake**
  - ∞ explained why certain crops e.g. sugarcane, root crops, oil crops, etc. absorb more K than other cations
  - ∞ proposes that ions enter an outer space in the roots by diffusion
  - ∞ a carrier energized by plant metabolism picks up the ion and carries it to the inner space of the roots
  - ∞ after depositing the ion in the inner space, the carrier is ready to repeat the process
  - ∞ the 1st stage of diffusion is called passive uptake
  - ∞ the 2nd stage is called active uptake which requires energy

- **Difference between Passive and Active Uptake**

i. Passive Uptake

v

- ∞ Uptake is by diffusion and ion exchange, hence controlled by concentration and electrical gradient
- ∞ non-selective process and not requiring energy from metabolic reactions in the cell
- ∞ occurs outside the casparian strip and plasmalemma as a barrier to diffusion and ion exchange

ii. Active Uptake

- ∞ transport of ions into the inner cells requiring energy due to the higher concentration of ions beyond the plasmalemma and into the cytoplasm which is against an electrochemical gradient
- ∞ The process is selective in that specific ions are transported by specific carriers

♦ **Nitrogen uptake**

- ∞ taken up as NO_3^- and /or NH_4^+ but the nitrate is often the predominant form
- ∞ NH_4^+ is easily oxidized by bacteria in aerobic soil to NO_3^- as soon as NH_4^+ appears
- ∞ NO_3^- uptake occurs against an electrochemical gradient or actively absorbed (energy requiring).
- ∞ NO_3^- and NH_4^+uptake differ with pH of medium.
  - o NH_4^+ uptake is optimum at neutral pH and decreases as pH decreases.
  - o NO_3^- uptake increases with decreasing pH and decreases with increasing pH probably due to competition with OH.
- ∞ NH_3 is toxic to plant roots; it can penetrate cell membranes.
- ∞ The fertilizer *Urea* which is converted toNH_4^+ by *urease* in soil can be taken directly by plants, though at slower rate than NO_3

♦ **Phosphorus uptake**

- ∞ The active uptake is pH-dependent i.e. higher P uptake at low pH (4.0) than at high pH (8.7).
- ∞ P is readily translocated up and down plant and quickly assimilated into organic compounds.

♦ **Potassium uptake**

- ∞ actively taken up in high rate by plant tissues even to the point of luxury consumption
- ∞ K is the only one essential nutrient cation which can be transported against an electrochemical gradient into plant cell.
- ∞ K in plant is very mobile with main transport direction towards the meristematic tissues.
- ∞ K uptake is high when plant is sufficiently supplied with N, with bulk of K uptake during the vegetative stage (in cereals, from tillering to ear emergence)
- ∞ K uptake and retention in plants are competitively affected by H^+, Ca^{++}, Mg^{++} and Na^+.
- ∞ Plants with enough amount of K have lower transpiration rate and require relatively lower amounts of water (more drought resistant) due to the lowering of the osmotic potential of cell sap, and the regulation of stomatal opening by the guard cells with the presence of K.

♦ **Calcium uptake**

i. absorption is passive

ii. Ca is largely immobile in the plant. Once deposited, it is not moved from older to younger leaves, but with the preferential direction is the shoot apex (actively growing parts).

iii. Ca content of legumes is higher in dicotyledons than in monocotyledons and also higher in legumes than in other species

- **Magnesium uptake**
  - ***i.*** Taken up in lower amount than Calcium
  - ***ii.*** Competitive relationships: NH_4, K, Ca, Mn
  - ***iii.*** Mg moves similarly as Ca in plant, except that Mg (unlike Ca) is mobile in the phloem; passive uptake in the transpiration stream.

- **Sulfur uptake**
  - ***i.*** Active uptake; absorbed as SO_4^{2-}
  - ***ii.*** Translocation is mainly upward (acropetal).
  - ***iii.*** Plant use atmospheric S as S_2 (sulfide) by absorption through the stomata.
  - ***iv.*** S is also an important component of mustard oil.

- **Yield response to increasing nutrient supply**
  - ∞ the growth curve is described as a Sigmoid curve
  - ∞ the development of plants is initially rapid, exponential or quadratic [with increasing level of nutrients], then slows down and finally levels off
  - ∞ crop yield increases as nutrient supply increases but the increment progressively becomes smaller for each succeeding increase in nutrient supply until further addition reduces yield
  - ∞ beyond the maximum yield is the zone of luxury consumption of nutrients

- **Liebig's Law of Minimum**
  - ∞ Plant growth is limited by that nutrient present below the minimum requirement
  - ∞ "By the deficiency or absence of one necessary constituent all others being present, the soil is rendered barren for all those crops to the life of which that one constituent is indispensable."

- **Mitscherlich's equation**
  - ∞ The equation: $DY/DX = (A-Y)c$
    where: DY = increase in yield
    DX = increase in input
    A = maximum possible yield
    Y = actual yield
    c= constant depending on the nature of x
  - ∞ If plants were supplied with adequate amounts of all nutrients except one, the growth is proportional to the amount of this limiting element which was added to the soil.
  - ∞ Plant growth increases as more of the element was added but not in direct proportion to the amount of the growth factor added.
  - ∞ The total increase in growth becomes less as increments of the growth factor increases.

- **Growth Factors**

i. Temperature

  - ∞ temperature range for agricultural crops; 15ºC – 40ºC
  - ∞ has effects on photosynthesis, respiration, cell wall permeability, absorption of water and nutrients, transpiration, enzyme activity, protein coagulation

- optimum temperature is lower for photosynthesis than for respiration
- increasing temperatures (0ºC-60ºC) increase absorption of water, nutrients and activity of soil organisms

ii. Moisture supply

- water is needed to manufacture carbohydrates, maintain hydration of protoplasm, and for translocation of carbohydrates and nutrients
- low moisture level impairs nutrient absorption thru its effect on mass flow, diffusion and root interception
- excess water impairs nutrient absorption due to respiration caused by lack of O_2

iii. Solar Energy

- most plants grow best in full sunlight; Some are shade tolerant (e.g. black pepper, cacao)
- high density plant cause shading
- less shading in plants with more erect leaves

iv. Soil Properties

- physical (texture, structure, bulk density, porosity, water holding capacity, hydraulic conductivity)
- chemical (pH, CEC, base saturation, salinity, toxic elements)
- biological (OM content and kind and amount of microbial population)

- **Soil Fertility Evaluation**

i. Quantitative methods

- Soil analysis
- Plant tissue analysis
- Fertilizer Field Trials
- Pot experiments

ii. Qualitative methods

- Nutrient deficiency symptoms

- **Soil Analysis**
  - Quick and precise methods of evaluating soil fertility status
  - Principle: the amount of nutrient extracted by chemical reagents at any one time is the amount available throughout the growth period of the crop
  - consist of taking soil samples properly, subjecting soil samples to chemical analysis, and interpretation of results
  - In making interpretations, the following are considered:
    - Kind of crops grown during the preceding 3-5 years
    - The crop intended to grow
    - The kind and amount of fertilizer used
    - When was the soil last limed
    - The slope and extent of erosion
- **Soil sampling**
  - Main objective is to collect a small amount of soil sample weighing about 0.5 kg that will represent the soil in a large area
  - Accuracy of soil testing and the fertilizer recommendation depends largely on proper soil sampling
  - Rooting habit of plants must be considered
    - Shallow rooted crops: samples should be collected from the surface layer (20-30cm)

- Deep rooted crops: soil samples must be collected up to the subsoil
- Steps in proper soil sampling:
  - Make a map of the farm showing the sampling areas.
  - Collect spot soil samples from each sampling area
  - Take composite sample

- **Plant Analysis**
  - The nutrient content in the plant tissue is related to the available nutrient supply of the soil.
  - chemical laboratory analysis of the plant tissue is related to the available nutrient status of the soil on which the plant is grown
  - fertilizer recommendations using this method become more reliable when correlated with the results of fertilizer field trials

- **Fertilizer Field Trials**
  - assesses the effect of fertilizers and their interactions with all existing factors of crop growth and development in any given location usually in a farmer's field
  - The resulting fertilizer recommendations are generally more realistic

- **Pot Experiment**
  - comparison of several fertilizer treatments including a control using small amount of soil in pots to have a better control of environmental factors
  - short duration under an artificial condition
  - preliminary in nature

- **Nutrient Deficiency Symptoms**
  - Requires skillful observation because the occurrence maybe due to
    - insufficient amount and supply of soil nutrients
    - unavailability of forms of the nutrients present
    - no proper balance among different nutrient levels

- **Fertilizer**
  - any substance that is applied to the soil or to the plantin solid, liquid, or gaseous form to supply one or more of the essential nutrient elements required for the nutrition and growth of plants
  - classified broadly into two organic and inorganic/chemical fertilizers

- **Rationale for Fertilization**
  - the amount of available nutrients in the soil is not enough to meet crop management for high yield
  - The nutrient in the soil is not present in readily available form.
  - Nutrient depletion or loss is continuous
  - There is an increase in crop production and farm income

- **Organic fertilizers**
  - any fertilizer product of plant and/or animal origin e.g. animal manures, green manures, compost that has undergone decomposition through biological, chemical and or any other process as long as the original materials are no longer

recognizable, soil-like in texture and free from plant or animal pathogens
  - *Pure organic fertilizer*: no chemical has been added to the finished product to increase nutrient content.
  - *Fortified or enriched*: has been enriched with microbial inoculants, hormones or chemical additives to increase nutrient content.
  - Examples of plant residues:
    - Rice straw is one of the most abundant crop residues in the country and is usually used with animal manure in compost making.
    - Corn stover can be composted but needs to be chopped further for faster decomposition
    - Ipil-ipil (*Leucaena leucocephala*) leaves with their high nitrogen content can also be used as green manure.
    - Kakawate (*Glyricidia sepium*) leaves have more than 4% nitrogen content and can be applied to the soil directly as N fertilizer.

- **Inorganic fertilizers**
  - synthesized or are processed from mineral deposits
  - any fertilizer product whose properties are determined primarily by its content of mineral matter or synthetic chemical compounds
  - contain one or more combination of the three primary elements, N, P, or K
    - *Single nutrient fertilizers* : fertilizers that supply one primary nutrient; also called straight fertilizers; Examples: urea , ammonium sulfate
    - *Multinutrient fertilizers* : fertilizers containing two or three primary nutrients; also known as: complex, compound and mixed fertilizers; Example: Ammonium phosphate (16-20-0)
    - *Complete fertilizer* : contains the 3 primary nutrients which are historically known to be deficient in most soils

- **Conventional units of expressing fertilizer nutrients**
  - Stated in either pure form or oxide form
  - Nitrogen is expressed as pure element N
  - P and K are in oxides, P_2O_5 and K_2O
  - The nutrient content in fertilizers is written in %N, %P_2O5 and %K_2O in that order.

- **Common Nitrogen fertilizers**
  - *Urea* (45-0-0) : highest N content among the solid N-fertilizers $(NH_2)_2CO$; Hygroscopic and 100% soluble
  - *Anhydrous ammonia:* with 82% N has the highest amount of N among all fertilizers; contained in pressure tanks and is usually custom-applied by injecting into the soil; Ammonia gas is basic, pungent and colorless
  - *Ammonium sulfate* (20-0-0): hygroscopic and nearly 100% soluble; contains sulfur (~24%), recommended for S-deficient soils

- **Common P fertilizers**

- ∞ *Ordinary superphosphate (OSP):* contains 20% P_2O_5; Pelleted as grayish granules and has a faint acid odor; About 85% of the P is water soluble and it contains traces of other nutrient elements
- ∞ *Triple superphosphate (TSP) :* monocalcium phosphate monohydrate

♦ **Common K fertilizers**

- ∞ *Muriate of potash or potassium chloride (KCl)* : highly soluble and contains traces of other elements

♦ **Fertilizer computations and recommendations**

i. Fertilizer grade

- ∞ weight percentage of the nutrients contained in a fertilizer
- ∞ Guaranteed minimum analysis of the plant nutrient in terms of % total N, % available Phosphoric acid (%P_2O_5) and % soluble potash (%K_2O)

ii. Fertilizer ratio

- ∞ relative proportion of each of the primary nutrients N, P_2O_5 and K_2O in a fertilizer material
- ∞ Example: 14-14-14 => 1:1:1

iii. General formula:

$$\text{Weight of fertilizer} = \frac{\text{weight of nutrient}}{\text{nutrient content}}$$

- ∞ Sample problem A

The fertilizer recommendation is 90-0-0
How many kg/ha Ammonium sulfate, AS (20-0-0) must be applied to meet the recommendation?

Solution: Kg AS/ha = 90/ 0.20 = 450

If we are going to use urea (45-0-0) instead of AS,
Kg urea/ha = 90/ 0.45 = 200
How many bags AS or urea are needed?
Bags AS/ha = 450 kg/ 50 kg/bag =9
Bags urea/ha = 200 kg / 50 kg/bag = 4

- ∞ Sample problem B

The fertilizer recommendation is 90-30-0
The available fertilizers:
Ammonium sulfate (20-0-0)
Ammonium phosphate (16-20-0)
Solution: Solving first for P,
Kg AP/ha = 30/0.20 = 150
150 kg AP contains 30 kg P_2O_5 and 24 kg N
150 x 0.16 = 24 kg N
The remainder N will come from AS,
90 – 24 = 66 kg N
Kg AS/ha = 66/ 0.20 = 330

♦ **Methods of fertilizer application**

- ∞ ***Broadcast***: when the fertilizer is spread evenly on the soil surface; suitable for rice crop since they are closely planted
- ∞ ***Band placement***: may be applied on the row below the seed level or slightly on the side of the seeds along the row; usually done for crops like corn, sorghum, tobacco, and fruit trees
- ∞ ***Foliar application:*** made when quick action of nutrients is desired or when certain micronutrients are needed to be supplied with the crop; usually

employed in very plantations such as pineapple or banana

- ***In-the-row:*** fertilizer is applied along the bottom of furrow
- ***Ring***: fertilizer is applied around the base of the plant or tree
- ***Hole***: fertilizer is dropped in holes around the tree
- ***Spot***: fertilizer is dropped in small amount on the side of each hill or plant
- ***Basal***: first of fertilizer applied at planting time
- ***Topdress***: application sometime after plants have emerged
- ***Fertigation***: application of fertilizer dissolved in irrigation water

- **Considerations in choosing method of fertilizer application**
  - Relative mobility of nutrients in the soil
  - Type of crop and its rooting pattern
  - Soil texture
  - Season of the year
  - Kind of fertilizer

- **Time of fertilizer application**
  - depends on climate, soil, nutrient and crop
  - In sandy soils, N is necessarily split as well as K
  - For heavy clays, all of N is sometimes placed at planting.
  - P and K are usually applied at planting as they are less mobile, less subject to leaching and less soluble
  - P is also needed at young age to accelerate root development
  - In alkaline soils, ammonium fertilizer is necessary deep placed to minimize volatilization of ammonia

VI. SOIL CONSERVATION AND MANAGEMENT

- **Soil erosion**
  - the detachment and subsequent transport of soil materials (including rock fragments) by an agent (water, wind, or gravity) to an area of deposition
  - an undesirable process in agriculture mainly because of the losses : soil + nutrient+ water + water holding capacity
  - Water is the most important agent of erosion in humid tropical areas and recognized as the major cause of land degradation in the Philippines

- **Mechanism of soil erosion**

i. ***Detachment/dispersion***:process by which raindrops splash soil sediments from the soil surface into the run-off; requires energy that is supplied by the kinetic energy of raindrops

ii. ***Entrainment***: transport of suspended soil particlesfrom upslope to downhill direction whether in rills, between rills and in sheet flow

iii. ***Deposition***:process by which sediment settles out under the action of gravity; a selective process depending on particle size, being rapid for sand and slow for clay

- **Two General types of soil erosion**

i. Geologic erosion

- soil erosion at natural rate
- group of natural processes (including weathering, dissolution, abrasion, corrosion, and transportation) by which material is worn away from the earth's surface
- the process of smoothing down the hills and mountains, etc.
- Soil loss in natural vegetation = 1mm/yr, but fairly matched with the rate of soil formation = 1mm/yr

ii. Accelerated erosion

- the removal of the topsoil faster than the rate of soil formation
- approximated to be 10mm/yr
- usually associated with human activities

- **Forms of soil erosion**

i. Raindrop erosion : soil particles are detached due to the impact of raindrops and splashed at a longer distance in the downslope than in the upslope direction

ii. Sheet erosion

- the uniform removal of thin layer or "sheet" of soil from the land surface by rainfall and surface runoff
- the most widespread and probably the most damaging form of soil erosion
- recognized by the soil deposition at the bottom of a slope, or by the presence of light - colored subsoil appearing on the surface, or stones left on pedestals

iii. Channel erosion

- occurs where surface water has concentrated, so that a large mass of water supplies the energy both for detaching and transporting the soil
- can exist as rill, gully, or stream erosion
  - *Rill Erosion:* an erosion process in which numerous small channels of only several centimeters in depth are formed; usually the result of water washing down between rows of cultivated crops that is planted up and down the hill or in implement marks and other slights and irregularities of the soil surface
  - *Gully Erosion:* also known as advance rill erosion due to the increasing size of rills eventually leading to a gully or a channel too large for crossing by farm or to be smoothed out by ordinary tillage tools
  - *Stream Erosion*: the carrying off of the soil material on the sides and on the bed of a permanent or intermittent stream

- **Factors affecting soil erosion**

i. Climate

- Rainfall is the climatic element that mainly affects erosion in humid tropics
- Rainfall intensity (not rainfall amount) is positively correlated to soil erosion if all other factors are held constant
- *Rainfall erosivity* : the potential ability of the rain to cause erosion

- ∞ Downpours of high intensity and comparatively short duration invariably cause maximum runoff of lands subject to erosion

ii. Relief/ slope

- ∞ slope steepness and slope length affect splash erosion and runoff behaviour by imparting velocity
- ∞ in longer slopes, the runoff water accumulates speed as it nears the bottom end of the slope
- ∞ a long steep slope causes the most severe soil erosion
- ∞ Land slopes cannot be directly changed but can be modified on their effect on runoff by the use traverse channels of terraces.

iii. vegetation

- ∞ intercepts rainfall by absorbing the energy of raindrops, thus reducing runoff
- ∞ retards erosion by decreased runoff velocity
- ∞ physically restrains the soil movement
- ∞ improves aggregation and porosity of soil by roots ad plant residue
- ∞ increases biological activity in the soil
- ∞ its transpiration through the body tissues decreases soil moisture, resulting in increased storage capacity

iv. soil properties

- ∞ *Soil erodibility* : the soil's vulnerability or proneness to erosion which is influenced by infiltration capacity and structural stability of the soil
- ∞ high clay content induces surface runoff and increases transportability but decreases detachability

v. Human activities

- ∞ include management practices and choice of cropping system
- ∞ Farm practices contributing to soil erosion:
  - o shortening of fallow periods: more cropping period due to increase demand in food
  - o Kaingin system of farming/ swidden agriculture/slash and burn
  - o Monoculture system : planting of only one crop may have heavy demands for a particular nutrient
  - o Overgrazing
  - o Plowing along the slope of the land
  - o Logging
  - o Other practices such as; road construction, area development for housing and resettlement

♦ **<u>On-site effects of soil erosion</u>**

- ∞ effects of erosion from the farm where it occurs
  - o Loss of soil and particle selectivity
    - – fine soil particles along with the nutrients are selectively removed
    - – the fraction of the coarse primary soil particles increases in the eroded area
  - o surface sealing and hardening
    - – soil particles are washed into the surface pores, forming a seal up to 1cm thick which restricts water infiltration and increases water runoff

- upon drying, the seal becomes a crust (a dense surface layer of soil particles) which impedes seedling emergence
- Loss of nutrients/decreased fertility
  - selective removal of abse0froming elements (K, Ca, Mg)
  - nutrients attached to soil sediments are lost
  - dissolved nutrients are also lost in runoff
  - added nutrients (fertilizers) are also washed away
- Decreased soil depth
  - degrades soil as a medium for plant growth
  - rooting depth is reduces
  - thin topsoil, often mixed with the subsoil which is generally more acidic and less fertile

- **Off-site effects of soil erosion**
  - effects of soil erosion downstream where soil sediments are deposited; usually a consequence of the on-site effects
    - Siltation of irrigation dams, canals, paddy fields, etc.
    - Reduce life span of reservoirs
    - Destruction of crops and animals downstream; buried crops adjacent bottomlands
    - Destruction of infrastructure like bridges, roads and buildings
    - sediment deposits raise the level of riverbeds reducing its capacity to hold water and increases the chances of overflowing; hazard to navigation

- **Estimation of Soil erosion**: (USLE) Universal Soil Loss Equation
  - Developed to estimate the rate of soil erosion under various conditions
  - It can be a guide for selecting the most appropriate system and management practices that limit soil loss through erosion
  - A = 0.224 R * K * L * S * C * P

    where: A = predicted rate of soil loss in tons/ha/year
    R = rainfall erosivity index
    K = soil erodibility factor
    L = slope length factor
    S = slope gradient factor
    C = cropping system and management factor
    P = erosion control practice factor

- **R factor**
  - reflects climate(rainfall intensity and erosivity) as a factor of soil erosion
  - found in long term records of rainfall specific to each county or state
  - determined by the total kinetic energy and the maximum 30-minute intensity of rain for a given time interval of a given rainstorm

- **K factor**
  - reflects the fact that different soils erode at different rates
  - the measure of rate of erosion per unit quantity of erosion for a specific soils determined using the standard erosion plot
  - can be estimated using data of texture, organic matter, structure and permeability

- **L factor**
  - ∞ result of correlation studies of slope length and erosion using standard plots

- **S factor**
  - ∞ shows the correlation of erosion to percent slope and slope gradient

- **C factor**
  - ∞ The C factor is the crop management factor and is the ratio of soil loss compared to fallow (bare, exposed) soil.

- **P factor**
  - ∞ The P factor is the erosion control factor expressed as a ratio of the soil loss with practices
  - ∞ If a farmer plows up and down the slope of a hill, P=1. When plowing is done following the contours of the hill, P is reduced.

- **Tolerable soil loss (T)**
  - ∞ T is the maximum level of soil erosion that will permit a high level of crop productivity to be maintained economically and indefinitely

- **Soil and Water Conservation Measures**

i. Mechanical/engineering measures

  - ∞ *Terracing* : involves construction of broad channels or benches across the slope to break the flow of runoff water; not a practical method for shallow soils
  - ∞ *Grassed waterways*: refers to canals or channels planted with grasses to provide outlets for disposal of unavoidable runoff water
  - ∞ *Pond* : a depression of considerable size located below the check dam to collect runoff
  - ∞ *Check dam*: a structure above the pond which retards runoff velocity

ii. Biological/ Vegetative Measures

  - ∞ *Mulching*
    - o the practice of covering the soil surface with crop residues
    - o Mulches maintain a greater infiltration rate under prolonged erosive rainfall event by preventing the sealing off of surface soil pores
    - o Residue mulches are effective in reducing soil erosion because the scour forces of runoff are distributed among the mulch elements instead of acting entirely on the soil surface
  - ∞ *Cover cropping*
    - o involves planting of close-growing grasses and legumes to cover and protect the surface of the soil
    - o maintains and increases organic matter content and improves soil physical condition, suppresses weeds, and conserves water
    - o recommended cover crops: tropical kudzu, centrosema, calopogonium, guinea grass, para grass, napier grass, Alabang x

- may not be acceptable to small farmers because it gives no immediate income and the cover crop may compete with the main crop for water and nutrients

∞ *Strip Cropping* (Pilas–tanim) : refers to the growing of erosion-permitting crop and soil-conserving crop in alternate strips aligned on the contour

∞ *Crop Rotation* (Ikot-tanim)
- the systematic planting of different crops in succession on the same piece of land
- general guide: grain crops such as corn and/or upland rice should be followed by legumes such as mungbean, soybean, and peanut
- allows the soil to renew the supply of nutrients which are preferentially depleted by specific crops
- advantages
  - soil-building crops are distributed over all fields
  - rotation provides for more uniform distribution of stable manure and fertilizer to all fields
  - well-planned rotations provide for more continuous cover
  - soils are given time to recuperate from the effects of crops that may have extra-heavy demands for certain nutrients
  - crops vary in the feeding range of their roots, therefore provides for more complete use of the soil profile
  - rotation favors control of weeds, pests and diseases
  - rotation results in a broader distribution of labor and income

∞ *Relay Cropping* (usod-tanim)
- involves the planting of two or more annual crops with the second crop planted after the first crop has flowered or nearing its harvest
- the objective is to allow the second crop to make use of the residual moisture and to provide continuous ground cover to protect the soil from erosive rains throughout the year
- Example: corn and sweet potato

∞ *Multiple Cropping*
- refers to a practice which increase crop productivity while providing better protection of the soil from erosion
- can be sequential cropping(growing of two or more crops a year in sequence) or intercropping and/or mixed cropping (growing of two or more crops on the same piece of land at the same time)
- Example: while sugarcane is still young, intercrop with mungbean, sorghum or corn

∞ *Alley Cropping* (interhedgerow cropping)
- system where arable crops are grown in the alleys between rows of shrub/tree legumes which are pruned periodically to prevent shading and to provide green manure to the companion crops
- commonly used contour hedges are ipil-ipil, gliricidia, camachile (should be deep rooted compared to the main crop)

∞ *High density planting* : practice of increasing the population of the crop per unit of land area with due regard to the effect of crop competition

- ∞ *Agroforestry* : refers to the system of land management where woody perennials and agricultural crops are raised at the same time or sequentially

- **Cultural practices reinforcing soil and water conservation**

i. Conservation tillage : broad term referring to the reduction of soil and water losses relative to conventional tillage; technically refers to a tillage system which leaves 30% residue cover after planting; Involves the following:

- ∞ *contour cultivation*
  - ○ plowing, harrowing and furrowing across the slope of the land
  - ○ effective in minimizing soil erosion on gentle slopes reducing soil loss up to 50%
  - ○ should be used with other conservation practices on areas with steeper slopes, high rainfall and erodible soils
- ∞ *minimum tillage*
  - ○ preparation of the seedbed with minimal soil disturbance
  - ○ done with the use of herbicide or farm tools to remove weeds, followed by tillage to open only a narrow seedbed or hole where the seeds are sown
  - ○ leaves the interrow areas untilled
  - ○ tillage, weeding and planting are carried out simultaneously to minimize exposure time of bare soil surface to the elements of soil erosion
- ∞ *mulch tillage* : tillage practice that leaves a large percentage of residues (leaves, stalks, crowns, and roots) on or near surface as a protective mulch
- ∞ *strip or zone tillage*: preparation of seedbed by conditioning the soil along narrow strips in and adjacent to the seed rows
- ∞ *subsoiling* : practice of breaking up the hard pan below the plow layer to increase infiltration and to reduce runoff
- ∞ *ridge-tying*
  - ○ the technique of connecting the ridges with cross-ties to form depressions for storing rainwater which is allowed to infiltrate later

ii. correction of soil problems e.g. Liming

VII. SOIL SURVEY AND CLASSIFICATION

- **Soil survey**
  - ∞ an inventory of the soil resourcedescribing the characteristics of the soils in a given area
  - ∞ a Province is usually the unit of publication. Example: Soil Survey of Bohol Province
  - ∞ classifies the soils according to a standard system of classification
  - ∞ plots the boundaries of the soils on a map; the map uses an aerial photo as the base
  - ∞ makes predictions about the behavior of soils

- **3 Elements of a Soil Survey**

i. a map showing the geographic relationships of each soil
ii. a text describing the soils

iii. tables giving physical and chemical data and interpretations for various uses.

- **Map Scale** : refers to how many inches on the map represents inches on the ground
  - ∞ Scale of 1:24,000 says 1 inch on map = 24,000 inch on the ground
  - ∞ Soil maps differ in their map scale

- **Orders of Soil Survey**

i. First order: very intensive (detailed); experimental plots, building sites; minimum size delineation is ≤ 1 hectare

ii. Second order: intensive (detailed); general agriculture, urban planning; minimum size delineation is 0.6 to 4 has.

iii. Third order: extensive; rangeland, community area planning; min. size delineation is 1.6 to 16 has.

iv. Fourth order: extensive (reconnaissance); for broad land use potential and general land management; min. size delineation is 16 to 252 has.

v. Fifth order: exploratory; regional planning, national planning; min. size delineation is 252 to 4000 has

- **Soil Taxonomy** :refers to the system of classification developed by the USDA Soil Survey with the following basic guidelines

i. Classify soils on basis of properties

ii. Soil properties should be readily observable and / or measurable

iii. Soil properties should either affect soil genesis or result from soil genesis

- **Reasons for classifying soils**
  - ∞ To organize knowledge about soils
  - ∞ To understand relationships among different soils
  - ∞ To establish groups or classes for practical purposes
    - o predicting behavior
    - o identifying best uses
    - o estimating productivity
    - o extending research results

- **Levels of soil classification**

e.g. Fine-loamy mixed, mesicAquicArgiudolls**;** Lipa series – from the town or landscape feature near where the soil was first recognized (Lipa)

i. Order
  - ∞ Soil-forming processes as indicated by presence or absence of major diagnostic horizons

ii. Suborder
  - ∞ subdivision of soil order based on moisture and temperature regime

iii. Great group
  - ∞ subdivision of suborder based on differences, arrangement, and degree of expression between soil horizons

iv. Subgroup
  - ∞ typic (central concept of the great group); intergrades or transitional forms to other orders, suborders, or great groups; extragrades or additional properties not common to great group characteristics

v. Family
  - ∞ Properties important for plant root growth; broad soil textural classes averaged over control section or "solum"; mineralogical classes for dominant mineralogy of solum; soil temperature classes

vi. Series

- a class of soils and the basic units used to classify soils; nearly 400 soil series in the Philippines
- parent material; kind, number and arrangement of horizons in the profile; kind and arrangement of horizons; color, texture, structure, consistence and reaction of horizons; chemical and mineralogical properties of the horizons

- **Required knowledge in classifying soils**
  - i. ***Diagnostic Horizons*** : distinct types of horizons that reflect nature of soil formation
  - ii. ***Mineralogy*** : dominant type of clay minerals
  - iii. ***Particle size distribution***: proportion of coarse fragments (2mm–74mm size particles) in combination with fine fragments (<2 mm size particles)
  - iv. ***Temperature Regimes*** : mean annual soil temperature (MAT) measured at 50 cm from surface
  - v. ***Moisture Regimes*** : number of days when soil contains available water during the period when soil temperature at 50 cm below the surface is above 5°C

- **Diagnostic horizons:** used for differentiating or classifying soil order level

  i. ***Diagnostic surface horizon***: the *Epipedon* (Gr. *epi*, over, upon, and *pedon*, soil); a horizon that forms at or near the surface and in which most of the rock structure has been destroyed; upper horizon, not necessarily the A horizon only but may include B or part of B horizon
    - *Mollic* (L. *mollis*, soft) : dark, soft, surface layer; thick, greater than 10 inches; high base saturation of > 50%; mineral soil; soils formed under prairie vegetation
    - *Anthropic* : like mollic but contains more than 250 ppm of citric acid soluble P_2O_5
    - *Umbric* (L. *umbra*, shade) : like mollic, but low base saturation
    - *Histic* (Gr. *histos*, tissue) : Organic soil (20-30% organic matter); saturated with water
    - *Ochric* (Gr. *ochros*, pale) : thin, light colored surface layers that do not fit any of the above
    - *Plaggen* (Gr. *sod*, grass roots): man-made, surface horizon that is greater than 50 cm thick created by many years of addition of manure

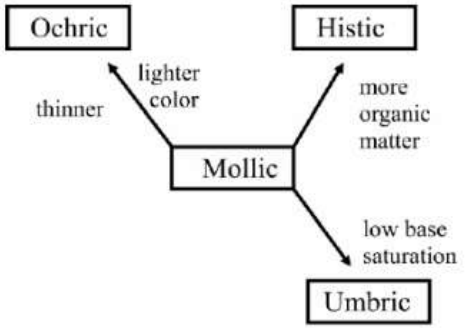


Fig 3. Characteristics of selected surface horizons.

ii. ***Diagnostic subsurface horizon*** (or the lower horizons)
  - *Argilic* (L. *argilla*, white clay) : illuvial horizon of clay accumulation; Bt

- *Agric* (L. *ager*, field) : has an accumulation of clay and humus to the extent of 15% of the soil volume
- *Natric* (L. *natrium*, sodium) : same as argillic but with > 15% exchangeable sodium (Na); Btn
- *Spodic* (Gr. *spodos*, wood ash): illuvial accumulation of oxides of Al and Fe (sesquioxides) and OM; red or dark red color; only found in acid sandy soils; with high rainfall; generally found below E horizon; contains a Bhs or Bs horizon
- *Oxic* : very weathered layer of only Fe and Al oxides and 1:1 clay minerals; low pH and not very fertile (found in tropical soils); Bo
- *Sombric* : light-colored, low % base-saturation and well-drained
- *Placic* (Gr. *plax*, flat stone): a thin, black to dark reddish pan cemented by iron, iron and manganese or by iron-organic matter complex
- *Duripan* (L. *durus*, hard) : subsoil cemented by silica
- *Fragipan* (L. *fragis*, brittle) : subsoil that is hard when dry but brittle when moist
- *Albic* (L. *albus*, white) : light colored subsoil from where clay and free iron oxides have been leached out
- *Calcic* : accumulation of $CaCO_3$ or $Ca\,Mg(CO_3)_2$
- *Gypsic* : accumulation of gypsum
- *Petrocalcic* : cemented by $CaCO_3$
- *Cambic* : slightly altered layer; not weathered enough to be argillic; Bw horizon designation or development of color and or structure
- *None* : no diagnostic subsurface horizon present

♦ **Soil Temperature Regimes** are measured at 50 cm from ground surface

i. Pergelic : mean annual temperature (MAT) is $<0^{\circ}C$
ii. Cryic : MAT is $0^{\circ}C - 8^{\circ}C$
iii. Frigid : MAT is $< 8^{\circ}C$ (warmer than cryic in summer)
iv. Mesic : MAT is $8^{\circ}C - 15^{\circ}C$
v. Thermic : MAT is $15^{\circ}C - 22^{\circ}C$
vi. Hyperthermic: MAT is $> 22^{\circ}C$

∞ Prefix "Iso" is used if mean summer (June, July, August) and winter (December, January, February) temperature differ by $<5^{\circ}C$
- Isofrigid : MAT is $< 8^{\circ}C$
- Isomesic: MAT is $8^{\circ}C - 15^{\circ}C$
- Isothermic: MAT is $15^{\circ}C - 22^{\circ}C$
- Isohyperthermic: MAT is $> 22^{\circ}C$

♦ **Soil Moisture Regimes**

∞ measured in terms of the absence or presence of water held at a tension of <15 bars in the moisture control section by a period of one year
∞ soil moisture control section: 10-30 cm in clayey soils; 20–60 cm in loamy soils; and 30–90 cm in sandy soils
- *aquic moisture regime* : soil is saturated and no dissolved oxygen (reducing regime)
- *aridic and torric* : soil moisture control section is dry more than half the time when soil temp. at 50 cm is $>5^{\circ}C$; moist for <3 months only
- *ustic moisture regime*: dry for >3 months and continuously moist for at least 3 months

- *udic moisture regime* : soil is dry for < 3 months only
- *xeric moisture regime* : soil is continuously dry 45 days after summer and continuously moist 45 days after winter (dry summer-wet winter)

- **The 12 Soil Orders**: Each Order has a diagnostic epipedon and subsurface horizons; could be "none"

1. ***Entisol*** (ent, recent): very young soil showing very limited profile development; characteristically have A/C or A/R profiles, exhibit only ephemeral soil development; largely confined to surface horizon; may have an Ap horizon; 12.5% of world
2. ***Inceptisol*** (ept, inception) : young soil with moderate profile development; shows the beginning of horizon development; little or no illuviation; soil formed in colluvial material
3. ***Aridisol*** (id, L. *aridus*, dry) : limited change in parent material due to dryness; Arid regions of the world (19%), < 10 in of rainfall, usually contain carbonates
4. ***Gelisol*** (el, no meaning) : young soils with little profile development; presence of permafrost layer; remains at temperatures below 0°C for >2 consecutive years; 8.6% of the world
5. ***Mollisol*** (oll, L. *mollis*, soft) : soils with thick, dark, soft surface; soils of the grassland
6. ***Andisol*** (and, no meaning) : soils from volcanic ash and cinders; very light, low bulk density, early-stage secondary minerals (allophane, imogolite, ferrihydrite clays), High P fixing capacity; 0.7% of the world
7. ***Spodosol*** (od, Gr. *spodos*, wood ash) : acid sandy soils with thick E and red; Bhs, ochric and spodic; subsoil has accumulation of Fe and Al oxides, humus and amorphous clays
8. ***Alfisol*** (alf, no meaning) :argillic B horizon with high base saturation; fertile forested soils with ochric and argillic
9. ***Ultisol*** (ult, L. *ultimus*, last) : the B horizon has high amount soft clay but low base saturation; soils more weathered than Alfisols
10. ***Oxisol*** (ox, Fr. oxide) : highly weathered soil with B horizon containing mainly 1:1 Kaolinite clays
11. ***Vertisol*** (ert, L. *verto*, to turn) : shows large cracks upon drying due to dominance of montmorillonite
12. ***Histosol*** (ist, Gr. *histos*, tissue) : organic soils; peat soils, organic material

    Peat : undecomposed to slightly decomposed organic matter in waterlogged areas;

    Muck : highly decomposed organic matter

- **Classification of soils into Land suitability classes**
  - soils are classified according to their capability for agricultural use or non-agricultural use with a primary aim of protecting the soil from erosion and degradation
  - the major considerations are the following:
    - risk of runoff and erosion
    - wetness or need for drainage
    - limitations to root development and tillage operations e.g. shallow soil, low water holding capacity, salinity, presence of stones or boulders and climatic characteristics

- **9 suitability classes of soils**

1. ***Class A*** : good land that can be cultivated safe and extensively to most crops with ordinary good farming practices
2. ***Class B*** : good land which can be cultivated safely using easily applied conservation practices
3. ***Class C*** : moderately good land that can be used regularly for cultivated crops in good rotation but needs intensive soil conservation treatments
4. ***Class D***: fairly good land that is best suited for pasture but which can be used for agricultural crops in good rotation provided intensive soil conservation practices are applied
5. ***Class L*** : land that is flat but is too wet or stony and therefore more suited to pasture or forestry
6. ***Class M***: land that is too steep, eroded or shallow for cultivation of regular agricultural crops and is better left to pasture forestry
7. ***Class N*** : land that is very steep, eroded, rough, shallow or dry and is better suited to pasture forestry if handled carefully
8. ***Class X*** : level land that is wet most of the time and cannot be drained economically; best suited for ponds or recreational areas
9. ***Class Y***: land that is too steep, eroded, barren and rugged and should be left for wildlife or parks

----------End of Soil Science----------

Review Questions in Soil Science

1. A dynamic natural body on the earth's surface composed of both living and non-living materials where plants can grow
    a. Soil profile
    b. Soil
    c. Soil horizon

d. Soil pedon

2. The study of soil from the standpoint of higher plants or plant production
   a. Petrology
   b. Edaphology
   c. Pedology
   d. Physiology
3. The size of this soil particle is less than 1 µm.
   a. Soil colloids
   b. Silt
   c. Sand
   d. Organic matter
4. Nitrification carried out by autotrophic bacteria is not affected by which of the following?
   a. Temperature
   b. pH
   c. Oxygen supply
   d. Redox potential
5. In relation to crop production, clayey soils are known to be
   a. easy to cultivate
   b. more fertile than sand
   c. low water holding capacity
   d. high percolation rate
6. A soil consists of the three components, namely: solid, liquid and gas
   a. the solid is composed of inorganic matter and organic matter
   b. the liquid is a solution with dissolved ions in it
   c. the gas component is about 80% nitrogen gas (N_2)
   d. all of the above
7. This macronutrient is not a component of any organic molecule in the plant; its function is more catalytic in nature and usually deficient in coarse-textured soils.
   a. Nitrogen
   b. Phosphorus
   c. Potassium
   d. Calcium
8. Component of amino acids such as methionine, cystein, and cystine and is usually deficient in waterlogged soils.
   a. Sulfur
   b. Calcium
   c. Magnesium
   d. Copper
9. The soil is called a _____ because it comes from the weathering of naturally occurring rocks and minerals.
   a. Dynamic body
   b. Natural body
   c. Natural resource
   d. Weathered rock
10. Needed in chlorophyll synthesis and usually deficient in alkaline soil.
    a. Iron
    b. Zinc
    c. Molybdenum
    d. Boron
11. Needed in the synthesis of auxin and is usually deficient in waterlogged soils.
    a. Iron
    b. Zinc
    c. Molybdenum
    d. Copper
12. Rocks formed by cooling and solidification of molten magma and lava in the crust
    a. Extrusive rocks
    b. Igneous rocks
    c. Sedimentary rocks
    d. Intrusive rocks
13. Individual soil layers or layers parallel to the ground surface.

a. Profile
b. Pedon
c. Horizon
d. Solum

14. What is the moisture regime of the soil Tropaquepts which are Inceptisols that are found in the tropics?
    a. ustic
    b. aquic
    c. aridic
    d. xeric
15. The non-crystalline organic colloidal fraction of the soil.
    a. Organic material
    b. Humus
    c. Clay
    d. Silt
16. Soil microorganism that degrade carbon – containing pesticide are considered
    a. Phototrophs
    b. Chemotrophs
    c. Heterotrophs
    d. Autotrophs
17. The most abundant gas in the soil atmosphere is
    a. CO_2
    b. O_2
    c. N_2
    d. Ar
18. The physicist who formulated the law governing the rate of settling particles in viscous medium
    a. Jenny
    b. Dokuchaev
    c. Lal
    d. Stoke
19. Under its natural occurrence a soil is aggregated and porous
    a. An aggregate is composed of millions of individual particles
    b. The pores are interconnected channels to other pores
    c. Water and air occupy the pores
    d. All of the above
20. Rocks that are formed when magma did not reach the earth's surface but solidifies in the cavities or cracks that the magma had made by pushing the surrounding rock apart or by melting or dissolving it.
    a. Extrusive rocks
    b. Intrusive rocks
    c. Granitic rocks
    d. Basaltic rocks
21. Loose earth materials above solid rock
    a. Regolith
    b. Solum
    c. Pedon
    d. Profile
22. Haplauents are young soils with minimal development. In what order does the soil belong?
    a. Entisols
    b. Inceptisols
    c. Mollisols
    d. Vertisols
23. The Philippine adopts the _____ Soil Classification System
    a. United States Department of Agriculture (USDA)
    b. Food and Agriculture (FAO)
    c. International Society of Soil Science (ISSS)
    d. British Soil Classification System (BSCS)
24. A soil horizon is defined as _____.
    a. The depth of finely divided soil mineral over bed rock
    b. A soil layer that differs in recognized properties from other layers below
    c. The slope of the soil surface relative to the horizon
    d. All of the above
25. Soil texture that would be best for growing lowland rice

a. sandy loam
b. clay
c. silty loam
d. silty sand

26. A sedimentary rock which is a recemented clay
    a. Conglomerate
    b. Sandstone
    c. Siltstone
    d. Shale
27. A soil order characterized as shrinking and swelling dark clay soils
    a. Gelisols
    b. Vertisols
    c. Inceptisol
    d. Entisols
28. It is an amorphous or less crystalline clay developed from volcanic ash.
    a. Allophane
    b. Iron oxide
    c. Kaolinite
    d. Montmorillonite
29. The biochemical oxidation of ammonium to nitrate, predominantly by autotrophic bacteria.
    a. Denitrification
    b. Ammonium fixation
    c. Nitrification
    d. Immobilization
30. An example of physical weathering process is
    a. Exfoliation
    b. Hydrolysis
    c. Hydration
    d. Oxidation
31. Generally, coarse-textured soils are characterized as soils with
    a. low water holding capacity
    b. low total surface area
    c. high percolation rate
    d. all of the above
32. These are naturally occurring inorganic substances with fairly definite chemical composition and specific physical properties
    a. Rocks
    b. Igneous rocks
    c. Primary mineral
    d. Minerals
33. A soil order characterized as embryonic soil with few diagnostic features
    a. Alfisols
    b. Spodosol
    c. Inceptisol
    d. Entisols
34. In strongly acid soils, the availability of most micronutrient cations is
    a. Increased
    b. Decreased
    c. Not affected
    d. Remains the same
35. Generally, fine-textured soils are characterized to have
    a. low water holding capacity
    b. high ability to supply plant nutrients
    c. low total surface area
    d. high percolation rate
36. The relative distribution of sand, silt, and clay is called soil _____.
    a. Texture
    b. Structure
    c. Cation exchange capacity
    d. pH
37. Minerals that are crystallized from the cooling of magma
    a. Primary minerals
    b. Secondary minerals
    c. Quartz

d. Tertiary minerals

38. Andepts are soils that were derived from volcanic activity and were originally classified as Inceptisols. What is the new order of these soils?
    a. Gelisols
    b. Andisols
    c. Oxisols
    d. Vertisols
39. It belongs to the 1:1 non-expanding type of silicate clay mineral.
    a. Vermiculite
    b. Illite
    c. Kaolinite
    d. Montmorillonite
40. The percent water remaining in soil 2 to 3 days after it had been saturated and the free drainage had practically ceased
    a. Hygroscopic water
    b. Permanent wilting point
    c. Plant availability water
    d. Field capacity
41. The study of rock
    a. Pedology
    b. Rockology
    c. Petrology
    d. Hydrology
42. Which of these soils has the most rapid percolation rate?
    a. sandy soils
    b. silty soils
    c. clayey soils
    d. none of the above
43. Soil texture refers to the coarseness or fineness of a soil
    a. sand is gritty
    b. silt is sticky and plastic
    c. clay is smooth
    d. all of the above
44. The primary source of calcium in the soil
    a. Gypsum
    b. Hematite
    c. Shale
    d. Calcite
45. An example of a 2:1 expanding type of silicate mineral.
    a. Halloysite
    b. Kaolinite
    c. Illite
    d. Montmorillonite
46. Most of the N in the solid fraction of the soil is in the form of
    a. Ammonium N
    b. Nitrate N
    c. Nitrite N
    d. Organic N
47. The molten mass where igneous rocks solidify from is:
    a. Core
    b. Magma
    c. Mantle
    d. Soil
48. The decomposition of the complex substances of rocks and minerals resulting to changes in chemical composition, release of soluble materials and formation of new minerals.
    a. Exfoliation
    b. Weathering
    c. Chemical weathering
    d. Physical weathering
49. The general term for the process whereby ions adsorbed on the surface of soil colloids are exchanged for ions in the soil solution.
    a. Anion exchange
    b. Cation exchange
    c. Ion exchange
    d. Isomorphous substitution

50. It refers to the amount of exchangeable cations per unit weight of dry soil.
    a. Anion exchange capacity
    b. Base saturation
    c. Cation exchange capacity
    d. Exchangeable acidity
51. Nitrate is not removed from the soil system by which of the following?
    a. Nitrogen fertilization
    b. Erosion
    c. Leaching
    d. Plant uptake
52. Metamorphosis is caused by
    a. Leaching
    b. Earthquake
    c. High pressure and temperature
    d. Floods
53. It refers to the arrangement of primary soil particles into secondary units or aggregates
    a. soil consistency
    b. soil texture
    c. soil structure
    d. soil density
54. This regime has mean annual soil temperature of 15℃ or higher but lower than 22℃.
    a. Cryic
    b. Mesic
    c. Thermic
    d. Hyperthermic
55. The weathering that takes place below the soil solum
    a. Pedochemical weathering
    b. Geochemical weathering
    c. Physical weathering
    d. Exfoliation
56. A subsoil with high clay accumulation is written in symbol as
    a. Bt
    b. Btc
    c. Ct
    d. Ct1
57. The source of permanent negative charge of clays.
    a. Anion exchange
    b. Cation exchange
    c. Isomorphous substitution
    d. Protonation
58. The source of positive charge of silicate clays.
    a. Anion exchange
    b. Cation exchange
    c. Isomorphous substitution
    d. Protonation
59. Microaerophillic microorganisms require
    a. Extremely high oxygen level
    b. No oxygen level
    c. Minimal oxygen level
    d. High oxygen level
60. The weathered parent material corresponds to this horizon
    a. AB
    b. E
    c. C
    d. ABC
61. These are natural soil aggregates
    a. Pebbles
    b. Clods
    c. Peds
    d. Granules
62. A mean annual temperature of 8℃ or higher but lower than 15℃ defines this soil temperature regime
    a. Thermic
    b. Mesic

c. Hyperthermic
d. Cryic

63. This compound reacts with carbonic acid forming a more soluble bicarbonate. Its reaction contributes to the weathering process.
    a. Hydration
    b. Hydrolysis
    c. Carbonation
    d. Solution
64. This horizon is plowed and rich in humus. It will be designated as __ horizon.
    a. Ap
    b. Bt
    c. Ct
    d. All of above
65. A 25 gram soil saturated with 5 me Ca^{2+} has a cation exchange capacity equal to
    a. 5 me/100 g soil
    b. 25 me Ca/100 g soil
    c. 10 me Ca/100 g soil
    d. 20 me Ca/100 g soil
66. The principal form of nitrogen utilized during rapid plant growth period is
    a. N_2
    b. NO_3^-
    c. NH_2
    d. NH_4^+
67. The true soil corresponds to horizon
    a. A,B,C
    b. A,B,C,D
    c. C
    d. A,B
68. Characteristic soil structure of sandy soils
    a. single-grained
    b. massive
    c. platy
    d. crumb
69. In relation to crop production clayey soils are known to be
    a. sticky to cultivate
    b. fertile than sand
    c. high water holding capacity than sand
    d. all of the above
70. The mean annual soil temperature is 22 ℃ or higher
    a. Mesic
    b. Hyperthermic
    c. Thermic
    d. Cryic
71. A Russian pedologist who published the first soil forming factor equation
    a. Lafinikov
    b. Jennykov
    c. Gerasinov
    d. Dokuchaev
72. Compute the % base saturation of a soil with a CEC of 100 me/100 g and whose exchange sites are occupied by 20 me/100 g of basic cations.
    a. 20%
    b. 25%
    c. 75%
    d. 68%
73. The relationship of percent base saturation and soil pH
    a. %BS increases as soil pH decreases
    b. %BS decreases as soil pH increases
    c. %BS decreases as soil pH decreases
    d. %BS decreases does not affect soil pH
74. Particle density is a stable soil property and most agricultural soils would have particle densities close to this value
    a. 1.33 g/cm^3
    b. 2.66 g/cm^3

c. 1.65 g/cm^3
d. 2.33 g/cm^3

75. The fitness of a given type of land for specified kind of land use.
    a. Land suitability
    b. Land mapping unit
    c. Land quality
    d. Land utilization type
76. The most influential factor in soil formation
    a. Biosphere
    b. Climate
    c. Parent material
    d. Time
77. _____ are chemical elements taken up by plants in large quantities.
    a. Essential elements
    b. Macronutrients
    c. Trace elements
    d. Micronutrients
78. Which of the following process is not mediated by soil microorganisms?
    a. N mineralization
    b. P immobilization
    c. S oxidation
    d. Biological nitrogen fixation
79. Soil texture could be determined by
    a. "feel" method
    b. pipette method
    c. hydrometer method
    d. all of the above
80. The minimum size of delineation is 0.2 hectare to 4 hectare. The order of soil survey is
    a. 1st
    b. 3rd
    c. 4th
    d. 5th
81. In the soil profile, parent material of soil is usually located in
    a. Topmost
    b. Lowest part
    c. Middle
    d. Any place
82. The general form of nutrients taken up by plants is
    a. Molecules
    b. Nutrients
    c. Compounds
    d. Ions
83. Iron oxide mineral that contribute red color to many soils.
    a. Chlorite
    b. Hematite
    c. Flouroapatite
    d. Quartz
84. The mineral supplying P is
    a. Feldspar
    b. Apatite
    c. Talc
    d. Pyrite
85. Soil grown to corn is best cultivated when the soil consistency is
    a. Plastic
    b. Hard
    c. Friable
    d. Viscous
86. Soil texture could be determined in the laboratory by
    a. ammonium acetate method
    b. buoyancy method
    c. hydrometer method
    d. none of the above
87. The minimum size of delineation is 16 ha to 259 ha. The order of soil survey is
    a. 1st

b. 4^{th}
c. 3^{rd}
d. 5^{th}

88. Soil formation slows down because of constant mixing within the profile, nullifying the colloid movement downward by
    a. Plant roots
    b. Burrowing animals
    c. Leaching
    d. Hydration
89. The lowest category of the US Soil Taxonomy is
    a. Order
    b. Subgroup
    c. Great group
    d. Series
90. The form of nitrogen taken up by plants from the soil.
    a. NO_2
    b. NH_3
    c. NH_4^+
    d. N_2
91. What do you expect when you increase OM of the soil?
    a. Decrease the amount of N to apply
    b. Increase the amount of N to apply
    c. Maintain the amount of N to apply
    d. None of the above
92. Calculate the gravimetric moisture content of the soil sample if its fresh weight (FW) is 25 g and its oven dry weight (ODW) is 20 g.
    a. 10%
    b. 15%
    c. 20%
    d. 25%
93. The upper diameter size limit of clay particles is
    a. 2.0 mm
    b. 0.002 mm
    c. 0.2 mm
    d. 0.02 mm
94. Represent areas that should be permanently retained as forest environment
    a. Agricultural areas
    b. Preservation areas
    c. Expansion areas
    d. Rehabilitation areas
95. Movement of material out of a portion of a soil profile as in an albic horizon.
    a. Illuviation
    b. Eluviation
    c. Leaching
    d. Enrichment
96. This will retard soil profile development because it exposes new materials
    a. Low rainfall
    b. Steep slopes
    c. high temperature
    d. All of the above
97. Water deposited sediments are called
    a. Colluvial deposits
    b. Alluvial deposits
    c. Glacial deposits
    d. Aeolian deposits
98. The major form of nitrogen in the soil is
    a. Organic
    b. Elemental
    c. Inorganic
    d. Available
99. An element which is an important component of plant cell wall.
    a. Nitrogen
    b. Phosphorus
    c. Calcium
    d. Magnesium

100. Non-symbiotic N_2 fixing organisms in lowland soil.
    a. Actinomycetes
    b. Bacteria
    c. Cyanobacteria
    d. Fungi
101. The resistance of a mineral to abrasion is
    a. Hardness
    b. Luster
    c. Specific gravity
    d. Cleavage
102. The softest mineral is
    a. Diamond
    b. Talc
    c. Quartz
    d. Apatite
103. Available water capacity is calculated as
    a. Saturation or maximum holding minus permanent wilting point
    b. Saturation or maximum holding minus hygroscopic coefficient
    c. Field capacity minus permanent wilting point
    d. Field capacity minus hygroscopic coefficient
104. The upper diameter size limit of silt particle is
    a. 0.02 mm
    b. 2.0 mm
    c. 0.2 mm
    d. 0.0002 mm
105. The upper diameter size limit of sand particles is
    a. 0.2 mm
    b. 0.02 mm
    c. 2.0 mm
    d. 0.002 mm
106. The removal of soluble salts from salic horizon
    a. Decalcification
    b. Desalinization
    c. Calcification
    d. Salinization
107. The smallest volume that can be called a soil individual.
    a. Soil profile
    b. Regolith
    c. Pedon
    d. Polypedon
108. The conversion of ammonium form of nitrogen to nitrate.
    a. Nitrification
    b. Ammonification
    c. Denitrification
    d. Volatilization
109. The hardest mineral is
    a. Diamond
    b. Talc
    c. Quartz
    d. Apatite
110. If the field capacity of the soil is 35% and the permanent wilting point is 25%, the available water in the soil is
    a. 10%
    b. 15%
    c. 20%
    d. 25%
111. Soil textural class wherein sand, silt and clay are in almost equal proportion in a soil mass
    a. Sand
    b. Silt
    c. Loam
    d. Clay
112. The transformation of raw organic material to humus
    a. Humification
    b. Leucinization
    c. Addition

d. Paludization

113. The highest category in US Soil Taxonomy.
    a. great group
    b. order
    c. suborder
    d. series
114. The microorganism responsible for the conversion of ammonium to nitrite.
    a. Nitrosomonas
    b. Azotobacter
    c. Mycorrhizae
    d. Nitrobacter
115. Considered as zone of eluviation
    a. AB
    b. E
    c. C
    d. ABC
116. This mineral is hardly soluble in water
    a. Talc
    b. Quartz
    c. Gypsum
    d. Fluorite
117. The ideal bulk density value of a soil
    a. 2.33 g/cm^3
    b. 1.33 g/cm^3
    c. 1.65 g/cm^3
    d. 2.66 g/cm^3
118. The chemical migration of Al and Fe and/or organic matter
    a. Ferrugination
    b. Podzolization
    c. Laterization
    d. Gleization
119. The movement of material out of a portion of soil profile.
    a. Illuviation
    b. Leaching
    c. Podzolization
    d. Eluviation
120. Organic soils that exhibit or possess a histic epipedon belong to the order
    a. Mollisols
    b. Histosols
    c. Oxisols
    d. Ultisols
121. One of the following is immobile in plants
    a. Nitrogen
    b. Potassium
    c. Calcium
    d. Sulfur
122. This is not an element of climate
    a. Relief
    b. Precipitation
    c. Temperature
    d. Sunshine
123. The physicist who formulated the law governing the movement of water in the soil
    a. Stoke
    b. Dokuchaev
    c. Darcy
    d. Aristotle
124. Characteristic feel of sand separates when rubbed in between the finger is
    a. Gritty
    b. Floury
    c. Sticky when moist
    d. All of the above
125. Consists of sand in ridges and intervening troughs that shift with the wind
    a. Beaches

b. Duneland
c. Pits
d. Riverwash

126. These are microorganisms that can grow at high temperatures (45℃ and 75℃).
a. Psychrophiles
b. Thermophiles
c. Pedophiles
d. Mesophiles

127. A combination of all the management and land use methods to safeguard the soil against depletion, loss and deterioration by natural and/or man-induced factors.
a. Soil Science
b. Pedology
c. Soil Conservation and Management
d. Universal Soil Loss Equation

128. Soil moisture and temperature regimes are commonly used in what category of the US Soil Taxonomy?
a. Suborder
b. Order
c. Great group
d. Family

129. The microorganism responsible for the conversion of nitrite to nitrate.
a. Nitrobacter
b. Azotobacter
c. Mycorrhizae
d. Nitrosomonas

130. Temporary unavailability of nitrogen in the soil because it is being used up by microorganisms to build their tissues.
a. Ammonification
b. Immobilization
c. Mineralization
d. Nitrification

131. Bio-N is a biofertilizer which enhances shoot growth and root development of host crop. Who developed Bio-N?
a. Dr. Erlinda Paterno
b. Dr. Bayani Espiritu
c. Dr. Reynaldo Ebora
d. Dr. Ida Dalmacio

132. Parent material deposited in lakes is referred to as
a. Alluvium
b. Marine
c. Lacustrine
d. Tuff

133. Identify the soil physical property that is not readily subject to change, so it is considered a basic soil property
a. soil structure
b. soil texture
c. bulk density
d. soil color

134. Soils with very little development. The profile properties are largely inherited from parent material.
a. Entisol
b. Vertisol
c. Aridisol
d. Mollisol

135. Characteristic feel of clay separates when rubbed in between the finger is
a. Gritty
b. Floury
c. Sticky
d. All of the above

136. Characteristic feel of silt separates when rubbed in between the finger is
a. Gritty
b. Floury
c. Sticky

d. All of the above

137. Bacteria with flagella all around the cell, with one or two at each pore
   a. Atrichous
   b. Lopotrichous
   c. Amphitrichous
   d. Peritrichous

138. Residues of living things in all state of decomposition whose influence on the soil properties is very significant even if present in very small amount.
   a. Inorganic matter
   b. Organic matter
   c. Soil air
   d. Soil solid

139. The most abundant element in the earth's crust is
   a. Ca
   b. Ti
   c. Si
   d. N

140. A master horizon that shows accumulation or deposition of either clay, silt, salts or other materials is
   a. B
   b. C
   c. A
   d. R

141. Soil with high clay content and base saturation, fertile, not cracking and can support good crop growth is
   a. Ultisols
   b. Oxisols
   c. Alfisols
   d. Andisols

142. It is the conversion of organic to inorganic forms of nitrogen.
   a. Ammonification
   b. Mineralization
   c. Nitrification
   d. Volatilization

143. The loss of nitrogen to the atmosphere in the form of ammonia.
   a. Ammonification
   b. Denitrification
   c. Nitrification
   d. Volatilization

144. What soil order predominates in the Philippines?
   a. Ultisols
   b. Vertisols
   c. Entisols
   d. Histosols

145. Which of these processes contribute to global warming?
   a. Nitrogen fixation
   b. Mineralization
   c. Immobilization
   d. Organic matter decomposition

146. The most abundant elements in the earth crusts are
   a. N, S, K, Ca, Mg
   b. C, S, O, N, P, K
   c. Fe, Al, S, N, P
   d. O, Si, Al, Fe, Ca

147. Which of the following is a secondary mineral?
   a. Montmorillonite
   b. Quartz
   c. Feldspar
   d. Olivine

148. Which of the following is not a soil forming factor?
   a. Climate
   b. Organism
   c. Time
   d. Soil color

149. Soils of the arid regions with limited change in parent material due to low climatic intensity.

a. Entisol
b. Spodosol
c. Aridisol
d. Mollisol

150. Soils with friable surface horizons darkened by organic matter accumulations.
a. Entisol
b. Mollisol
c. Inceptisol
d. Aridisol

151. Which of the following is not a soil structure?
a. Clay
b. Crumb
c. Platy
d. Sub-angular blocky

152. The highest gas composition of soil air.
a. N_2
b. Ar
c. CO_2
d. O_2

153. The element which contributes to phosphorus fixation at high soil pH.
a. Aluminum
b. Calcium
c. Iron
d. Manganese

154. Aside from neutralizing soil acidity, lime like $CaCO_3$ may also
a. Improve soil structure
b. Improve soil texture
c. Increase CEC
d. Both A and C

155. Fixation of elements usually converts the elements from available to unavailable forms. Which of these processes render the element from unavailable to available form?
a. NH_4 fixation
b. P fixation
c. N_2 fixation
d. K fixation

156. In the absence of O_2, nitrate is used by facultative bacteria as their electron acceptor; NO_3 is therefore reduced and lost in the form of
a. NH_4^+
b. NO_2^-
c. N_2
d. N

157. In flooded soils, nitrate undergoes reduction and lost as gas in a process termed as
a. denitrification
b. nitrogen fixation
c. nitrification
d. volatilization

158. During OM decomposition, the released N is utilized by microorganisms for the formation of new cells. This process is called
a. mineralization
b. nitrification
c. immobilization
d. denitrification

159. The basic elements lost in weathering are
a. Fe, P
b. Ca, Mg
c. Zn, Mn
d. K, P

160. Soils that are described to be self-plowing because of the large cracks formed upon drying
a. Vertisol
b. Alfisol
c. Ultisol

d. Oxisol

161. Soil densities and porosities are affected by soil texture and soil structure. Which of the following statement is true?
    a. Porosity increases with increasing bulk density
    b. Soil compaction increases bulk density
    c. Soil aggregation increases bulk density
    d. None of the above
162. P = P_2O_5 multiplied by ____
    a. 0.34
    b. 0.43
    c. 0.54
    d. 0.45
163. The _____ contains dissolved electrolytes, non-electrolytes, ions, etc.
    a. Soil organic matter
    b. Soil solution
    c. Soil air
    d. Soil solid
164. The study of the mechanical behavior of soils.
    a. Soil physics
    b. Soil microbiology
    c. Soil chemistry
    d. Soil mechanics
165. The mineral matter component of soils makes up about
    a. 25%
    b. 30%
    c. 50%
    d. 45%
166. In soil profile description, soil coatings or cutans must be properly observed. Which of the following is a cutan name?
    a. iron coatings
    b. Ferran
    c. Slickensides
    d. Both a and c
167. Pedon is the smallest volume that can be observed for purposes of soil classification. What is its range of dimension?
    a. 1-2 m^2
    b. 1-10 m^2
    c. 8-12 m^2
    d. 10-20 m^2
168. Soil temperature regimes are classified based on the normal prevailing temperature of the site. If the temperature is usually greater than 21 ℃, the soil belongs to
    a. Cryic
    b. Hyperthermic
    c. Thermic
    d. Mesic
169. The element which fixes phosphorus at low soil pH.
    a. Calcium
    b. Aluminum
    c. Magnesium
    d. Potassium
170. The measure of alkalinity or basicity of the soil
    a. Acid saturation
    b. Base saturation
    c. CEC
    d. pH
171. Which of the following causes soil acidity?
    a. Green manuring
    b. Irrigation
    c. Leaching of bases
    d. Liming
172. Soils with high buffering capacity are generally those which are
    a. Sandy soil with low organic matter
    b. Clayey with high organic matter
    c. Sandy with high organic matter
    d. Clayey with low organic matter

173. Which of the following soil microorganisms is the most numerous in soils?
    a. Bacteria
    b. Fungi
    c. Virus
    d. Actinomycetes
174. Parent material that has formed by weathering of bedrock in place is
    a. Transported
    b. Residual
    c. Lacustrine
    d. Eoline
175. Soils with extremely high amount amounts of organic matter
    a. Mollisol
    b. Histosol
    c. Aridisol
    d. Ultisol
176. Soils found in cold regions
    a. Aridisol
    b. Spodosol
    c. Gelisol
    d. Alfisol
177. One hectare furrow slice (HFS) is equal to
    a. 6×10^3 kg
    b. 3×10^6 kg
    c. 2×10^6 kg
    d. 6×10^2 kg
178. The nutrient element that is easily lost and mostly required by plants.
    a. Nitrogen
    b. Phosphorus
    c. Sulfur
    d. Calcium
179. When the soil is flocculated, it means that the soil has a high amount of
    a. Phosphorus
    b. Potassium
    c. Calcium
    d. Nitrogen
180. The major source of most of the organic matter in soil
    a. Rocks and minerals
    b. Bodies of dead animals and insects
    c. Plant residues
    d. B and C
181. Type of silicate clay with two or more linked tetrahedra
    a. Sorosilicates
    b. Nesosilicates
    c. Cyclosilicates
    d. Tectosilicates
182. Rock classification that are laid down by water
    a. Metamorphic rocks
    b. Sedimentary rocks
    c. Gravitational rocks
    d. Mechanical rocks
183. A metamorphosed limestone produces
    a. Shale
    b. Marble
    c. Dolomite
    d. Schist
184. Which is a more detailed map?
    a. 1:5,000
    b. 1:50,000
    c. 1:15,000
    d. 1:10,000
185. In mapping, the base map in which the survey data will be transferred and ultimately be presented is
    a. Land Use map

b. Soil map
c. Fertility map
d. Topographic map

186. Soil color is described using hue, value and chroma. In the soil color notation 4 YR 3/6, the hue is
a. A. 4 Y
b. 3
c. 4 YR
d. 6

187. In 10R 2/5 color notation, the value is
a. 10R
b. 2
c. 10
d. 5

188. Soil mineralogy is commonly used in identifying names at this category
a. Order
b. Great group
c. Family
d. Series

189. The ability of the soil to resist pH change
a. Base saturation
b. Buffering capacity
c. CEC
d. Neutralization reaction

190. Which of the following manures contains the highest amount of nitrogen?
a. Bat
b. Cattle
c. Goat
d. Poultry

191. In the list given below, identify the potential source of toxins in the soil.
a. Sewer sludge
b. Decomposing OM
c. Soil microorganism
d. Plant roots

192. This soil category defines largely on the basis of physical and mineralogical properties importance to plant growth.
a. Subgroup
b. Soil series
c. Great group
d. Family

193. In continuous flooding such as in waterlogged lowland rice, there is a decrease in the availability of these essential elements.
a. Zn, S and Cu
b. N, P and K
c. Ca, Mg and S
d. C, H and N

194. Which of the following is called the white mica?
a. Muscovite
b. Illite
c. Montmorillonite
d. Kaolinite

195. The dark color of igneous rocks is usually caused by
a. Ferromagnesian minerals
b. Quartz
c. Feldspar
d. Calcite

196. Current record on the total numbers of Soil Orders as of 2009
a. 100
b. 47
c. 12
d. >1000

197. Number of soil orders found in the Philippines, as of 2009
a. 11
b. 12
c. 7

d. 10

198. It refers to grouping of soils in an orderly manner so that their properties can be easily remembered
    a. soil science
    b. soil classification
    c. land suitability
    d. soil topography

199. The process of classifying soil types and other properties in a given area
    a. soil science
    b. soil classification
    c. soil survey
    d. soil map

200. Studies the field observable attributes of the soil within the various soil horizons and the description of the kind and arrangement of the horizons
    a. Soil Physics
    b. Soil Fertility
    c. Soil Morphology
    d. Soil Taxonomy

201. Refers to the vertical cross sections of the earth which shows the different soil horizons
    a. soil profile
    b. horizon
    c. pedon
    d. polypedon

202. A collection of soil individual essentially uniform in differentiating characteristics and in arrangement of horizons
    a. Series
    b. Family
    c. Sub groups
    d. Great groups

203. A soil with a bulk density of 1.3 g/cm^3 and a particle density of 2.60 g/cm^3 will have a porosity of
    a. 50%
    b. 25%
    c. 5%
    d. 75%

204. Bulk density is a good indicator of soil degradation
    a. Bulk density does not change with poor soil cultivation practices
    b. Increasing bulk density indicates deteriorating soil physical condition
    c. Decreasing bulk density indicates deteriorating soil physical condition
    d. None of the above

205. Type of soil structure that is best for growing upland crops
    a. Crumb
    b. Massive
    c. Platy
    d. Loam

206. The soil structure of a compacted plow soil is
    a. Platy
    b. Crumb
    c. Massive
    d. Loam

207. Which of the following is an igneous rock?
    a. Granite
    b. Limestone
    c. Shale
    d. Sandstone

208. A mineral that is composed of SiO_2
    a. Tourmaline
    b. Gypsum
    c. Quartz
    d. Apatite

209. Wind deposited parent materials
    a. Lacustrine

b. Alluvium
c. Tuff
d. Aeolian

210. The major source of all P in soils
a. Kaolinite
b. Feldspar
c. Dolomite
d. Apatite

211. Profile depths vary depending on what type of soil formation took place and what present material was the source or origin. What is the standard depth of profile used for description
a. 1 m
b. 1.5 m
c. 2 m
d. less than 1 m

212. Plowing or cultivation has a great impact on soil formation. Which horizon shows cultivation?
a. Bt
b. Ap
c. R
d. C

213. Calcite weathers easily and forms a thick solum usually high in clay content. If the soil exhibits shrinking and swelling, the order most likely is
a. Inceptisol
b. Mollisol
c. Vertisol
d. Oxisol

214. It is a material used to ameliorate acid soils.
a. Fertilizer
b. Gypsum
c. Lime
d. Manure

215. It is also called as burned lime.
a. $CaCO_3$
b. CaO
c. $CaMg(CO3)_2$
d. Ca(OH)2

216. The lime produced by hydrating calcium oxide is
a. $CaCO_3$
b. CaO
c. $CaMg(CO_3)_2$
d. $Ca(OH)_2$

217. One of the major gaseous products of OM decomposition under anaerobic soil conditions.
a. O_2
b. CO_2
c. CH_4
d. CH_3CH_3

218. Which among the following does not form of endomycorrizial association with fungi?
a. Rice
b. Orchids
c. Corn
d. Coffee

219. The chemical element in dolomite that is not present in calcite is:
a. Mg
b. P
c. Na
d. C

220. The primary mineral most likely to accumulate at the site of chemical weathering of granite is
a. Mica
b. Muscovite
c. Quartz
d. Clay

221. Soil textural classes are defined in terms of ranges in variation in
a. Structure

b. Weathering
c. Texture
d. Drainage

222. Properties and materials are intended to reflect features which are widely recognized as occurring in soils and which can be used to describe and define soil classes
a. Polypedons
b. Epipedons
c. Diagnostic horizons
d. Sub surface horizons

223. Refers to the upper most soil horizons used in the description of diagnostic horizons
a. Polypedons
b. Epipedons
c. Diagnostic horizons
d. Sub surface horizons

224. A man-made surface horizon that is >20 cm thick, created by years of manure accumulation
a. Histic
b. Plaggen
c. Anthropic
d. Calcic

225. Which of the following is true?
a. dark or black color indicates high organic matter
b. dark or black color indicates that the soil is high in oxides of iron
c. dark or black color indicates that the soil is at oxidized state
d. all of the above

226. Which of the following is true?
a. reddish color indicates high organic matter
b. reddish color indicates that the soil is high in oxides of iron
c. reddish color indicates that the soil is young
d. none of the above

227. A chemical element is considered essential if
a. It is taken up by plants
b. It is involved in metabolic functions in the plants
c. It makes the plants greener
d. All of the above

228. The physical state of the soil as it relates to plant growth is known as soil
a. Texture
b. Consistency
c. Tilth
d. Structure

229. Consists of maps that shows the distribution of soils, description of the soils, some recommendation as to their use and management, and general information of a particular area
a. Soil survey report
b. Climate map
c. Topographic map
d. Soil map

230. Plants depend on the water stored in the soil
a. the upper limit of available water is saturated moisture content
b. the upper limit of available water is hygroscopic point
c. the upper limit of available water is field capacity
d. all of the above

231. The reaction of a compound with carbonic acid
a. Hydration
b. Oxidation
c. Carbonation
d. Exfoliation

232. It is defined as the capacity of a liming material to neutralize acids expressed as a percentage of the molecular weight of $CaCO_3$.
a. Percent base saturation
b. Percent calcium carbonate

c. Neutralization reaction
d. Relative neutralizing power

233. Soil fertility is the ability of the soil to supply nutrients in
a. Sufficient and balanced amount
b. Amounts above the optimum
c. Readily available forms
d. All of the above

234. Soil horizon with organic debris partially decomposed
a. Oi
b. Oe
c. A
d. E

235. The color of a soil indicates some chemical conditions. Which of the following is true?
a. dark or black color indicates high organic matter
b. reddish color indicates that the soil is high in oxides of iron
c. yellowish color indicates that the portion of lowland soil is at oxidized state
d. all of the above

236. Plants depend on the water stored in the soil
a. the upper limit of available water is field capacity
b. the lower limit available water is permanent wilting point
c. available water capacity is field capacity minus permanent wilting point
d. all of the above

237. A running water deposit is
a. Lacustrine
b. Marine
c. Alluvial
d. Eolian

238. A loosening or scaling of rock surface
a. Unloading
b. Exfoliation
c. Defoliation
d. Weathering

239. An air dry soil weighs 15 grams. After oven drying, the weight became 12.5 grams. What is the moisture content of the soil?
a. 20%
b. 24%
c. 22%
d. 23%

240. Type of silicate clay composed of a framework of tetrahedra
a. Phyllosilicates
b. Cyclosilicates
c. Inosilicates
d. Tectosilicates

241. Which among these is not a soil moisture regime?
a. Aquic
b. Ustic
c. Udic
d. Mesic

242. In map, the upper portion is usually indicating what direction?
a. West
b. North
c. South
d. East

243. The element in the soil that reacts with the liming material during the process of neutralization.
a. Hydrogen
b. Magnesium
c. Calcium
d. Sodium

244. What is the approximate volume composition of a loam soil in a good tilth?
a. 25% solid and 75% pore space
b. 50% solid and 50% pore space
c. 75% solid space and 25% pore space
d. 40% solid and 60% pore space

245. Symbiotic association of algae and fungi is termed as
    a. Humin
    b. Lichens
    c. Muck
    d. Symbiosis
246. What is the moisture content of a moist soil sample that weighs 12.5 g originally and 10 g after the oven drying?
    a. 12.5
    b. 10
    c. 25
    d. 22.5
247. The force that determines that height to which water will rise in a vertical capillary tube.
    a. Surface tension
    b. Capillarity
    c. Infiltration
    d. Capillary fringe
248. A soil that is formed from limestone would likely to have this soil reaction
    a. strongly acidic
    b. moderately alkaline
    c. moderately acidic
    d. slightly acidic
249. The function of parent material in soil formation with other factors as constant.
    a. Lithofunction
    b. Chronofunction
    c. Biofunction
    d. Climofunction
250. This is not a cementing agent
    a. Organic matter
    b. Fragipan
    c. Oxides of Fe and Al
    d. Plant root
251. Soil loss is estimated using the Universal Soil Loss Equation (USLE). What is the constant factor multiplied to the other factors of rain erosivity, soil erodibility, slope length and gradient, cropping, and conservation?
    a. 0.224
    b. 0.024
    c. 1.224
    d. none
252. Type of silicate clay with single or double chains of tetrahedra
    a. Inosilicates
    b. Nesosilicates
    c. Cyclosilicates
    d. Tectosilicates
253. The entry of surface applied water into soil is known as
    a. Infiltration
    b. Leaching
    c. Seepage
    d. Erosion
254. A group of related soils that differ due to time
    a. Chronosequence
    b. Lithosequence
    c. Climosequence
    d. biosequence
255. The deficiency symptom is yellowing of the lower leaves
    a. Phosphorus
    b. Potassium
    c. Nitrogen
    d. Sulfur
256. The deficiency symptom is yellowing of the upper leaves
    a. Nitrogen
    b. Phosphorus
    c. Potassium
    d. Sulfur
257. The formula of sulfate is

a. S
b. S_2^-
c. SO_4^{2-}
d. H_2S

258. The available form of nitrogen is
a. NO
b. NH_4^+
c. $(NH_4)_2SO_4$
d. N_2O

259. The solum includes horizons
a. A,B,C,R
b. A,B
c. A,B,C
d. B,C

260. A recreated soil profile mounted for observation
a. Regolith
b. Pedolith
c. Litolith
d. Monolith

261. The reference chart for soil color determination
a. Soil map
b. Munsell color chart
c. Soil pH color chart
d. Topographic map

262. A simple test for calcium carbonate on rock samples
a. Feel method
b. Roll method
c. HCl method
d. Nitrate method

263. Gully formation in mountains or steep areas usually starts at
a. Top
b. Below
c. Middle
d. Anywhere

264. A soil that is fertile is
a. Not productive
b. Always productive
c. Not necessarily productive
d. None of the above

265. The immediate source of carbon by plants is
a. CO_2 from air
b. CO_2 from carbon minerals
c. CO_2 from decay of OM
d. All of the above

266. Of all the essential elements, these are not absorbed in ionic forms.
a. C, H and O
b. N, P and K
c. Ca, Mg and S
d. All of the above

267. Iron is more available to plants in
a. Its oxidized form, Fe^{3+}
b. Its reduced form, Fe_2O_3
c. Its reduced form, Fe^{2+}
d. All of the above

268. The zone of saturated soil where water is held under sunction immediately above the water table is known as
a. Water table
b. Spring
c. Capillary fringe
d. Capillary

269. Which does not relate to CEC?
a. Amount of clay
b. Amount of OM
c. Kind of clay
d. Bulk density

270. Which of the following ions promote soil dispersion?
a. Na^+

b. Ca^{2+}
c. H^{+}
d. Al^{3+}

271. This refers to organic and inorganic matter which are exceedingly small but have high surface area per unit weight or volume
a. Organic matter
b. Soil colloid
c. Soil solid
d. Soil texture

272. These cations are dominant in strongly acidic soils
a. H and Al
b. H and Ca
c. Al and Ca
d. Ca and Mg

273. Movement of water in the soil is always from
a. higher to lower soil moisture content
b. higher to lower total potential energy
c. higher to lower soil moisture tension
d. all of the above

274. If soil moisture content is 40%, field capacity is 30% and permanent wilting point is 20%, the amount of available water in the soil is
a. 10%
b. 20%
c. 30%
d. none of the above

275. Occurs when the pore spaces are filled with water or at its maximum water holding capacity
a. irrigation
b. saturation
c. hygroscopic coefficient
d. mass flow

276. The fertilizer is broadcasted over a growing plant
a. Broadcasting
b. Top dressing
c. Side dressing
d. Bedding

277. The fertilizer is placed along or between the rows of crops
a. Broadcasting
b. Top dressing
c. Sidedressing
d. Bedding

278. A red soil is generally
a. Basic
b. Acidic
c. Sodic
d. Saline

279. This describes the darkness or lightness of a soil color.
a. Intensity
b. Value
c. Hue
d. Chroma
e. Moderate

280. What type of erosion took place when soil which is washed away creating small channels that are still repairable?
a. Sheet
b. Gully
c. Rill
d. Splash

281. Given the following conditions, select the soil which is less erodible
a. Clayey, steep but with full cover
b. Clayey, steep but with sparse vegetation
c. Sandy, steep but with full cover
d. Sandy, steep with sparse vegetation

282. The group of soil microorganisms which have the ability to photosynthesize.

a. Algae
b. Fungi
c. Nematodes
d. Protozoa

283. The bacteria which lives symbiotically with the roots of legumes and are able to fix atmospheric nitrogen.
a. Rhizobia
b. Aspergillus
c. Mycorrhizae
d. Penicillium

284. The most widespread association between microorganisms and higher plants.
a. Associative N fixation
b. Mychorrhizae
c. Symbiotic N fixation
d. Rhizobium-legume association

285. Liebig's Law of the Minimum in effect states that plant growth and yield
a. are limited by excess of a particular nutrient
b. are limited by the absence of a nutrient
c. are limited by excess of one nutrient
d. All of the above

286. Poorly drained soils can result into
a. Increased ethylene content in the leaf resulting to yellowing and etiolation
b. Increased incidence of root diseases
c. Increased rooting density
d. cannot be determined

287. When depicted graphically, the Mitscherlich's equation shows that with addition of a limiting nutrient
a. Yield increase linearly
b. Yield increases exponentially
c. Yield increase but in decreasing increment
d. None of the above

288. The soil depth from which plants obtain the major part of the water absorbed as turned
a. Solum
b. Effective rooting depth of plant
c. Regolith
d. Rhizosphere

289. Porosity, which is the total pore-space volume of soils
a. is the same for all soil
b. Is highest in fine-textured soils
c. Is highest in coarse-textured soils
d. Varies little with difference in texture

290. This cation is dominant in sodic soils
a. Calcium
b. Sodium
c. Potassium
d. Magnesium

291. When applied which of the following materials increase the CEC of the soil
a. organic matter
b. sand
c. silt
d. none of the above

292. Soil grown to corn is best cultivated to have a soil consistency that is
a. Hard
b. Friable
c. Plastic
d. Viscous

293. Lowland rice land is prepared to have a soil consistency that is
a. Hard
b. Friable
c. Plastic
d. Viscous

294. The following can occur when soil particles are washed into the surface pores, except one
    a. siltation
    b. surface sealing
    c. water infiltration is restricted
    d. water runoff increases
295. The incorporation of leguminous plants during their blooming/flowering stage into the soil
    a. Organic farming
    b. Green manuring
    c. Recycling
    d. Littering
296. Advocates the maximum use of compost and organic materials
    a. Organic farming
    b. Green manuring
    c. Recycling
    d. Littering
297. Poorly drained soils have prominent
    a. Bluish gray mottles
    b. Reddish concretion
    c. Yellowish or reddish mottles
    d. Greenish mottles
298. Determination of soil textural class of a soil by rubbing a sample of the soil in a moist to wet condition and observing how the soil develops a continuous ribbon when pressing between the thumb and fingers to indicate the amount of clay present.
    a. Feel and roll method
    b. Particle analysis
    c. Sieve method
    d. Hydrometer method
299. Given the following conditions, when do you expect to have run off or overland flow?
    a. Infiltration rate is exceeded by rainfall intensity
    b. Infiltration rate is higher than rainfall intensity
    c. Prevailing soil structure is massive
    d. Both a and c
300. Soil conservation measures maybe either agronomic or engineering. What is the other name for agronomic conservation measures?
    a. Crop factor
    b. Biological
    c. Mechanical
    d. Both a and c
301. This factor is related to human activities of controlling soil erosion and has a numeric value that can be reduced by contour plowing, etc.?
    a. P factor
    b. C factor
    c. K factor
    d. Both a and b
302. A group of microorganisms which can produce antibiotic compounds that kill other microorganisms.
    a. Bacteria
    b. Nematodes
    c. Actinomycetes
    d. Protozoa
303. Which of the following is not part of the nitrogen cycle?
    a. Mineralization
    b. Fixation by rhizobia and other organisms
    c. Disintegration of minerals containing N
    d. Plant uptake
304. It refers to the influence of one adsorbed ion on the release of another from the surface of colloid.
    a. Cation exchange
    b. Complementary ion effect
    c. Fixation
    d. Synergism

305. This element(s) has a critical role in sugarcane fertilization because of its function in the synthesis of sugar
    a. All of below
    b. Nitrogen
    c. Phosphorus
    d. Potassium
306. Nutrient enrichment of lakes and other bodies of water that stimulate the growth of aquatic organism which leads to a deficiency of oxygen in the water body.
    a. Eutrophication
    b. Algal bloom
    c. Red tide
    d. Salinization
307. What is the greatest advantage of no-plow system of reduced tillage?
    a. Greater yields
    b. Less fertilizer required
    c. Reduced labor and operation costs
    d. All of the above
308. The available form of nitrogen which predominates under upland condition is
    a. Ammonium
    b. Nitrate
    c. Nitrite
    d. Microbial Biomass N
309. The reduced form of sulfur under anaerobic conditions in paddy soils is
    a. Hydrogen sulfate
    b. Hydrogen sulfite
    c. Hydrogen sulfide
    d. Hydrogen disulfate
310. Soil sunction in a saturated zone beneath a water table is:
    a. Greater than zero
    b. Less than zero
    c. Zero
    d. 10,000
311. An iron-coating substance found in root nodules which controls the entry of oxygen into the bacteroid is called
    a. Auxin
    b. Leghemoglobin
    c. Plastocyanin
    d. Chlorophyll
312. Some of its species can be found in extreme environments, thus they considered to be the most adaptable and versatile microorganisms
    a. Rhizobium
    b. Azolla
    c. fungi
    d. actinomycetes
313. The ability of the root-nodule bacteria to cause nodulation of the host plants is called
    a. Ineffectiveness
    b. Pathogenicity
    c. Effectiveness
    d. Host-specificity
314. In terms of nitrogen fixation, the most efficient biological nitrogen fixing system is
    a. Symbiotic
    b. Associative
    c. Free-living
    d. All of the choices
315. Nitrogen-fixing organisms possess this enzyme which reduces nitrogen gas into available form
    a. Phosphatase
    b. Nitrogenase
    c. Nitratereductase
    d. Hydrogenase

316. N-mineralization results in the release of available N in the soil like
   a. NH_4^+
   b. NO_2
   c. N_2
   d. Urea
317. The following processes are transformations of the N in the soil. Which is not a biological process?
   a. N_2 fixation
   b. Volatilization
   c. Nitrification
   d. Denitrification
318. Vermicompost is produced from the decomposition of organic materials by this soil organism
   a. Protozoa
   b. Earthworm
   c. Nematode
   d. Beetle
319. In magnitude and algebraic sign, the matric potential of soil water is equal to
   a. Soil suction
   b. Negative hydraulic pressure
   c. Soil water tension
   d. Positive hydraulic pressure
320. Plant wilting commences when _____.
   a. Water flow into roots stops
   b. Water starts flowing from roots back into the soil
   c. Water flow into roots drops below transpirational loss
   d. Soil is at field capacity
321. Which one is not true if soil pH decreases
   a. fertility decreases
   b. availability of nutrients increases
   c. more H^+ ions in soil solution
   d. % base saturation decreases
322. What is not true if the soil is submerged
   a. redox potential increases
   b. pH of acid soils increase
   c. pH of alkaline soils decrease
   d. the soil become anaerobic
323. Which is not a characteristic of paddy soils?
   a. Saturated with water
   b. Presence of oxidized soil components
   c. Reduced state
   d. Low redox potential
324. The composting process using earthworm is known as
   a. Green manuring
   b. Deworming
   c. Vermicomposting
   d. Windrow composting
325. Mature soil have the following horizons
   a. A,B
   b. B,C
   c. A,B,C
   d. A,C
326. Young soils have the following horizons
   a. A,C
   b. A,B,C
   c. A,B,C,D
   d. A,B
327. The solum is composed of these horizons
   a. A,B,C
   b. B,C
   c. A,B,C,R
   d. A,B
328. The regolith is composed of these horizons
   a. A,B
   b. B,C
   c. A,B,C

d. A,B,C,R

329. Which of the following is an organic soil colloid
   a. Aluminosilicates
   b. Humus
   c. Hydrous oxides of Fe and Al
   d. Amorphous alumina-silicate materials

330. A 1:1 type silicate clay
   a. Montmorillonite
   b. Illite of hydrous mica
   c. Kaolinite
   d. Chlorite

331. Which of the following is not a 2:1 type silicate clay
   a. Montmorillonite
   b. Illite of hydrous mica
   c. Kaolinite
   d. Vermiculite

332. A non-expanding 2:1 type clay
   a. Vermiculite
   b. Montmorillonite
   c. Illite
   d. Kaolinite

333. A moderately expanding 2:1 type clay
   a. Montmorillonite
   b. Vermiculite
   c. Illite
   d. Kaolinite

334. What element is fixed in the interlayer of Illite?
   a. Hydrogen
   b. Magnesium
   c. Potassium
   d. Calcium

335. The relative magnitude of CEC of colloids is in the order of
   a. oxides of Fe and Al > Kaolinite > Halloysite > Illite > Montmorillonite > Vermiculite > Humus
   b. oxides of Fe and Al < Kaolinite, Halloysite < Illite, Montmorillonite < Vermiculite < Humus
   c. oxides of Fe and Al < Kaolinite < Halloysite < Illite < Montmorillonite < Vermiculite < Humus
   d. oxides of Fe and Al < Kaolinite, Halloysite < Illite, Montmorillonite, Vermiculite < Humus

336. An indication of the compactness of the soil
   a. Soil texture
   b. Particle density
   c. Bulk density
   d. Soil structure

337. Which of the following may lead to a lower bulk density?
   a. Compaction caused by the weight of the overlying layers
   b. Addition of organic matter in large amounts
   c. Heavy foot traffic
   d. Less aggregate and root penetration

338. Which among these is considered as a mechanical method of soil conservation?
   a. Mulching
   b. pond and check dam
   c. Strip cropping
   d. High density planting

339. The best method of plowing in hilly areas to prevent soil erosion is to
   a. plow along contour lines
   b. plow up and down the hill
   c. plow using carabao up and down the hill
   d. Both a and b

340. In which land form do you expect high amount of soil loss?
   a. steep slope
   b. plateau
   c. plain
   d. hilly

341. Among the factors considered in USLE, which is the most difficult to manipulate?
    a. L and S
    b. R
    c. K
    d. C and P
342. The stable fraction of the soil organic matter that remains after decomposition.
    a. Carbohydrates
    b. Carbon
    c. Humus
    d. Organic matter
343. The inherent capacity of the soil to provide nutrients to plants in the right amount and proportion.
    a. Nutrient supplying capacity
    b. Soil fertility
    c. Soil resilience
    d. Soil productivity
344. The mechanism of nutrient absorption whereby dissolved nutrients go with the convective flow of water from the soil to the plant root.
    a. Mass flow
    b. Contact exchange
    c. Diffusion
    d. Root interception
345. Which of the following agro-environments would produce the greatest amount of greenhouse gases?
    a. Lowland rice land
    b. Upland rice land
    c. Sugarcane field
    d. Corn field
346. Basic properties described in a soil profile.
    a. Color, texture, stoniness, structure
    b. Texture, bulk density, consistency
    c. CEC, OM (%) content, BS, BD
    d. Plasticity, structure, consistency
347. The exchange of energy in radiant form between the soil and the atmosphere goes on:
    a. Only during daylight hours
    b. Only during night
    c. Continuously
    d. Only during cloudy day
348. Among are the main characteristics of organic fertilizers except
    a. low nutrient content
    b. application in big volumes
    c. high solubility
    d. Slow release of nutrients
349. The cation exchange capacity of a soil is a measure of
    a. The force of bonding between the soil and exchangeable cations
    b. The negative charge of the soil neutralized by easily replaceable cations
    c. The speed with which ions added to the soil solution become adsorbed on soil particle surfaces
    d. Soil acidity and basicity
350. Among the following, the material with the highest cation-exchange capacity is
    a. Vermiculite
    b. Montmorillonite
    c. Organic matter
    d. Kaolinite
351. The excreta or manure of African night crawlers is called
    a. Vermicast
    b. Vermicompost
    c. Organic compost
    d. African manure
352. The regulatory body in the manufacture of fertilizer (inorganic and organic) in the Philippines is

a. Bureau of Soils and Water Management
b. National Food Authority
c. Fertilizer and Pesticide Authority
d. Department of Agriculture

353. The growth factor that ultimately limits plant growth
a. Biotic factor
b. Genetic factor
c. Edaphic factor
d. Environmental factor

354. The most critical nutrients in the Philippine soils are
a. N and P
b. Na and K
c. Na and Ca
d. Na and Mg

355. Nutrient uptake that requires energy is called
a. Passive
b. Active
c. Inactive
d. Fast

356. The topsoil usually refers to this horizon
a. AB
b. A
c. B
d. R

357. The subsoil usually refers to this horizon
a. AB
b. A
c. B
d. C

358. The government agency in charge of the survey and classification of soils in the Philippines
a. Bureau of Plant Industry
b. Bureau of Soils and Water Management
c. Department of Agriculture
d. Department of Public Works and Highways

359. A group of soils which developed from the same parent material and whose profile characteristics are the same
a. soil order
b. soil series
c. soil family
d. great group

360. Describes darkness or lightness of a soil color
a. Hue
b. Value
c. Chroma
d. Intensity

361. Sign of poor drainage
a. yellowish mottles
b. bluish gray mottles
c. reddish concretion
d. reddish orange mottles

362. Natural soil aggregates
a. Peds
b. Crumbs
c. Clods
d. Pebbles

363. Broadest category of soil taxonomy
a. order
b. great group
c. sub group
d. family

364. Soil formation factor that determines mineralogy and hence the nutrition of the soil
a. Relief
b. Time
c. Parent Material
d. Climate

365. Mathematically described as the negative logarithm of H^+ ion concentration.
    a. Dissociation constant
    b. pH
    c. pH buffer
    d. PCO_2
366. Soil acidity which refers to the H^+ ion in the soil solution
    a. Buffering capacity
    b. Reserve acidity
    c. Active acidity
    d. Base saturation
367. Soil acidity which include the Al^{+3} and H^+ ions adsorbed on the surface of soil colloids
    a. Reserve acidity
    b. Active acidity
    c. Buffering capacity
    d. Base saturation
368. What is $CaCO_3$ equivalent of 100% pure CaO?
    a. 100
    b. 135
    c. 95
    d. 179
369. What is the formula of quartz?
    a. SiO_2
    b. $KAl(Mg,Fe)_3Si_3O_{10}(OH)_2$
    c. $CaCO_3$
    d. $CaMg(CO_3)_2$
370. This is the property of water that explains how water molecules interact with each other and explains why water molecules are attracted to electrostatically charged ions.
    a. Ionic bonding
    b. Oxygen bonding
    c. Covalent bonding
    d. Polarity
371. It is referred to as the circuit of water movement from the atmosphere to the earth and back to the atmosphere.
    a. Hydrologic cycle
    b. mass flow
    c. evaporation
    d. Precipitation
372. Soil under its natural occurrence is aggregated and porous.
    a. The aggregates are composed of millions of individual particles
    b. The pores are occupied by water and air.
    c. The pores are interconnected channels to other pores
    d. All of the above
373. Which of the following statement is true?
    a. The solid is composed of soil separates called sand, silt and clay.
    b. The solids stick or cluster together to form soil aggregate.
    c. The diameter range of sand is 2.0-0.02 mm, silt is 0.02-0.002 mm and clay is less than 0.002 mm.
    d. All of the above
374. A method of soil fertility evaluation whereby nutrients are known before a crop is planted.
    a. Soil Test
    b. Biological test
    c. Plant analysis
    d. Nutrient deficiency symptoms
375. It is also referred to as troubleshooting type of plant analysis.
    a. Prognostic
    b. Diagnostic
    c. Monitoring
    d. Predictive
376. The most common biological test to evaluate soil fertility.
    a. Use of deficiency symptoms
    b. Plant analysis
    c. Field fertilizer experiment

d. Soil chemical analysis

377. Materials which are natural or synthetic in origin which when added to the soil can supply nutrients to the growing plants.
    a. Fertilizers
    b. Humus
    c. Minerals
    d. Organic manure

378. An 18-46-0 fertilizer material contains:
    a. 18% N and 46% P
    b. 18% N and 46% K
    c. 18% N and 46% K_2O
    d. 18% N and 46% P_2O_5

379. The guaranteed minimum amount of nutrients in a fertilizer material is referred to as
    a. Fertilizer mixture
    b. Fertilizer recommendation
    c. Fertilizer formula
    d. Fertilizer grade

380. The most preferred form of nitrogen fertilizer since energy can be saved in protein synthesis.
    a. Ammonium nitrate
    b. Complete fertilizer
    c. Ammonium sulfate
    d. Urea

381. Complete fertilizers normally supply the following combination of nutrients
    a. NP only
    b. NPK
    c. All the 16 essential elements
    d. NPKS

382. It is considered one of the "lime nutrients"
    a. Calcium
    b. Phosphorus
    c. Potassium
    d. Sulfur

383. A compound excreted by plant roots during the process of respiration which is one of the causes of soil acidity
    a. Carbonic acid
    b. Hydrogen
    c. Carbon dioxide
    d. Oxygen

384. The localized fertilizer placement wherein fertilizers are applied along the furrows prior to seeding or as strips on one or both sides of the row about 5 cm away and below the seeds.
    a. Banding
    b. Basal
    c. Sidedressing
    d. Topdressing

385. It is an inorganic fertilizer material which is also a source of sulfur.
    a. Ammonium phosphate
    b. Gypsum
    c. Muriate of potash
    d. Urea

386. High-pH soil which has relatively low soluble salts but high in exchangeable sodium.
    a. Acidic
    b. Saline
    c. Saline-sodic
    d. Sodic

387. The most important step in soil chemical test.
    a. Soil sampling
    b. Sample drying
    c. Reagent preparation
    d. Sieving

388. A method of fertilizer application mostly adapted for orchard and ornamental trees.
    a. Foliar

b. Mudball
c. Seed pelleting
d. Trench or perforation

389. The process of the N transformation in anaerobic paddy soils whereby N is lost as gaseous N_2, NO and N_2O.
a. Denitrification
b. Immobilization
c. Nitrification
d. Ammonium fixation

390. Nutrient antagonism means that reduced availability or absorption of a nutrient occurs _____.
a. When another nutrient is deficient
b. When another nutrient is in equal amounts
c. When another nutrient is excessive
d. All of the above

391. Under strongly acid soil conditions, Phosphorus is usually complexed into unavailable form as
a. Tricalcium phosphate
b. Al and Fe hydroxyphosphate
c. Zn phosphate
d. All of the above

392. Which among the following cation has the lowest relative flocculating power?
a. Na^+
b. K^+
c. Mg^{2+}
d. Ca^{2+}

393. Which of this C/N ratio of organic materials will transform organic N and inorganic N?
a. 40/1 ratio
b. 22/1 ratio
c. 60/1 ratio
d. 5/1 ratio

394. Major product of the biological transformation of Nitrosomonas
a. Nitrate + Hydrogen + energy
b. Nitrite + Sulfur + energy
c. Nitrite + Hydrogen + energy
d. Nitrate + Sulfur + energy

395. A soil has a cation capacity of 10 me/100 g and the following compliment of exchangeable cations, the amount being expressed in me per 100g of soil: H = 3.0; Ca = 2.0; Al = 3.0; Mg = 1.0; Na = 0.25; and K = 0.75. The percent base saturation of this soil is:
a. 10
b. 40
c. 70
d. 50

396. In slightly acid soils such as in those with pH between 6.0 and 7.0, the two most abundant cations will probably be
a. H and Al
b. K and Na
c. Ca and Mg
d. Fe and Mn

397. An illuvial horizon in a soil is designed by the symbol
a. A1
b. A2
c. B2
d. O2

398. This agro-industrial waste is the most plentiful solid waste produced after extracting juice from sugarcane stalks and has potential to be a fertilizer material
a. mudpress
b. filter cake
c. bagasse
d. distillery slop

399. The removal of excess water from a waterlogged soil depends on the
a. difference in soil solution
b. force of gravity

c. Atmospheric pressure
d. Temperature

400. The CEC of the soil is 20 me/100g. If it has 8 me/100g H and the remaining cations are bases, what is the % BS?
a. 80
b. 40
c. 60
d. 50

401. Which soil property is not influenced by OM?
a. Bulk density
b. Texture
c. Structure
d. Color

402. Which is the seat of chemical activities in the soil?
a. Sand
b. Salt
c. Colloid
d. Clay

403. Which has the highest pH dependent negative charges?
a. Organic matter
b. Illite
c. Montmorillonite
d. Kaolinite

404. The dominant basic cation in agricultural soil is
a. Na
b. K
c. Mg
d. Ca

405. A form of fertilizer that is applied through the leaves
a. Commercial fertilizer
b. Foliar fertilizer
c. Organic fertilizer
d. Inorganic fertilizer

406. A fertilizer material that is effective in restoring fertility of N and S deficient soils
a. Urea
b. Ammonium phosphate
c. Ammonium sulfate
d. Ammonium chloride

407. Which is not considered feldspar?
a. orthoclase
b. albite
c. apatite
d. plagioclase

408. What are the natural resources of plant nutrients?
a. Organic matter
b. Mineral matter
c. Air and water
d. All of the above

409. What is the form of nutrients in the soil that is absorbed by the plants?
a. Solid
b. Liquid
c. Ionic
d. Ion pair

410. What are the nutrients that cause euthrophication?
a. Phosphates and nitrates
b. Phosphates and calcium
c. Phosphates and magnesium
d. Phosphates and aluminum

411. Results in the loss or removal of electrons from an ion or compound
a. Reduction
b. Oxidation
c. Hydrolysis
d. Hydration

412. This macroelement is a component of protein and chlorophyll and is most limiting element in crop production except for legumes
    a. Nitrogen
    b. Phosphorus
    c. Potassium
    d. Calcium
413. The relative ease by which a nutrient is supplied by the soil
    a. Soil productivity
    b. Soil fertility
    c. Nutrient availability
    d. Intensity factor
414. This macroelement is a metal component of chlorophyll and is deficient in acid upland soil
    a. Nitrogen
    b. Calcium
    c. Copper
    d. Magnesium
415. When nutrients are immobile, deficiency shows up first in which part of the plant?
    a. Stems
    b. oldest leaves
    c. youngest leaves
    d. senescent leaves
416. The fertilizer with the higher percent N
    a. Ammonium sulfate
    b. Anhydrous ammonia
    c. Urea
    d. Ammonium nitrate
417. This enzyme is needed to transform urea to $(NH_4)_2CO_3$ in the soil.
    a. Carboxylase
    b. Anhydrase
    c. Urease
    d. Papase
418. The weak acid form upon hydrolysis and subsequent reaction of urea in soils is
    a. Acetic acid
    b. Carbonic acid
    c. Uric acid
    d. Silicic acid
419. The percent N, P_2O_5, and K_2O in a fertilizer is _____.
    a. Fertilizer ratio
    b. Fertilizer grade
    c. Fertilizer recommendation
    d. Fertilizer brand
420. A single-element or straight fertilizer:
    a. Complete fertilizer (14-14-14)
    b. Ammonium Phosphate
    c. Urea
    d. All of the above
421. The fertilizer nutrients that are generally applied all at planting (basal).
    a. N & P
    b. P & K
    c. N & K
    d. P & Ca
422. Enzyme in nitrogen transformation in legumes:
    a. Nitrogenase
    b. Dehydrogenase
    c. Decarboxylase
    d. Anhydrase
423. This ratio determines mineralization rate of organic matter.
    a. N/S
    b. C/N
    c. P/N
    d. N/K
424. This is an acid forming reaction of NH_4+

a. Nitrification
b. Denitrification
c. Ammonification
d. Mineralization

425. Most micronutrients become less available at
a. decreasing pH
b. Increasing pH
c. Neutral pH
d. Strongly acid pH

426. These are the organisms actively and directly involved in the decomposition of organic matter.
a. bacteria
b. actinomycetes
c. fungi
d. all of the above

427. Deficiency of these elements causes chlorosis.
a. N & Ca
b. P & Ca
c. N & S
d. Fe & Cl

428. The suitable fertilizer for an alkaline N deficient soils
a. Anhydrous NH_3
b. Ammonium sulfate
c. Urea
d. Calcium nitrate

429. The soil is best cultivated when the consistency is:
a. Dry
b. Moist
c. Wet
d. Very wet
e. Fluid

430. Type of structure with the fastest rate of water infiltration
a. Platy
b. Block-like
c. Prism-like
d. Columnar

431. Loss of nutrient with percolating water
a. Infiltration
b. Percolation
c. Leaching
d. Capillarity

432. The combined loss of water from the surface of the soil and plant leaves
a. Evaporation
b. Evapotranspiration
c. Respiration
d. Transpiration

433. The total porosity is highest in
a. Coarse textured soils
b. Rock soils
c. Fine textured soils
d. Paddy soils

434. The form of water that moves from the water table upwards
a. Capillarity water
b. Hygroscopic water
c. Superfluous water
d. Water field capacity

435. Soil density and porosities are affected by soil texture and soil structure. Which of the following statement is true?
a. Porosity increases with increasing bulk density
b. Soil compaction increases bulk density
c. Soil aggregation increases bulk density
d. Density is equal to soil porosity

436. Pore-size distribution affects movement and retention of water and air in the soil. Which of the following statement is true?
a. Macropores retains water
b. Micropores are important in root respiration
c. Micropores are more important than macropores

d. None of the above

437. Pore-size distribution affects movement and retention of water and air in the soil. Which of the following statements is true?
   a. Micropores are for water retention.
   b. Macropores are important in drainage and root respiration
   c. Macropores and micropores are equally important to root growth
   d. All of the above

438. Bulk density is a good indicator of soil degradation.
   a. Land preparation using tractor results to low bulk density
   b. Bulk density does not change with poor soil cultivation practices
   c. Increasing bulk density indicates deteriorating soil physical condition
   d. Decreasing bulk density indicates deteriorating soil physical condition

439. Type of soil structure that is best for growing upland crops
   a. Massive
   b. Granular or crumb
   c. Platy
   d. Single-grain

440. The reverse of oxidation and involves the gain of electrons
   a. Reduction
   b. Oxidation
   c. Hydration
   d. Hydrolysis

441. The moisture content of an air dry soil is known as
   a. Saturation Point
   b. Permanent writing
   c. Field Capacity
   d. Hygroscopic coefficient

442. The movement of water in the soil is always from:
   a. Higher to lower soil moisture content
   b. Higher to lower total potential energy
   c. Lower to higher soil moisture tension
   d. All of the above

443. One of the following is an organic source of nitrogen.
   a. Ammonium nitrate
   b. Ammonium phosphate
   c. Ammonium sulfate
   d. Azolla

444. Under upland condition, this is the most preferred source of N because it leaves less acidity.
   a. Ammonium nitrate
   b. Ammonium sulfate
   c. Potassium nitrate
   d. Urea

445. A method of fertilizer application whereby the materials are dissolved in water and applied as sprays to the foliage of the plant.
   a. Foliar
   b. Topdressing
   c. Seed pelleting
   d. Trench/perforation

446. This phosphate fertilizer is manufacture by the reaction of apatite with sulfuric acid and water.
   a. Ammonium phosphate
   b. Complete fertilizer
   c. Ordinary superphosphate
   d. Triple superphosphate

447. A phosphate fertilizer manufactured by reacting the superphosphate with ammonia.
   a. Ammonium phosphate
   b. Complete fertilizer
   c. Ordinary superphosphate
   d. Triple superphosphate

448. The form of soil potassium fixed within clay minerals such as illite and vermiculite.

a. Slowly available
b. Mineral K
c. Readily available
d. Relatively unavailable

449. One of the materials below is not a source of calcium.
a. Epsom salt
b. Calcite
c. Dolomite
d. Gypsum

450. This is one of the most common sources of magnesium.
a. Calcite
b. Epsom salt
c. Gypsum
d. Pyrite

451. The form of potassium that is present in the soil solution.
a. Mineral K
b. Relatively unavailable
c. Readily available
d. Slowly available

452. At same level of OM which will have the highest water holding capacity?
a. Loamy sand
b. Clay loam
c. Clay
d. Sandy loam

453. The capability of the soil being molded by hands is
a. Stickiness
b. Tilth
c. Plasticity
d. Cracking

454. A soil chemical property which largely controls nutrient availability and microbial activities
a. buffering capacity
b. cation exchange capacity
c. soil pH
d. electrical conductivity

455. Indicates excessive level of nutrient in the plant or soil
a. Sufficiency
b. Toxicity
c. Deficiency
d. Poverty adjustment

456. The most appropriate soil management which increases availability of adsorbed P in acid upland soil
a. fertilizer application
b. prolonged anaerobic conditions
c. organic matter application
d. liming

457. A term that indicates low level of nutrient elements in plant or soil
a. Sufficiency
b. Toxicity
c. Deficiency
d. Poverty adjustment

458. The essential element that functions as a constituent of energy transfer metabolites
a. Potassium
b. Phosphorus
c. Sulfur
d. Magnesium

459. Which of the following is not an essential element to plants?
a. Carbon
b. Hydrogen
c. Molybdenum
d. Vanadium

460. These elements are micronutrients and are required by plants in small amounts
a. N, P and K
b. Cu, Mn and S

c. Cu, Mg and S
d. Zn, Co and Mn

461. Essential elements derived from air and water
a. C, O, and H
b. C, H and S
c. N, C and H
d. N, C and S

462. Which of these elements is available to plants in anionic form?
a. Ca
b. Mg
c. P
d. Fe

463. The micronutrient involved in the translocation of sugar in plant
a. Copper
b. Potassium
c. Calcium
d. Boron

464. The process that renders P available to plants
a. Fixation
b. Nitrification
c. Solubilization
d. Ammonification

465. A physical effect of lime
a. Increase the cation exchange capacity
b. Increase decomposition of organic matter
c. Increase water holding capacity of soil
d. Increase P availability

466. A term for the initial application of fertilizer for crops
a. basal application
b. top dressing
c. side dressing
d. band application

467. An example of a liming material
a. $Ca(OH)_2$
b. $CaSO_4$
c. $MgCl_2$
d. $MgSO_4$

468. The amount of lime to be applied to the soil in order to increase its pH
a. Fertilizer recommendation
b. Analysis grade
c. Lime requirement
d. Relative neutralizing power

469. It is a mixture of animal excreta and soiled beddings that accumulates in stables or barns
a. Compost
b. Green manure
c. Farm manure
d. Poultry manure

470. The soil's inherent susceptibility to erosion which is influenced by infiltration capacity and structural stability
a. Rainfall erosivity
b. Soil erodibility
c. Rainfall intensity
d. Rainfall duration

471. Which of these elements is available to plants in cationic form?
a. Potassium
b. Sulfur
c. Chlorine
d. Molybdenum

472. Soil loss through erosion can be calculated by the
a. Mitscherlich's equation
b. Universal soil loss equation
c. Einstein's relativity equation
d. Trigonometric equation

473. Which statement is true for Fungi?
a. Fungi are less numerous than bacteria

b. Fungi build up large biomass in the soil because of their filament networks
c. Fungi can survive even at extreme pH conditions
d. all of the above

474. Medium silts refer to ____.
a. Fine silts soils
b. Coarse silty soils
c. Loamy silty soils
d. None of the above.

475. Soil particles larger than 2 mm in size.
a. Sand
b. Rockiness
c. Stones
d. Gravelly

476. Refers to the abundance of stone.
a. Stoniness
b. Outcrop
c. Rockiness
d. Gravelly

477. Stone shape is determines by these properties:
a. Abundance
b. roundness, sphericity
c. Angle
d. Orientation

478. Which belongs to the most soluble components of organic matter?
a. sugars
b. starches
c. simples proteins
d. all of the above

479. El Nino phenomenon causes drought. The source of water for plant roots is supplied by
a. Infiltration
b. Leaching
c. Percolation
d. Capillarity

480. Which is a consequence of applying immature compost such as fresh chicken manure into the soil?
a. rapid reduction reactions in paddy soils due to the rapid oxygen consumption of microorganism
b. "suffocation" disease in upland crops
c. killing of seedlings due to rapid oxygen depletion
d. all of the above

481. White coloration in soils indicate the predominance of
a. Organic matter
b. Salts
c. Iron oxides
d. Reduce iron

482. Mechanisms of addition, losses, translocation, and transformation permit this process to proceed
a. crystallization
b. melting
c. horizon differentiation
d. recementation

483. Black color indicates the predominance of
a. Organic matter
b. Salts
c. Iron oxides
d. Manganese

484. Dots of different colors found in the soil are called
a. Mottles
b. Color
c. Tints
d. Polka

485. The hydrometer and pipette method of mechanical analysis follow this Law
a. Dick's Law
b. Freundlick's Law

c. Stoke's Law
d. Dalton's Law

486. The pore spaces meant to retain moisture are
a. Macropores
b. Maxipores
c. Micropores
d. Mesopores

487. A soil condition when fine particles clog the pore spaces which may not allow seed emergence and even prevents infiltration
a. Porosity
b. Puddling
c. Crusting
d. Compaction

488. The pore spaces meant to drain excess moisture
a. Macropores
b. Micropores
c. Mesopores
d. Endopores

489. Movement of heat in the soil is called
a. Conduction
b. Consistence
c. Capillarity
d. Insulation

490. Bulk density is more meaningful to practical agriculture than particle density
a. Bulk density indicates the physical condition of the soil
b. Bulk density indicates the porosity and drainage condition of the soil
c. Bulk density indicates the biological condition of the soil
d. Bulk density indicates the dryness of the soil

491. This is not a soil structure
a. Crumb
b. Platy
c. Loam
d. Prismatic

492. Sticky when wet is a characteristic of
a. Loam
b. Clay
c. Silt
d. Rock

493. Grittiness is a characteristic of
a. Clay
b. Silt
c. Sand
d. Loam

494. Poorly drained condition is a characteristic of
a. Crumb structure
b. Platy structure
c. Prismatic structure
d. Single grained

495. The pH of the soil at which the soil colloids possess no net charge.
a. Neutrality
b. Alkaline
c. Acidic
d. Zero point of charge

496. Alkali soils with pH of less than 8.5 and an electrical conductivity greater than or equal to 4 mmhos/cm.
a. Alkaline
b. Saline
c. Saline-sodic
d. Sodic

497. The only group of soil organisms which can thrive at any soil pH range.
a. Actinomycetes
b. Azotobacter
c. Bacteria
d. Fungi

498. The first redox reaction to occur upon submergence of an aerated soil.
    a. Disappearance of oxygen
    b. Disappearance of carbon dioxide
    c. Disappearance of nitrate
    d. Formation of methane
499. This macronutrient is a part of the middle lamella and is deficient in acid upland soil.
    a. Nitrogen
    b. Potassium
    c. Calcium
    d. Magnesium
500. Movement of inorganic and organic materials from one horizon to another, either up or down
    a. Addition
    b. Removal
    c. Translocation
    d. Transformation
501. They are soft, unconsolidated deposits of calcium carbonate.
    a. Calcium carbonate
    b. Calcium oxide
    c. Marl or marlstone
    d. Slag
502. The major group of soil microorganisms where molds and mushrooms belong
    a. Algae
    b. Fungi
    c. Actinomycetes
    d. Bacteria
503. Leaves and stems accumulate in the forest. Remnants of annual and perennial grasses are trampled in a pastureland. These illustrate how the kind and amount of organic materials decomposed can affect soil formation. Which soil formation factor is being described here?
    a. Climate
    b. Parent material
    c. Living organisms
    d. Temperature
504. In soil genesis, what is considered to be the starting point of the soil formation at time zero?
    a. master horizons
    b. Bedrock
    c. Parent material
    d. magma
505. The most dominant soil microorganisms in the organic layer of forest soils.
    a. Algae
    b. Actinomycetes
    c. Bacteria
    d. Fungi
506. Soil conditions which can reduce the ferric to ferrous, hence, making the iron-phosphate complex more soluble
    a. Continuous tillage
    b. Prolonged anaerobic conditions
    c. Organic matter application
    d. Liming
507. It is a wet oxidation method of determining the organic matter content of soils.
    a. Combustion
    b. Micro-Kjeldahl method
    c. Titration
    d. Walkey-Black method
508. Organic compounds which range in complexity from simple sugars and starches to cellulose.
    a. Fats and waxes
    b. Lignins
    c. Carbohydrates
    d. Proteins

509. The process by which one plant infuses the soil with a chemical that affects the growth of other plants.
    a. Allelopathy
    b. Production of antibiotics
    c. Productivity of hormones
    d. Synergistic effects
510. If a ring without crack is formed in the roll method of determining texture; the texture is most likely
    a. Sandy loam
    b. Loamy sand
    c. Clay
    d. Clay loam
511. Which among this mineral does not contribute any soil nutrient?
    a. Quartz
    b. Talc
    c. Apatite
    d. Calcite
512. Aside from carbon and hydrogen, the other macroelement constituent of organic compound in the plant is
    a. Oxygen
    b. Nitrogen
    c. Potassium
    d. Calcium
513. This horizon is seldom reached by the plant roots, and is little affected by soil forming factors because it is outside the zone of soil development.
    a. C horizon
    b. B horizon
    c. AB horizon
    d. B horizon
514. Involved in energy storage in the plant and is a constituent of phospholipids, nucleoproteins, and is deficient in acid upland soil.
    a. Nitrogen
    b. Phosphorus
    c. Potassium
    d. Calcium
515. This micronutrient is needed in nitrogen fixation by leguminous plant and is usually deficient in acid upland soil.
    a. Zinc
    b. Molybdenum
    c. Iron
    d. Manganese
516. In a very extremely acidic soil, these elements are toxic to plants except
    a. Aluminum
    b. Calcium
    c. Iron
    d. Manganese
517. Which of the following elements is not essential to plant growth?
    a. Nitrogen
    b. Molybdenum
    c. Copper
    d. Aluminum
518. It is not a function of organic matter in the soil.
    a. Increase CEC
    b. Provides carbon and energy source to soil organisms
    c. Provides essential nutrients
    d. Provides soil air
519. The soil enzyme which catalyzes the hydrolysis of starch
    a. Amylase
    b. Lipase
    c. Cellulase
    d. Catalase
520. The sum of all tillage operations, cropping practices, fertilizer, lime and other treatments conducted on, or applied to a soil for the production of plants.
    a. Soil fertility
    b. Soil management

c. Soil nutrition
d. Soil productivity

521. The trade name of potassium chloride fertilizer.
a. Ammophos
b. Muriate of potash
c. Solophos
d. Sulfate of potash

522. An organic fertilizer material which had been enriched with microbial inoculants, hormones, and/or chemical additives to increase its nutrient content.
a. Activated organic fertilizer
b. Fortified organic fertilizer
c. Impure organic fertilizer
d. Pure organic fertilizer

523. The process by which nutritional problems are diagnosed and fertilizer recommendations are made
a. Soil fertility evaluation
b. Soil productivity evaluation
c. Soil sampling
d. Soil testing

524. It is an indicator of biological activity in the soil.
a. Soil structure
b. Soil respiration
c. Soil fertility
d. Soil oxidation

525. It belongs to 2:1 silicate clay minerals.
a. Dickite
b. Halloysite
c. Kaolinite
d. Montmorillonite

526. The mineral nutrient needed by the plant in the smallest amount.
a. Copper
b. Molybdenum
c. Zinc
d. Iron

527. Involves the accumulations of organic matter in the upper layers of the soil.
a. Podzolisation
b. Calcification
c. Laterization
d. Gleization

528. The most common iron oxide in soil.
a. Gibbsite
b. Hematite
c. Goethite
d. Lepidocrocite

529. The most important aluminum oxide in soils.
a. Gibbsite
b. Hematite
c. Goethite
d. Lepidocrocite

530. The most resistant component of plant materials to decomposition.
a. Cellulose
b. Lignin
c. Starch
d. Sugars

531. It is a soil chemical condition that is common in dry regions.
a. Soil acidity
b. Soil alkalinity
c. Soil salinity
d. All of the above

532. The weight of 1 me Ca is _____.
a. 0.002 g
b. 0.02 g
c. 0.2 g
d. 2 g

533. Which among the following cations has the weakest attraction to the clay?
    a. Calcium
    b. Aluminum
    c. Potassium
    d. Sodium
534. Which among the following cations has the strongest attraction to the clay?
    a. Calcium
    b. Aluminum
    c. Potassium
    d. Sodium
535. It is the most important soil animal
    a. Termite
    b. Earthworm
    c. Snails
    d. Ants
536. The theory of mineral nutrients was formulated by
    a. Theophrastus
    b. Liebig
    c. Berzelius
    d. Davy
537. Accumulation on the mineral soil surface of organic litter and associated humus to a depth of less than 30 cm
    a. Leaching
    b. Erosion
    c. Illuviation
    d. Littering
538. The percentage of mineral matter in the soil.
    a. 5%
    b. 25%
    c. 45%
    d. 35%
539. The sand fraction is composed mainly of
    a. Secondary minerals
    b. Primary minerals
    c. Mineral matter
    d. Organic matter
540. Organic matter decomposition is an example of
    a. Transformation
    b. Translocation
    c. Addition
    d. Losses
541. He introduced the factors of soil formation
    a. Jenny
    b. Hilgard
    c. Fallou
    d. Dokuchaev
542. The geologic or organic precursor of the soil.
    a. Pedogenic material
    b. Organic material
    c. Parent material
    d. None of the above
543. The parent material that has been deposited by gravity.
    a. Alluvial
    b. Colluvial
    c. Marine
    d. Lacustrine
544. The collective term given to accumulated plant debris.
    a. Fibric
    b. Muck
    c. Peat
    d. Humus
545. The configuration of the island surface
    a. Slope
    b. Elevation
    c. Topography
    d. Landscape

546. The time at which the development of soil begins
    a. Initial time
    b. Final time
    c. Time zero
    d. None of the above
547. Well-drained slopes would
    a. Retard soil development
    b. Enhance soil development
    c. Have no effect
    d. None of the above
548. Rocks formed from the solidification and crystallization of magma.
    a. Igneous rocks
    b. Sedimentary rocks
    c. Metamorphic rocks
    d. Volcanic rocks
549. The term for fine-texture igneous rocks.
    a. Aphanitic
    b. Phaneritic
    c. Mafic
    d. Felsic
550. It is an example of sedimentary rocks.
    a. Andesite
    b. Basalt
    c. Marble
    d. Sandstone
551. The common characteristics of sedimentary rocks.
    a. Color
    b. Texture
    c. Foliation
    d. Stratification
552. The most common primary mineral in rocks.
    a. Feldspar
    b. Hornblende
    c. Quartz
    d. Calcium carbonate
553. The most resistant rock-forming mineral.
    a. Olivine
    b. Pyroxene
    c. Feldspar
    d. Quartz
554. The reaction between water and the elements of the rock or mineral.
    a. Hydration
    b. Hydrolysis
    c. Carbonation
    d. Oxidation
555. Stokes' Law states that settling of particles in a liquid medium is directly proportions to the square of its
    a. Weight
    b. Mass
    c. Diameter
    d. Density
556. The type of soil structure common in A horizons.
    a. Granular
    b. Plate like
    c. Block like
    d. Prism like
557. It is considered as the start of aggregation
    a. Dispersion
    b. Flocculation
    c. Cementation
    d. Attraction
558. A basic cation which inhibits aggregation
    a. Ca^{2+}
    b. Na^{+}
    c. K^{+}
    d. Mg^{2+}

559. A basic cation which enhances dispersion
    a. Ca^{2+}
    b. Na^{+}
    c. K^{+}
    d. Mg^{2+}
560. The formula of particle density
    a. P.D.= Ms/Vs
    b. P.D.= Ms/Mt
    c. P.D.= Vs/Vt
    d. P.D.= Vt/Ms
561. The attraction of water for soil particles.
    a. Cohesion
    b. Adhesion
    c. Surface tension
    d. Capillarity
562. The force resulting from the attraction of soil solids.
    a. Matric force
    b. Osmotic force
    c. Gravitional force
    d. Cohesion force
563. The standard method for soil water content measurement.
    a. Gravimetric
    b. Neuron scattering
    c. Tensiometer
    d. Pressure membrane
564. The matric potential in the soil at saturation point.
    a. 0 bar
    b. 1 bar
    c. 1/3 bar
    d. 15 bars
565. At field capacity, water is held at a tension of
    a. 1/3 bar
    b. pF 2.5
    c. 33 kPa
    d. All of the above
566. At permanent wilting point, water is held at a tension of
    a. 15 bars
    b. pF 5.0
    c. 500 kPa
    d. 31 bars
567. The driving force of water flow under saturated condition.
    a. Tension gradient
    b. Hydraulic gradient
    c. Hydraulic conductivity
    d. Gravity
568. The law that governs the diffusion of gases in soils.
    a. Darcy's Law
    b. Stoke's Law
    c. Fick's Law
    d. None of the above
569. A general guideline in liming: Lime only soils that have a pH of
    a. >5.0
    b. >6.5
    c. <5.0
    d. >7.0
570. As the concentration of H^{+} ion decreases, the pH
    a. Increases
    b. Decreases
    c. Remains equal with H^{+}
    d. Increases the H^{+} ions
571. The charge produced when the soil is too acid
    a. Negative
    b. Positive
    c. Zero
    d. Neutral
572. The ion that replaces the Si in the tetrahedron
    a. Mg^{2+}
    b. Al^{3+}

c. Ca^{2+}
d. H^+

573. Which one of the element possesses a positive charge?
a. Zn
b. Cl
c. NO_3
d. SO_4

574. The net charge of most agricultural soil is _____.
a. Positive
b. Negative
c. A and b
d. Zero

575. This colloid obtains its negative charge from dissociation of H^+ ions from carboxylic and/or phenolic functional groups.
a. Allophane
b. Montmorillonite
c. Humus
d. Kaolinite

576. The kind of charge produced through isomorphous substitution is
a. pH dependent charge
b. Isomorphous charge
c. Permanent charge
d. Temporary charge

577. This ion aids in the dispersion of colloids
a. Na^+
b. Ca^{2+}
c. Mg^{2+}
d. H^+

578. This ion aids in flocculation of colloids
a. Na^+
b. Ca^{2+}
c. Cl^-
d. NO^{3-}

579. The determination of soil pH using color indicators is referred to as
a. Electrometric
b. Colorimetric
c. Gravimetric
d. Volumetric

580. Imparts a yellowish color to soils.
a. Lepidocrite
b. Goethite
c. Hematite
d. Humus

581. Dark-colored soils
a. Absorb more solar radiation
b. Reflect more solar radiation
c. Retains more solar radiation
d. None of the above

582. The acronym ESP means
a. Exchangeable salt percentage
b. Exchangeable sodium percentage
c. Excellent salt percentage
d. Excellent sodium percentage

583. At very low pH, available P may be precipitated as
a. Orthophosphoric acid
b. Ca-hydroxyapatite
c. Apatite
d. Al-hydroxyapatite

584. At very high pH, available P may be precipitated as
a. Orthophosphoric acid
b. Ca-hydroxyapatite
c. Apatite
d. Mg-hydroxyapatite

585. The horizon with the maximum leaching of constituents.
a. A horizon
b. B horizon

c. C horizon
d. E horizon

586. A horizon that has the properties of two adjacent horizons.
a. Master horizon
b. Diagnostic horizon
c. Transition horizon
d. Genetic horizon

587. The abrupt change in texture or mineralogy in the soil profile is termed
a. Lithologic discontinuity
b. Pedologic irregularity
c. Horizonation
d. None of the above

588. The rock that has been weathered but has retained the general rock structure is called
a. Concretion
b. Mottles
c. Saprolite
d. C horizon

589. It is the standard reagent to determine the cation exchange capacity of the soil.
a. Ammonium acetate
b. Sodium hexametaphosphate
c. Ammonium phosphate
d. Potassium chloride

590. A crop residue that has 75% organic carbon and 5% total nitrogen will have a C/N ratio of
a. 20:1
b. 10:1
c. 15:1
d. 25:1

591. With the assumption that N is a component of OM, to calculate the total N of the soil is to multiply OM by:
a. 2%
b. 3%
c. 4%
d. 5%

592. Earthworm burrowing activity in the soil enhances
a. Aeration
b. Drainage
c. water holding capacity
d. A and B

593. Which crop is not capable of N-fixation?
a. Garden pea
b. Peanut
c. Bean
d. Potato

594. Sunlight is the specific source of energy of this microorganisms
a. Autotrophs
b. Chemoautotrophs
c. Photoautotrophs
d. Heterotrophs

595. A greenhouse gas that is produced by the decomposition of organic matter in wet soils such as in rice paddies.
a. Carbon dioxide
b. Methane
c. Carbon monoxide
d. Hydrogen sulfide

596. A greenhouse gas that is produced during decomposition of organic matter in well-drained soils.
a. Carbon dioxide
b. Methane
c. Carbon monoxide
d. Hydrogen sulfide

597. A 50 Kg Urea (46-0-0) contains how many kilograms of nitrogen?
a. 23
b. 46
c. 2.3

d. 4.6

598. A cabbage plant needs 240 kg N per hectare. How many kilograms of 21-0-0 is needed to satisfy the requirement?
   a. 114.28 kg
   b. 1142.80 kg
   c. 50.04 kg
   d. 5.04 kg

599. To be more effective, a liming material should be applied at the proper time. This is usually done at
   a. Plowing
   b. Planting
   c. 3-4 weeks before planting
   d. Harvesting

600. Erosion which remove very less soil particles
   a. Sheet erosion
   b. Rill erosion
   c. Gully erosion
   d. Stream bank erosion

601. An erosion which begins at the lower end of a slope and findits way back uphill
   a. Sheet erosion
   b. Rill erosion
   c. Gully erosion
   d. Stream bank erosion

602. Erosion which is prevalent on river bodies
   a. Sheet erosion
   b. Rill erosion
   c. Gully erosion
   d. Stream bank erosion

603. Among the following, which soil conservation technique is the least effective in dissipating raindrop impact?
   a. Contour furrows
   b. Natural vegetation
   c. Contour composting
   d. Contour hedgerow

604. A type of erosion that results from the natural processes of weathering whereby soil erosion is nearly of the same rate of soil formation?
   a. Accelerated erosion
   b. Rill erosion
   c. Sheet erosion
   d. Geologic erosion

605. An instrument that is used to locate contour lines in a sloping area.
   a. Haga
   b. Level hose
   c. A-frame
   d. Telescope

606. A type of erosion control applicable to areas undergoing negligible erosion.
   a. Contour farming
   b. Preventive type
   c. Terracing
   d. Rehabilitative type

607. Rocks that were formed from the partial melting of existing rocks due to heat, pressure chemical action.
   a. Sedimentary rocks
   b. Metamorphic rocks
   c. Igneous rocks
   d. Volcanic rocks

608. Volcanic rocks consisting of accumulation of fragments blasted from volcanoes are
   a. Sediments
   b. Pyroclastics
   c. Lahar
   d. None of the above

609. In the Mohs' scale of hardness of minerals, it is the softest mineral.

a. Quartz
b. Gypsum
c. Talc
d. Diamond

610. The clay mineral with an average cation exchange capacity of 5 to 15 me/100 g.
a. Montmorillonite
b. Kaolinite
c. Illite
d. Vermiculite

611. At high moisture content in the soil, soil water potential is
a. Low
b. High
c. No relation
d. None of the above

612. At low moisture content in the soil, soil moisture tension is
a. Low
b. High
c. No relation
d. None of the above

613. If a crop residue contains 60% organic carbon and 5% total nitrogen, its C/N ration is
a. 10:1
b. 12:1
c. 15:1
d. 20:1

614. Which of the following microorganisms is very sensitive to potassium levels in soil and therefore useful in diagnosing potassium deficiency?
a. *Pseudomonas denitrificans*
b. *Aspergillus niger*
c. *Azotobacter chrococcum*
d. *Nitrobacter agilis*

615. The most efficient organic matter decomposers under acidic soil conditions are the
a. Bacteria
b. Actinomycetes
c. Fungi
d. Protozoa

616. A soil with bulk density of 1.3 g/cm^3 and particle density of 2.60 g/cm^3 will have a porosity of:
a. 5%
b. 25%
c. 50%
d. 75%

617. Type of soil structure best suited for growing upland crops
a. Massive
b. Platy
c. Crumb
d. Single-grain

618. A substance diagnostic horizon characterized by silicate clay accumulation.
a. Argillic
b. Nitric
c. Spodic
d. Cambic

619. A highly weathered subsurface horizon consisting of an accumulation of Fe and Al oxides.
a. Argillic
b. Spodic
c. Cambic
d. Oxic

620. A hard pan strongly cemented by silica.
a. Duripan
b. Calcic
c. Fragipan
d. Gypsic

621. The soil moisture regime characterized by sufficient moisture throughout the year.
    a. Aquic
    b. Udic
    c. Ustic
    d. Aridic
622. The soil temperature regime when the average annual temperature is more than 22°C and the difference between mean summer and mean winter is less than 5°C.
    a. Isothermic
    b. Isohyperthermic
    c. Isomesic
    d. Isofrigid
623. These are soils with little or no profile development.
    a. Udepts
    b. Fluvents
    c. Udands
    d. Ustalfs
624. These are soils formed from volcanic ash and young volcanic materials.
    a. Udepts
    b. Fluvents
    c. Udands
    d. Ustalfs
625. The cracking and swelling soils common in lowland areas which are used for rice production.
    a. Orthods
    b. Ustolls
    c. Ustalfs
    d. Uderts
626. These are well-developed soils with low base saturation common in forest and upland areas.
    a. Ustalfs
    b. Ustults
    c. Ustolls
    d. Usterts
627. These are highly weathered soils in the humid tropics.
    a. Udalfs
    b. Udults
    c. Udoxs
    d. Ustepts
628. The name Typic Tropudults is for the category of
    a. Order
    b. Great group
    c. Subgroup
    d. Suborder
629. The standard procedure to determine nitrogen content of soils.
    a. Potentiometric method
    b. Kjeldahl method
    c. Walkey-Black method
    d. X-ray diffraction method
630. A group of soils having the same profile characteristics and parent materials
    a. Soil type
    b. Soil series
    c. Soil association
    d. Soil phase
631. A type of soil survey which procedures maps with a scale of 1:15,000 to 1:5,000.
    a. Exploratory
    b. Reconnaissance
    c. Semi-detailed
    d. Detailed
632. Maahas clay is an example of a
    a. Soil type
    b. Soil series
    c. Soil association
    d. Soil phase

633. The most important cause of soil degradation.
    a. Soil pollution
    b. Soil erosion
    c. Soil denudation
    d. All of the above
634. The first step of soil erosion by water.
    a. Detachment
    b. Transportation
    c. Deposition
    d. Rainfall impact
635. A type of soil erosion characterized by uniform removal of soil.
    a. Rill erosion
    b. Gully erosion
    c. Sheet erosion
    d. Surface erosion
636. The ability of rainfall to cause soil erosion.
    a. Erodibility
    b. Erosivity
    c. Detachability
    d. None of the above
637. It is not a master horizon
    a. O
    b. A
    c. B
    d. R
638. It refers to the true soil.
    a. Solum
    b. Regolith
    c. Soil profile
    d. B horizon
639. A type of B horizon showing significantly clay accumulation.
    a. Bw
    b. Bt
    c. Bk
    d. Bc
640. The pores created by soil animals are called
    a. Capillary pores
    b. Biopores
    c. Voids
    d. None of the above
641. It is used to destroy organic matter during the textural analysis.
    a. Calgon
    b. H_2O_2
    c. HCl
    d. H_2SO_4
642. It is the chemical dispersing agent during textural analysis.
    a. Sodium phosphate
    b. Sodium hexametaphosphate
    c. Calcium phosphate
    d. Calcium chloride
643. A diagnostic horizon showing strong human influence such as phosphorus accumulation.
    a. Umbric
    b. Melanic
    c. Histic
    d. Anthropic
644. A diagnostic horizon that is like argillic except for its high sodium content.
    a. Spodic
    b. Natric
    c. Cambic
    d. Salic
645. The soil moisture regime that is characterized by water saturation
    a. Udic
    b. Aquic
    c. Ustic
    d. Xeric

646. The soil order of organic soils.
   a. Histosols
   b. Entisols
   c. Andisols
   d. Mollisols
647. They are young volcanic soils which are fertile except for their high P fixing capacity.
   a. Entisols
   b. Andisols
   c. Oxisols
   d. Vertisols
648. They are swelling and cracking soils common in lowlands.
   a. Entisols
   b. Andisols
   c. Alfisols
   d. Vertisols
649. The clay mineral characterized by a basal spacing of 7 Angstrom.
   a. Illite
   b. Kaolinite
   c. Montmorillonite
   d. Allophane
650. The clay mineral characterized by a basal spacing of 10 Angstrom.
   a. Illite
   b. Kaolinite
   c. Montmorillonite
   d. Chlorite
651. The oven-drying of soil samples is normally done at this temperature
   a. 70 °C
   b. 105 °C
   c. 205 °C
   d. 550 °C
652. The water in the largest pores that percolate downward
   a. Capillary water
   b. saturated water
   c. Gravitational water
   d. Percolating water
653. The moisture content of the soil at which plants wilt and fail to recover their turgidity when placed in a dark humid atmosphere.
   a. Field capacity
   b. Permanent wilting point
   c. Hygroscopic coefficient
   d. None of the above
654. The amount of moisture in a dry soil.
   a. Hygroscopic coefficient
   b. Adsorbed water
   c. Gravitational water
   d. Field capacity
655. The most active agent of soil erosion process in the Philippines and other areas in the humid tropics
   a. Wind
   b. Ice
   c. Water
   d. Glaciers
656. The wise use of land especially with respect to soil erosion control
   a. sustainable agriculture
   b. soil capability
   c. soil conservation
   d. soil management
657. The process by which soil nutrients are washed down by water from the root zone of the plants
   a. crop removal
   b. leaching
   c. volatilization
   d. denitrification

658. Growing of several crop species on a piece of land in spatial arrangement
    a. Monocropping
    b. Intercropping
    c. Alley cropping
    d. Multiple cropping
659. Biological control of soil erosion
    a. Contouring
    b. Rockwalling
    c. Strip cropping
    d. Terracing
660. Mechanical method of controlling soil erosion
    a. Terracing
    b. Mulching
    c. Strip cropping
    d. Alley cropping
661. This type of structure has disc-like aggregates and can be found in newly opened lands
    a. columnar
    b. massive
    c. crumb
    d. platy
662. Highly weathered soils with B horizon consisting primarily of sesquioxides
    a. Oxisol
    b. Alfisol
    c. Vertisol
    d. Aridisol
663. Order of montmorillonitic soils that forms crack during drying
    a. Spodosol
    b. Vertisol
    c. Histosol
    d. Oxisol
664. A diagnostic horizon with an accumulation of free iron oxides and organic matter
    a. Spodic
    b. Cambic
    c. Oxic
    d. Nitric
665. Net Nitrogen immobilization in the soil occurs if the C/N is
    a. less than 20:1
    b. greater then 20:1
    c. greater than 35:1
    d. less than 15:1
666. Individually, which among the following soil microorganisms have the least biomass?
    a. Actinomycetes
    b. Fungi
    c. Bacteria
    d. Protozoa
667. Which of the following soil organisms are acid-loving?
    a. Fungi
    b. Protozoa
    c. Bacteria
    d. Actinomycetes
668. The following illustrates how the value of B.D. is higher in the underlying subsoil, except one
    a. there is compaction brought about by the weight of overlying horizons
    b. there is less root penetration in subsoil
    c. subsoil is well-aggregated
    d. OM content is lower in subsoil
669. It states that the yield of the plant is regulated by the nutrient present in the lowest amount relative to its optimum requirement.
    a. Stoke's law
    b. Mineral theory
    c. Humus theory

d. Law of minimum

670. Which among the following is not true for humus?
   a. unstable and can be further degraded
   b. representative of organic colloids
   c. a complex organic product
   d. high molecular weight

671. Which is not a characteristic of cation exchange reactions?
   a. Instantaneous
   b. Reversible
   c. Stoichiometric
   d. Specific

672. Which is not a characteristic of upland soils?
   a. Upland soils are aerobic most of the time.
   b. Organic matter decomposes with CO_2 as a major product
   c. Nutrient elements exist generally in their oxidized state
   d. Nutrient elements exist generally in their reduced state

673. Which is not a characteristic of lowland soils?
   a. Lowland soils are anaerobic most of the time.
   b. Organic matter decomposes with methane, hydrogen sulfide, organic acids, alcohols and ketones as products
   c. Nutrient elements exist generally in their oxidized state
   d. Nutrient elements exist generally in their reduced state

674. Type of chemical weathering that takes place within the soil solum
   a. Geochemical weathering
   b. Pedochemical weathering
   c. Oxidation
   d. Reduction

675. The attack of the mineral by water is termed ____.
   a. Hydrolysis
   b. Hydration
   c. Oxidation
   d. Reduction

676. Equilibrium reaction between a metal ion and a complexing agent characterized by bond formation between the metal and complexing agent.
   a. Oxidation
   b. Reduction
   c. Chelation
   d. Hydration

677. Which of the following statement is not true regarding stability and weathering of minerals:
   a. Stability of mineral generally increases with increasing linkage between tetrahedral
   b. Stability within structural group increases with increased isomorphous substitution.
   c. Stability within a structural group decreases with decreasing electronegativity of metal ions
   d. Stability is influenced by the type and structure of metal ion-oxygen polyhedral linking silicate units

678. Describes the order in which minerals crystallize from magma:
   a. Bowen's reaction series
   b. Lyotropic series
   c. Discontinuous series
   d. Continuous series

679. It describes the formation of the mafic minerals (olivine, pyroxene, amphibole and biotite) each taking turns to form as the temperature progressively decreases:
   a. Discontinuous reaction series
   b. Continuous reaction series
   c. Lyotropic series
   d. Bowen's reaction series

680. It describes the evolution of the plagioclase feldspars as they evolve from being calcium rich to more sodium rich.
   a. Discontinuous reaction series
   b. Continuous reaction series
   c. Lyotropic series

d. Bowen's reaction series

681. Which among the following is considered as variable charge clay?
   a. Kaolinite
   b. Vermiculite
   c. Montmorillonite
   d. Intergrades

682. Calculate the weight (g) of Ca^{2+} needed to replace 1 g of H^{+}.
   a. 20
   b. 10
   c. 15
   d. 50

683. Calculate the weight (g) of Ca^{2+} needed to replace 1 g of NH^{4+}.
   a. 2.22
   b. 1.11
   c. 3.33
   d. 4.44

684. The net accumulation of materials at the interface between a solid phase and an aqueous solution phase is called
   a. Adsorption
   b. Absorption
   c. Attraction
   d. Adhesion

685. A soil has a pH of 5.5 and a CEC of 20 me/100g. The grower needs to lime the soil to pH 6.5. If the %BS at pH 5.5 is 50%, and 75% at pH 6.5, calculate the amount of $CaCO_3$ required to raise the pH of 1 hectare of soil.
   a. 10 tons $CaCO_3$/ha
   b. 50 tons $CaCO_3$/ha
   c. 30 tons $CaCO_3$/ha
   d. 5 tons $CaCO_3$/ha

686. It is a measure of salinity or concentration of dissolved salts
   a. Electrical conductivity
   b. Soil pH
   c. Total dissolved solids
   d. Residual calcium carbonate value

687. A property of solutions and has been used to quantify the alkalinity hazards of irrigation water applied to soils:
   a. Electrical conductivity
   b. Soil pH
   c. Total dissolved solids
   d. Residual calcium carbonate value

688. Refers to total concentration of inorganic solids and is usually expressed in mgL^{-1} or ppm.
   a. Electrical conductivity
   b. Soil pH
   c. Total dissolved solids
   d. Residual calcium carbonate value

689. System classification approach that attempts to organize the divisions of soils from a more holistic appraisal of soil attributes.
   a. Natural
   b. Technical
   c. Broad
   d. Narrow

690. Pesticides will be retained much longer in soils with
   a. Low organic matter
   b. High moisture content
   c. 2:1 dominant clay type
   d. Low pH

691. Once a soil has been placed under cultivation, its organic matter content usually
   a. Increases
   b. Decreases
   c. Relatively unchanged
   d. Unchanged

692. Tissue nutrient analysis is used to determine the nutrient status of the plants. Correct sampling of tissue always gives reliable results. The most common tissue used is

a. Leaf
b. Petiole
c. Bark
d. Roots

693. One important practical application of soil survey is to match it with the basic requirements of production systems. This is referred to as:
a. Soil survey and classification
b. Suitability assessment
c. Soil analysis
d. Soil morphological description

694. San Manuel loam can be cultivated safely and extensively to most crops. This soil type belongs to what suitability class?
a. Class A
b. Class B
c. Class C
d. Class D

695. A soil condition usually associated with a salinity problem is
a. fine texture
b. poor internal drainage
c. level topography
d. soil acidity

696. The fertilizer grade 10-12-10 means:
a. 10% N - 12% P – 10% K
b. 10 kg N -12 kg P - 10 kg K
c. 10% N - 12% P_2O_5 - 10% K_2O
d. 10kg N -12 kg P_2O_5 - 10 kg K_2O

697. A 500 Kg Urea (46-0-0) contains how many kilograms of nitrogen?
a. 230
b. 460
c. 23
d. 46

698. It is a characteristic of rainfall that falls per unit time usually expressed in millimeter per hour
a. Drop size
b. Amount
c. Intensity
d. Distribution

699. Soil colloids with the lowest cation exchange capacity.
a. Allophane
b. Montmorillonite
c. Organic matter
d. Kaolinite

700. Which among the following has the highest N and P contents?
a. poultry manure
b. cattle manure
c. goat manure
d. guano

701. Iron deficiency is commonly observed in these types of soils:
a. acid soils
b. neutral soils
c. alkaline soils
d. saline soils

702. Iron toxicity is commonly observed din this type of soils
a. acid soils
b. neutral soils
c. alkaline soils
d. saline soils

703. Organic materials with wide C/N ratios are not ready sources of available nitrogen because the nitrogen that they contain is subject to
a. Nitrification
b. Volatilization
c. Immobilization
d. Fixation

704. The soil microbial population is generally highest in the

a. A horizon
b. B horizon
c. C horizon
d. B2 horizon

705. Chemoautotrophs are those organisms which derive their energy from
a. Sunlight
b. Oxidation of organic materials
c. Fermentation
d. Oxidation of inorganic substances

706. For soil bacteria, growth results in an increase in the
a. Size of the individuals
b. Number of the individuals
c. Form of the individuals
d. Size and number of the individuals

707. The number and activity of bacteria in the soil are affected by
a. pH
b. Moisture
c. Oxygen supply
d. All of the above

708. A type of microscope which provides 3-dimensional view of the soil microorganisms is called
a. Light microscope
b. Scanning electron microscope
c. Transmission electron microscope
d. Immune-fluorescent microscope

709. A 1:1000 soil-water dilution means that one part of soil is suspended in
a. 9 parts of sterile water
b. 99 parts of sterile water
c. 999 parts of sterile water
d. 1000 parts of sterile water

710. In a legume biological nitrogen fixing system, the microsymbiont is
a. Bacteria
b. Actinomycetes
c. Algae
d. Fungi

711. CO_2 evolution in soil is a function of
a. Microbial population
b. Aeration
c. pH
d. All of the above

712. The amount of molecular nitrogen (N_2) in the atmosphere is about
a. 88%
b. 78%
c. 68%
d. 58%

713. Minimum slope criteria which is considered vulnerable to soil erosion
a. 10%
b. 12%
c. 18%

714. It is the systematic examination, description, classification, and mapping of the soils n a given area
a. Soil survey
b. Soil science
c. Soil classification
d. Soil physics

715. A type of soil survey where the size of mapping unit is 0.5 to 4 hectares.
a. Intensive survey
b. Reconnaissance survey
c. Semi-detailed survey
d. Detailed survey

716. The total number of soil orders classified under the Soil Taxonomy

a. 9
b. 11
c. 10
d. 12

717. A subsurface horizon with silicate accumulation accompanied by more than 15% exchangeable sodium
a. Nitric
b. Oxic
c. Kandic
d. Spodic

718. A surface layer that is dark-colored, with more than 1 percent organic matter and typically friable granular structure.
a. Mollic epipedon
b. Umbic epipedon
c. Ochric epipedon
d. Melanic epipedon

719. A man-made surface horizon which was produced by long-continued manuring and contains artifacts such as bits of bricks and pottery through its depth.
a. Anthropic epipedon
b. Histicepipedon
c. Plaggenepipedon
d. Umbricepipedon

720. A subsurface horizon which is typically indicated by the accumulation of clay
a. Argillic horizon
b. Agric horizon
c. Cambic horizon
d. Oxic horizon

721. The property of the soil that enables water, or roots to move through it
a. Infiltration
b. Density
c. Permeability
d. Percolation

722. A soil temperature regime wherein the mean annual soil temperature is 22°C or higher and the difference between mean summer and mean winter temperature is less than 5°C.
a. Mesic
b. Thermic
c. Hyperthermic
d. Isohyperthermic

723. Increased bulk density is not favorable in practical agriculture. Which of the following may lead to reduced bulk density?
a. Less aggregation and root penetration
b. Compaction caused by the weight of the overlying layers
c. Addition of organic matter in large amounts
d. Heavy foot traffic

724. The following can be used as contour hedges except one
a. camachile
b. ipil-ipil
c. eggplant
d. kakawate

725. A relatively new term for an old practice of planting agricultural crops along with or in sequence with woody perennial. This can provide a better source of income for the community.

a. multicropping
b. Agroforestry
c. multistorey cropping
d. Upland farming

Write TRUE if the statement is correct, otherwise write FALSE

_____726. Field capacity is an estimate of the upper limit of available moisture range.
_____727. Infiltration is the downward entry of water via the soil surface.
_____728. Permanent wilting point is the lower limit of the available moisture range.
_____729. The higher the soil moisture tension, the greater the amount of water stored or retained in the soil.
_____730. Capillarity is the ability of a liquid to flow against gravity.
_____731. Soil colloids are greater than 0.0001 mm in size.
_____732. Illite is a 2:1 expanding type silicate clay.
_____733. The CEC of soils decreases with increasing amount of clay and organic matter.
_____734. CEC can be expressed in me/100g soil or cmolc/kg soil.
_____735. Soils generally possess a net positive charge.
_____736. Aluminum is the central ion in the tetrahedral units of clay colloids.
_____737. Unit layers of kaolinite are held together tightly by H-bonding.
_____738. Soils high in montmorillonite do not swell nor shrink on wetting and drying.
_____739. Soils dominated by kaolinite are good bases for roadbeds and building foundations.
_____740. Chlorite is a 2:1:1 non expanding type silicate clay.
_____741. Clayey soils generally have higher CEC than a sandy soil.
_____742. Negatively charged colloids attract cations from soil solution which become absorbed on the surface.
_____743. Low CEC corresponds to low nutrient retention capacity.
_____744. Sodium rich soils are in dispersed state.
_____745. $[H^+]$ increases as pH increases.
_____746. The pH range 6.6 to 7.3 is considered neutral.
_____747. Main objective of soil sampling is to collect a small amount of soil sample weighing about 0.5kg that will represent the soil in a large area.
_____748. Soil samples should be collected from the surface layer (20-30 cm) for shallow rooted crops.
_____749. Olsen method is use for determination of available P of neutral or alkaline soils.
_____750. Moisture release curve is a graph showing the relationship between moisture content and moisture tension of the soil and the characteristic of soil itself.

Answer Key for Review Questions in Soil Science

1	B	26	D	51	A	76	B	101	A	126	B	151	A	176	C
2	B	27	B	52	C	77	B	102	B	127	C	152	A	177	C
3	A	28	A	53	C	78	B	103	C	128	A	153	B	178	A
4	D	29	C	54	C	79	D	104	A	129	A	154	D	179	C
5	B	30	A	55	B	80	A	105	C	130	B	155	C	180	C
6	D	31	D	56	A	81	B	106	B	131	B	156	C	181	A
7	B	32	D	57	C	82	D	107	C	132	C	157	A	182	B
8	A	33	C	58	D	83	B	108	A	133	B	158	C	183	B
9	B	34	A	59	C	84	B	109	A	134	A	159	B	184	A
10	A	35	B	60	C	85	C	110	A	135	C	160	A	185	D
11	B	36	A	61	C	86	C	111	C	136	B	161	B	186	C
12	B	37	A	62	B	87	C	112	A	137	C	162	B	187	B
13	C	38	B	63	C	88	B	113	B	138	B	163	B	188	B
14	B	39	C	64	A	89	D	114	A	139	C	164	A	189	B
15	B	40	D	65	D	90	C	115	B	140	A	165	D	190	A
16	C	41	C	66	B	91	A	116	B	141	C	166	B	191	A
17	C	42	A	67	D	92	D	117	B	142	B	167	B	192	D
18	D	43	A	68	A	93	B	118	B	143	D	168	B	193	A
19	D	44	D	69	D	94	B	119	D	144	A	169	B	194	A
20	B	45	D	70	B	95	B	120	B	145	D	170	D	195	A
21	A	46	D	71	B	96	B	121	D	146	D	171	C	196	C
22	A	47	B	72	A	97	B	122	A	147	A	172	B	197	C
23	A	48	C	73	C	98	A	123	C	148	D	173	A	198	B
24	B	49	C	74	B	99	C	124	A	149	C	174	B	199	C
25	B	50	C	75	A	100	B	125	B	150	B	175	B	200	C

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201	A	226	B	251	A	276	B	301	A	326	A	351	A	376	C
202	A	227	B	252	A	277	C	302	C	327	D	352	C	377	A
203	A	228	C	253	A	278	B	303	C	328	C	353	B	378	D
204	B	229	A	254	A	279	B	304	B	329	B	354	A	379	D
205	A	230	C	255	C	280	C	305	C	330	C	355	B	380	C
206	C	231	C	256	D	281	A	306	A	331	C	356	B	381	B
207	A	232	D	257	C	282	A	307	C	332	C	357	C	382	A
208	C	233	A	258	B	283	A	308	B	333	B	358	B	383	B
209	D	234	B	259	B	284	B	309	C	334	C	359	B	384	C
210	D	235	D	260	D	285	B	310	C	335	C	360	B	385	B
211	C	236	D	261	B	286	B	311	B	336	C	361	B	386	D
212	B	237	C	262	C	287	B	312	C	337	B	362	A	387	A
213	C	238	B	263	B	288	B	313	A	338	B	363	A	388	D
214	C	239	A	264	C	289	B	314	A	339	A	364	C	389	A
215	B	240	D	265	A	290	B	315	B	340	A	365	B	390	C
216	D	241	D	266	A	291	A	316	A	341	B	366	C	391	B
217	C	242	B	267	C	292	B	317	B	342	C	367	A	392	A
218	B	243	A	268	C	293	D	318	B	343	B	368	D	393	D
219	A	244	B	269	D	294	A	319	B	344	A	369	A	394	C
220	C	245	B	270	A	295	B	320	C	345	A	370	D	395	B
221	C	246	C	271	B	296	A	321	B	346	A	371	A	396	C
222	C	247	A	272	A	297	A	322	A	347	C	372	D	397	C
223	B	248	B	273	B	298	A	323	B	348	C	373	D	398	C
224	B	249	A	274	A	299	D	324	C	349	B	374	A	399	B
225	A	250	B	275	B	300	B	325	C	350	C	375	B	400	C

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401	B	426	D	451	C	476	A	501	C	526	B	551	D	576	C
402	C	427	C	452	C	477	B	502	B	527	D	552	A	577	A
403	A	428	B	453	C	478	D	503	C	528	C	553	D	578	B
404	D	429	B	454	C	479	D	504	C	529	A	554	B	579	B
405	B	430	D	455	B	480	D	505	C	530	B	555	C	580	B
406	C	431	C	456	D	481	B	506	B	531	B	556	A	581	A
407	C	432	B	457	C	482	C	507	D	532	B	557	B	582	B
408	D	433	A	458	B	483	A	508	C	533	D	558	B	583	D
409	C	434	A	459	D	484	A	509	A	534	B	559	B	584	B
410	A	435	B	460	D	485	C	510	D	535	B	560	A	585	D
411	B	436	D	461	A	486	C	511	A	536	B	561	B	586	C
412	A	437	D	462	C	487	C	512	A	537	D	562	A	587	A
413	C	438	C	463	B	488	A	513	A	538	C	563	A	588	C
414	D	439	B	464	C	489	A	514	B	539	B	564	A	589	A
415	C	440	A	465	C	490	B	515	B	540	A	565	D	590	C
416	B	441	D	466	A	491	C	516	B	541	D	566	A	591	D
417	C	442	D	467	A	492	B	517	D	542	C	567	B	592	A
418	B	443	D	468	C	493	C	518	D	543	B	568	C	593	D
419	B	444	D	469	C	494	B	519	A	544	C	569	C	594	C
420	C	445	A	470	B	495	D	520	B	545	C	570	A	595	B
421	B	446	C	471	A	496	B	521	B	546	C	571	B	596	A
422	A	447	A	472	B	497	D	522	B	547	B	572	B	597	A
423	B	448	A	473	D	498	A	523	A	548	A	573	A	598	B
424	A	449	A	474	C	499	C	524	B	549	A	574	B	599	C
425	B	450	B	475	C	500	C	525	D	550	D	575	C	600	A

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601	C	626	B	651	B	676	C	701	C	726	TRUE
602	D	627	C	652	C	677	B	702	A	727	TRUE
603	A	628	C	653	B	678	A	703	C	728	TRUE
604	D	629	B	654	A	679	A	704	A	729	FALSE
605	C	630	B	655	C	680	B	705	D	730	TRUE
606	B	631	D	656	C	681	A	706	B	731	FALSE
607	B	632	A	657	B	682	A	707	D	732	FALSE
608	B	633	B	658	D	683	B	708	C	733	FALSE
609	C	634	A	659	C	684	A	709	C	734	TRUE
610	B	635	C	660	A	685	D	710	A	735	FALSE
611	B	636	B	661	D	686	A	711	D	736	FALSE
612	B	637	D	662	A	687	D	712	B	737	TRUE
613	B	638	A	663	B	688	C	713	C	738	FALSE
614	B	639	B	664	A	689	A	714	A	739	TRUE
615	C	640	B	665	C	690	C	715	A	740	TRUE
616	C	641	B	666	C	691	B	716	D	741	TRUE
617	C	642	B	667	A	692	A	717	A	742	FALSE
618	A	643	D	668	C	693	B	718	A	743	TRUE
619	D	644	B	669	D	694	A	719	A	744	TRUE
620	A	645	B	670	A	695	B	720	A	745	FALSE
621	B	646	A	671	D	696	C	721	C	746	TRUE
622	B	647	B	672	D	697	A	722	D	747	TRUE
623	B	648	D	673	C	698	C	723	C	748	TRUE
624	C	649	B	674	B	699	D	724	C	749	TRUE
625	D	650	A	675	A	700	D	725	B	750	TRUE

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