08/06/2018

Course content.

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- Definition of soil & approaches of soil science.
- Weathering of rocks & minerals
- Basic processes of weathering.
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- Chemical weathering of rocks.
- Biological weathering of rocks
- Weathering of minerals
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- Soil forming factors
- Passive soil forming factors.
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- Specific soil forming processes
- Development of soil profile
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- Soil structure
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- Role of functions in relation to plant growth
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- Soil moisture & importance of soil water
- Organs to retain water in the soil
- Factors affecting soil water
- Soil water potential
- Measuring soil moisture
- Classification of soil water

19/06/18

SST 202 Practical Introduction

Sequence which must be followed,

- Date of the experiment
- Title of the experiment.
- Introduction/Theory
- Materials/Apparatus used
- Method/Procedure (make use of past tense)
- Result/Calculations
- Observations
- Discussions.
- Precautions
- References
- Conclusion

22/06/18

Weathering of rocks

Weathering is the physical and chemical breaking down of rocks, silt, soil and mineral as well as wood and artificial materials. Weathering takes place at or near the soil surfaces and its favoured by the absence of equilibrium in temperature, pressure and moisture conditions of the environment.

The disintegration of the rocks during weathering leads to decomposition of minerals and their subsequent modification of stable forms.

This important classification of weathering are;

- Physical & chemical weathering
Each sometimes involves in the biological components

* Physical weathering – It is the disintegration or the breakdown of rocks which does not involve changes in the chemical or mineralogical state of the rock. This is brought about by stresses induced by variations in day & night temperatures. The processes of physical breakdown of rocks includes the following;

a) Thermal expansion & contraction (Heat)
b) Pressure released or unloading/erosion
c) Freezing & thawing (Ice)
d) Action of plants, animals & man

(A) Thermal Expansion & Contraction (Heat)

Temperature fluctuate due to differential heating & cooling of rocks can cause physical breakdown of rocks. Mineral grains which compose from a rock expanse and contrast at different rate and at different directions depending on their thermal properties.

Physical weathering of this type is sometimes called Thermal weathering.

The major source of heat from the earth surface comes from the sun through solar. When rocks are exposed to the earth surface, they are commonly found in most part of northern Nigeria. The rock surface eats off and gradually penetrates the inner portion.

Subsequently, the outer part of the rock is more intensely heated than the inner part. This differential heating condition further causes differential thermal expansion of mineral grains in the rock, thus causes stress and eventual break up of the rock.

(B) Pressure released or Unloading/Erosion

Some rocks like granite are formed deep in the earth under conditions of high pressure; when such rocks are exposed to the ground surface by erosion, the release from pressure causes the rock to expand, a process called unloading.

This produces cracks that are parallel to the topography and closely spaced near the ground surface.

c) Freezing and Thawing (Ice).
When the temperature drops below freezing point as happens in temperate regions at certain times of the year, the state of water changes from liquid to solid. The changes is accompanied by an increase in volume. When water gets into the rock, it cracks & turns into ice, the increase in volume resulting from the change of state exert pressure of water will be high. The pressure may be enormous or prolonged that it will cause a rock to breakdown.

d) Action of plants, animals & man
Plant roots can grow into cracks and joins in rocks. As the root grows, they expand the rocks and eventually break them down into small fragments. When trees with big lateral roots are planted close to a house or fence. The force exerted by the roots as they grow often cracks the walls and eventually can pull the house or wall down.
Man also contributes to rock breakdown through his mining and quarrying activities, using explosives, grinding machines & hammers, considerable amounts of rocks (granite) are harvested to support civil engineering construction in roads & bridges

Processes involved in chemical weathering
Causes a change in the chemical and/or mineralogical composition of the rock and its constituents minerals
Geochemical weathering takes place below the soil profile (A and B horizon) yielding to the formation of "saprolite". Chemical weathering takes place in the soil profile and possibly strips where geochemical. The main agent of chemical weathering includes; - Water
- Air,
- Organic acid.
The tendency of the chemical weathering depends on the type of agent, amount/quantity available as well as effective surface of the rock available. Chemical weathering processes are classified into:
- Hydration - This is where water molecules combine in humid areas is responsible for the formation of hydrous compound like serpentine, Gmynsite or dehydrates.
In hydration, water molecules attached to rock minerals cause increase in the volume of the rock thus weakening or even disintegrating to deeper or greater depth.

$CaSO_4 + 2H_2O \rightarrow CaSO_4 \cdot 3H_2O$
Gypsum

* Dehydration; It is a relatively difficult process under normal weathering conditions. The dehydration of geothite ($Fe(OH)_3$), haematite (Fe_2O_3) requires very high temperature up to 400c under laboratory condition.

* Hydrolysis: This is the most chemical process in chemical weathering due to the ~~bofas~~ splitting of water into H^+ & OH^- which chemically combines with minerals and results to absolute change.
Hydrolysis involves the attack of silicates clay by highly charged hydrogen ions (H^+) the process occurs as a result of the reaction between the molecules H^+ and OH^- of water and mineral elements of a rock. The process of hydrolysis is very important in the weathering silicate minerals. The association of water with free aluminium and silicate as the broken edges is the first step of hydrolysis.

$2KAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightleftharpoons$ + Hydrolic acid
Orthoclase (Aluminum feldspar)
$Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + 2K^+ + 2HCO_3^-$
Kalomite Siliciacid ~~Bicarbonate ions~~

Hydrolysis is favoured by repeated leaching, introduction of hydrogen ions, precipitation of insoluble ions and assimilation of the products by living organisms

* Oxidation; This is the process of addition & combination of water to minerals. The absorption of oxygen is from the water and atmosphere.
Oxidation is a chemical process by which an element loses an electron

$Fe^+ \rightarrow Fe^{++} + e^-$

The principal element in oxidation is oxygen which comes with 21% from the volume of the air near earth surface. When air is stored in water e.g. rain water, the free oxygen content of the water increases. Oxidation occurs in soil and rocks where oxygen supply is high and biological demand for it is low

* Reduction - This is the removal of oxygen from substance. Reduction is favoured by anaerobic conditions (water concentration) by low oxygen supply and high biological demand. When iron reduced it converted to ferrous form; a highly mobile.

if there's a net forward movement.

Oxidation – Reduction 29/06/18

This chemical reaction occurs mainly in the C-horizon. It is the fluctuation from oxidizing and reducing conditions in response to seasonal variation in moisture conditions.

Iron and manganese follows similar pattern of oxidation - Reduction in relation to prevailing pH and redox potentials; however, manganese remains in reduced form at high pH than iron.

Solution; Most substances in rocks are soluble in water. The most soluble substances are chloride and sulphate (Cl^- & SO_4^{2-}) common salt dissolve in water as follows;

$NaCl \longrightarrow Na^+ + Cl^-$

In solution weathering, dissolve substances tend to ionize and so can combine with other elements thereby activating the weathering reactions;

$Na^+ + Cl + H^+ + OH^- \longrightarrow NaOH + HCl$

Solution weathering is important in the removal of highly soluble substances.

CARBONATION

In carbonation, carbonate (CO_3^{2-}) or bicarbonate (HCO_3^{2-}) ions combine with rock element to dissolve it. When Carbondioxide (CO_2) dissolves in water, it forms carbonic acid. The solvent action of carbonic acid is enhanced in vegetated or forested areas where organic acid are also involved. Carbonation is an important process in lime stone.

BIOLOGICAL WEATHERING.

The number of plants & animals may create chemical weathering through the release of acidic compounds i.e the effect of moss growing on roofs it is classified as weathering.

General weathering can also be initiated by soil micro-organisms. Leaching on rocks, are to increase ~~soil~~ chemical weathering. The most common form of biological weathering are to release chelating compounds (organic acid and of acidifying molecules (proteins and organic acid) by plants so as to break down aluminium and iron containing compounds in the soil beneath them. The symbiotic micro-rizal fungi associated with tree roots can release inorganic nutrients to form minerals such as haptis and biotites and transfer these nutrients to trees.

Weathering of rocks.

Factors that influence the weathering of minerals are:

1) Climatic conditions
2) Physical characteristics
3) Chemical and structural characteristics.

1) **climatic conditions**; Under this condition; Low rainfall; there is a dominance of physical weathering which reduces the size and increases the surface of weathering area with little changes in volume. The weathering rates are generally fast during seasons in tropical areas as there is sufficient moisture and warmth to encourage chemical composition.

2) **Physical characteristics**; under this characteristic;
- Particle size;
- Hardness and degree of cementation
- Differential composition

3) **chemical & structural characteristics**; For minerals of a given particle size, chemical and crystaline characteristics determines the ease of decomposition e.g Gypsum is sparingly soluble in water. It is dissolved and removed in solution from under high ~~ten~~ rainfall.

Soil forming factors;

The soil formation is the process of 2 consecutive stages;

1) Weathering of rocks into regolith.
2) The formation of true soil through regolith.

Weathering soil factors

These are;
- Parent materials
- Climate
- organism, topography & time

It can be mathematically represented as;

$S = f(Pm + Cli + Topog + time + organism)$.

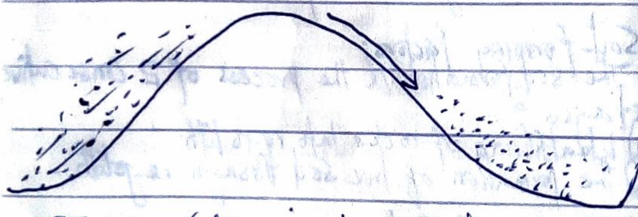
⇒ climate; climate elements such as rainfall, relative humidity, temperature, & duration of sunshine all affects the rate of soil formation.

In areas with high rainfall & high temperature the reaction of such soils are higher while microbes are also more active leading to more breakdown and incorporation of tissues, hence, a higher rate of soil development e.g The rate of soil formation in the humid tropics are higher than what occurs e desert.

organisms; The role of micro-organisms is ...ially important because without life there be no soil formation because bacteria and ...gi are both responsible for the initial breakdown of plant tissues upon a plant surface. The ... and dead organisms also provide the ... and energy that is required for further breakdown of organic materials & in-corporation ... the soil.

Parent materials; This can be described as the initial state of soil system or as the unconsolidated materials from which the soil develops.
All other factors being equal, the rate of soil formation will depend on the nature of parent materials. e.g. The rate of soil formation in the parent materials of sand stone to soil origin will be faster than in the areas with igneous rock.

⇒ Topography/Relief; The effect of relief of one climate includes:-
- Increase in temperature & increase in rainfall which will result in the increase in organic matter accumulation. The rate of soil formation will vary along the slope depending on their position.



⇒ Time; Time determines how much development the soil has undergone. Soil forming process takes time to show or manifest their effects.
Soil formation is a very slow process requiring thousand of years to develop a mature pedo. The period taken by a given soil from the stage of weathered rock (regolith) up to the stage of maturity is considered as time. A young soil will retain its features of its parent materials but it grows older and acquires its new features. A mature soil is a soil with A, B, C variety.

Passive soil forming factors
These are those which represent the source of soil forming mass and conditions affecting it.
This provides a base in which soil forming factor works or acts for the development of soil.
- Parent material - It is that mass (consolidated materials) from which the soil are formed. Two groups under parent materials are:
• Sedentary: It forms at original place. It is a residual parent material.
• Transported: The parent materials transported from their original place they are named according to the main force responsible for the transport & redeposition.

Forms of movement
* Colluvium; It is the poorly sorted material near the base of strong slopes transported by action of gravity.

* Alluvium: These are materials transported and deposited by water. It is found along the major stream courses at the bottom of slopes of mountains and along small streams flowing out of drainage basin.

* Lacustrine: These consists of materials that are settled out of quiet water of lakes.

* Moraine; These consists of all the materials mixed up; disintegrated, transported and deposited through the action of water resulting primarily from melting and glaciers (ice).

* Loess / Aeolian; These are wind blown materials. When the texture is loess, it is silty, when the texture is sandy, it is Aeolian.
The soil develops on such transported materials near the name of the parent material. Alluvium soil forms from alluvium and so on. In the initial stages, the soil properties are mainly determined by their parent materials.

Soil properties as influenced by Parent material
Different parent material affects the profile development and produces different soil especially at the initial stage;
1) Acid igneous rock (granite) produce light texture soil (Alfisols).
2) Basic igneous rock (Ba-salt, Alluvium or Colluvium derived from limestone or ba-salt produces fine texture cracking clay soil (Vertisols).
3) Basic alluvium or aeolian materials produces fine to coarse texture soil (Entisol / Inceptisol).
4) The nature of elements released during the weathering of rocks has a specific role in soil formation e.g. silicon and aluminium forms the production of secondary clay minerals.

5) Iron and manganese are important for imparting red colour of soil as for oxidation - reduction occurrence.
6) Sodium & Potassium are important to dispersing agent for clay & humus colloids.
7) Calcium and magnesium have a fluctuating effect and results in favourable and stable soil structure in growth.

Active soil forming factors:
These are those which supply energy that acts on the mass for the purpose of soil formation. This factors are climate & vegetation.

Climate; This is the physical factor for controlling the type of and rate of soil formation. Dominate climate recognized are;
- Arid climate; The vegetation here is far less than the water needed. Hence soil remains dry for most of the year.
- Humid climate; The precipitation is much more than the water needed.
The excess water leaching of salts and basic followed translocation of clay colloids.
- Oceanic climate; This is a moderate seasonal variation of rainfall & temperature.
- Mediterranean climate; The moderate precipitation.
- Continental climate; Warm summer and extremely cool and cold winter.
- Temperate climate; Cold humid conditions in warm summers.
- Tropical and sub-tropical climate; Warm to hot humid with isothermal conditions in the tropical zone.
Climate affects the soil formation directly or indirectly.
Directly; Climate affects the soil formation by supplying water and heat to react to the parent materials.
Indirectly; It determines the fauna & flora activity which is used to create a source of energy in the form of organic matter.
Precipitation & temperature are the 2 major climate elements which contributes most to soil formation.
02/07/2018
Precipitation; Precipitation and temperature are the two major climatic elements which contributes to soil formation. It is the most important among the climatic factors as it percolates and move from one part of parent material to another.
It carries with a substance, a solution as well as a suspension. The substance carried are redeposited in another part through percolation.
Temperature; This is another climatic agent influencing the process of soil formation. High temp. hinders the process of leaching and causes an upward movement of soluble salt.
High temperature favours the rapid decomposition of organic matter and increase microbial activities in soil while low temperature induce leaching by reducing evaporation and thereby, favour the accumulation of organic matter by slowing down the process of decomposition.

Organisms; The active components of soil ecosystem are;
- Plants
- Animals
- Micro organisms
- Man.
The role of micro-organism in soil formation is related to putrefaction & mineralization of vegetation.
- The action of animals especially burrowing animals to dig and mix up the soil mass and disturb the parent material.
- Man influences the soil formation through his manipulation of natural vegetation, agricultural practices - compaction by traffic of man & animal ~~decreases~~ decreases the rate of water infiltration into the soil and thereby increase the rate of run-off and erosion.

SOIL FORMING PROCESSES:
The basic processes involved in the soil-forming processes are;
1) Addition of water, organic & mineral matter to the soil.
Input of organic matter could be developing soil profile from outside source. Example;
- Falling plant leaf.
- Sloughed-off root.

2) Losses of the above material from the soil; Organic materials are lost from the soil by leaching, erosion or other forms of removal. Evaporation and plant use causes a loss of water. Leaching and drainage also causes a loss of water. Erosion removes final particles from the soil and leaving the surface ~~horizon~~ to rise and sandier and to be less rich in organic matter.

...nsformation of minerals and organic subs-[tances] within the soil; It involves weathering [of pri]mary minerals, Disintegrating and altering [...] of the soil forms, various kinds of [...]te clay. Other important transformation [...]es the decomposition of organic residues & synthesis of organic acids, humus and other [prod]ucts.

[T]ranslocation or movement of soil materials, [fro]m one point to another within the soil. [I]t is the movement of organic & inorganic [ma]terial ~~from one~~ laterally within the horizon [an]d vertically within from one horizon up and [do]wn to another. Water percolating down with [gr]avity or rising up by capillary action is the [m]ost common translocation agent.

[F]undamental soil forming processes

[1]) Humification
[2]) Elluviation
[3]) Horizonation

[H]umification – This is the transportation of raw organic material into humus. Simple compounds (sugar & starch) and very resistant compounds (Tannis are decomposed) and the dark colour substance known as humus is formed.

It is the mobilization and translocation of certain constituents (Fe_2O_3) and (Al_2O_3) then, (SiO_2), calcium carbonate and so on. They are moved from one point of the soil body to another.

[E]lluviation – This means washing away or washing out of materials from the soil. It [i]s the process of removal of constituents in suspension or solution by the percolating water from the upper to lower layers.

[-] The horizon formed by the process of elluviation [i]s termed as "elluvial horizon" (A_2 or e-horizon)

-It is the process of deposition of soil materials (removed from the elluvial horizon) in the lower layer is termed elluviation.

[-] The horizon formed ~~by~~ ~~[illegible]~~ this process [i]s termed "higher fine". Total clay ratio in the BT horizon is higher.

[H]orizonation – It is the process of differentia-[ti]on of soil horizons

- The differentation is due to the fundamental process-es is due to the fundamental processes of;
- humification
- elluviation.

Specific soil forming Processes

i) Calcification – It is the process of precipitation and accumulation of calcium carbonate ($CaCO_3$) in some part of the profile. The accumulation of calcium carbonate may develop in the process of calcium horizon.

Calcium is ~~[illegible]~~ soluble in acid soil water and when carbondioxide contribution is higher in root zone.

Decalcification – It is a reverse of calcification (the process of removal of calcium carbonate) or calcium ions from soil by leaching.

Podzolization – This is the process of soil formation resulting in the formation of "Podzols" and "Podzolic soils". It is the negative of calcification. Decalcification process tends to concentrate calcium in the lower part of the B- horizon whereas podzolization leaches the entire solum of mineral carbo[nate]

Laterization – It is referred specifically to a particular cemented horizon in certain soil which when dried becomes very hard like brick.
In tropics, such soil when rapidly saturated with sesqui oxide (Aluminium & iron oxide) are called laterites or latosols (oxisols). The soil forming process is called laterization or latozation.
Laterization is the process that removes silica instead of sesqui oxide from the upper layers & thereby causing sesqui oxide concentration to be highe[r]

Gleization – It is the process of soil formation resulting in the development of "Glei" (Glei horizon in the lower part of the soil profile above the parent material due to poor drainage condition (lack of oxygen) and where the water log condition prevents.

Salinization – It is the process of accumulation of salt such as sulphates & chlorides of calcium magnesium, sodium & potassium in soils in the form of salty horizon. Salt accumulation may also result from irrigation or sippage in areas of imposed drain[age]

Desalinization – It is the removal of leaching of

...ccess soluble salt from a horizon or soil profile by ponding water and improving the drainage conditions or by installing artificial drainage network.

Solonization or Alkalization - The process involves the accumulation of sodium ion on the exchange complex of clay, resulting in the accumulation of "sodic soil". All cations in solution are in place in the reversible reaction with the exchange sites of some clay and organic matter particles (K^+, Ca^+, Na^+).

Solodization or thick alkalization: The process refers to the removal of sodium ion from the exchange sites. The process involves dispersion of clay. Dispersion occurs when sodium ion becomes hydrated, calcium & magnesium ion can replace the sodium in exchange complex and the salt of sodium are leached out.

Pedoturbation - This is the process of mixing of soil. Mixing to a certain extent takes place in all soils. The most common types of pedoturbation; fauna pedoturbation (mixing of soil by animals such as ants, earthworms, rodents and so on); flora pedoturbation (mixing of soil by plants); Argillic pedoturbation (mixing of materials in solum).

Development of soil profile

The development of soil profile is a constructive process where the disintegrated materials results from weathering of rocks & minerals gets converted into soil body.

Soil profile - It is the vertical section of the soil showing the various layers from the surface to the unaffected parent materials. The various layers are known as horizons.

The soil profile contains three main layers, they are named as;

- Horizon A
- Horizon B
- Horizon C.

- Horizon A is the surface soil or layer of soil at the top which is liable to leaching and from which some soil constituents have been removed. It is a horizon of organic matter accumulation, adjacent to surface and that which has lost clay, iron and aluminium.

- Horizon B is the intermediate layer from which materials leached from horizon A are deposited. Its dominant features are; accumulation of clay, iron, aluminium or humus alone.

- Horizon C is the parent material from which the soil is formed. It is the horizon below the solum (A + B) relatively less affected by soil forming processes. It is outside the zone of major biological activities. It may contain accumulation of carbonates, sulphates, Ca or Mg.

A hypothetical mineral soil profile will include O, A, B, C & R, master horizon and all the possible sub-horizon.

- O-horizon: it is the organic horizon of the soil profile. Formed at the upper part of the mineral soil, dominated by fresh or partly decomposed organic materials. The organic horizon are commonly seen in the forest areas (where soils are left to nature for a long time). They are generally absent in grasslands and cultivated soils.

In organic horizon, the original form of plant and animal residue can be recognized through naked eyes.

Taxonomic classification (soil taxonomy).

Soil taxonomy depends on the soil profile or soil properties as they are found today. But does not mean that the soil genesis are ignored. One of the objectives of the system is to group soils that are similar in genesis (origin). The system was designed by USDA (United States Department of Agriculture). It classifies all soils into 12 groups referred to as soil order.

Each of the soil order were further sub-divided into sub-order, genus, family & series. This system has identified some diagnostic horizon from which classifications are based. Some of the diagnostic origin horizon are placed in the table below;

tic	Nomenclature	Definition
ion	A_0	It is a mineral surface horizon known for its dark colour surface layer saturated with organic carbon and high base saturation
nthropic	Ap	It is a human modified mollic-like horizon, high in available phosphorus.
Histic epipedon	A_0	This surface layer is saturated with water for parts of the year. It is high in organic carbon.
Argillic horizon	Bt	It is enriched in ~~[illegible]~~ silicate clay accumulation
Spodic horizon.	B_s	It is enriched with organic matter, iron and aluminium oxide accumulation

Based on the taxonomic classification, the world soil has been classified into twelve (12) orders as follows;

1) Alfisols.
2) Andisols.
3) Aridisols.
4) Entisols
5) Gelisols
6) Histosols.
7) Inceptisols
8) Mollisols
9) Oxisols.
10) Spodosols
11) Ultisols
12) Vertisols.

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Scope of soil science

Soil science deals with soil as a natural resource on the surface of the earth.

Classification of soil science includes;

1) Pedology; This talks about the soil genesis, classification and mapping.
2) Edaphology; It studies the physical, chemical and biological properties of the soil as well as the fertility properties.

Soil science has six (6) well defined and developed disciplines. These are;

a) Soil fertility; Nutrient supplying properties of soil.
b) Soil chemistry; It involves chemical constituents, chemical properties in the soil
c) Soil physics; It involves the study of the physical properties and engineering properties of soil (Geotechnical properties.
d) Soil microbiology; Deals with micro organism, its population, classification and role in nutrient transformation
e) Soil Conservation; This deals with the protection of soil against physical loss by erosion or against chemical deterioration.
f) Pedology; This deals with genesis, survey and classification of soil.

SOIL; According to Whitney, Hilgard, Dokuchaev and Joffee, soil is a natural body of mineral and organic constituents differentiated into horizons usually unconsolidated with varying depth which differs in physical make up, chemical properties and composition as well as biological characteristics.

characteristics

According to S.S.S.A (1970) soil is an unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent materials, climate, macro & micro organisms and topography, all acting over a period of time

– It is also defined as unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of the plants.

There are two approaches of soil.

1) Pedological approach
2) Edaphological approach.

Pedological approach – This deals with the origin of the soil, its classification and description. Pedology is the study of soil as a natural body and does not focus on the soil immediate practise use. A pedologist studies, examines & classifies soil as they occ

Why does potential acidity not affect the growth of plant? Ans: Because they are not in solution form, they exist in particles form.

in their natural environment.

(2) Edaphological approach - Edaphology is the study of soil from the standpoint of higher plants. Edaphologists consider the various properties of the soil in relation to plant production.

Soil chemical properties:

1) Soil reaction / Soil pH: Soil reaction which is otherwise called soil pH is the measure of the alkalinity of soil. Soil pH is defined as the negative logarithm of the hydrogen concentration. It is measured using a pH meter or scale which ranges from 0 - 14. pH 7 is the middle of the scale and its the neutral point.

As the amount of H^+ in the soil increases the soil increases the soil pH decreases and this means higher acidity. Also on the amount of OH^- (hydroxyl ion) concentration in the soil increases, the pH reading increases meaning higher alkalinity or basicity.

An acid could be defined as any substance capable of yielding hydrogen (H^+) which is a proton when dissolved in water. Pure water dissociates to produce H^+ and OH^- i.e ~~H_2O~~

$$H_2O \rightleftharpoons H^+ + OH^-$$

In pure water, the concentration of H^+ and OH^- are equal and the solution is said to be neutral (pH = 7).

Mathematically, $pH = -Log_{10} AH^+$

Where AH^+ represents acidity of H^+ in moles per litres or molarity.

The pH scale is shown below

Increase in acidity ← Neutral point → Increase in alkalinity

1 2 3 4 5 6 7 8 9 10 11 12 13 14

At neutral point, AH^+ is, $pH = -Log_{10} 10^{-7}$ $= 0.0000001m = 10^{-7}m$

Example (1): If the pH of the soil is 5.6 find the hydrogen ion concentration $[H^+]$?

$pH = -Log[H^+]$

$= 5.6 = -Log[H^+]$

$\therefore Log H^+ = -5.6$

$H^+ = 10^{-5.6}$

$= 10^{-6} \times 10^{0.4}$

$= 2.512 \times 10^{-6}$ Mol.

Active acidity → inside in a solution.

e.g

2) If hydrogen ion concentration $[H^+]$ is 0.000031. Find the pH of the soil.

$pH = -Log[H^+]$

$= -Log(3 \times 10^{-5})$

$= -(0.48 - 5)$

$= 4.52$

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2) Active acidity - This is the sum total of all the H^+ in the aq. solution or soil solution.

Potential/Reserved acidity - This is the potential or reserve of H^+ in the soil and it is always in dynamic equilibrium with active acidity. It is what is in the exchange site complex that is not yet in solution a called exchangeable acidity is caused by H^+ and Al^{3+} mo... are made soluble by buffered salt such as KCl.

- One difference between active acidity & potential or reserved acidity is that it is the active acidity that usually affect the growth and other metabolisms of plant while potential acidity does not affect the growth of plant.

Total acidity - This is the sum total of active acidity which is represented as H^+ concentration in the soil solution and the potential or reserved or exchangeable, latent acidity which is due to the H^+ and Al^{3+} absorbed on soil colloidal surface.

Mathematically:

Total acidity = ΣActive acidity + Potential acidity.

Questions to note:

1) If the pH of the soil is 4.5 calculate the hydrogen ion conc.

Soln

$pH = -log[AH^+]$

$4.5 = -log[H^+]$

$Log[4.5] = H^+$

$H^+ = 0.6532$

$= 0.7$ mol.

2) If the $[H^+]$ of a soil solution is 0.00006m. Calculate the pH of the soil

Soln $pH = -Log[H^+]$

$pH = -log[0.00006]$

$pH = 4.223$

$pH = 4.2m$

3) Find the pH of the soil whose $[H^+]$ concentration is $6.7 \times 10^{-4}m$.

$pH = -log[0.00067]$

$pH = 3.1739$

$= 3.2$

Buffer solution; These are the compounds that maintains the pH of a solution with a narrow range when small amount of acid or base is added. "Buffering" is defined as the resistance to a change in pH. Acetic acid and Sodium Acetate are common examples of buffered systems.

Acidity Ranges in Soils.

Reaction	pH	Hydrogen ion Conc.
Strongly acidic	3 - 4	10^{-3}
Acidic	4 - 5	10^{-4}
Weakly acidic	5 - 6	10^{-5}
Neutral	7	—
Weakly alkaline	7 - 8	10^{-7}
Alkaline	8 - 9	10^{-8}
strongly alkaline	9 - 14	10^{-9}

Causes of Soil Acidity

The following are some of the causes of soil acidity;

1) **Decomposition of soil organic matter (SOM)**: Decomposition of SOM has been known to lead to production of an organic & inorganic acid. Thereby, increasing soil acidity

2) **Carbondioxide (CO_2)**: When plants and micro-organisms respire, they release CO_2 into the soil which when mixed with the soil water releases hydrogen ion into the soil which causes acidity.

$CO_2 + H_2O \rightarrow H_2CO_3$

$H_2CO_3 \rightarrow 2H^+ + CO_3^-$

3) **Oxidation of ammonium compounds**:- This produces hydrogen ion into the soil. Again, decomposition of organic materials releases ammonium which later oxidizes to release hydrogen ion that may cause soil acidity.

$NH_3 + 2O_2 \rightarrow H^+ + NO_3 + H_2O$.

4) **Oxidation of sulphur**:- When elemental sulphur is ground and mixed with soil, it is oxidized to sulphate by sulphur oxidizing bacteria in the soil. (As shown in the equation).

$2S + 3O_2 + H_2O \rightarrow 4H^+ + 2SO_4^{2-}$

The sulphate will oxidize to produce sulphuric acid which causes soil acidity.

5) **Leaching of cation**:- The leaching of basic cations such as Ca^{2+}, K^+, Mg^{2+}, Na^+ (exchangeable cations)

6) **Harvesting of Crops**; removal of cations by crop harvesting could lead to soil acidity as crops are harvested, and removed from the soil. The basic cations that are absorbed by plants for growth and development are removed and this causes the release of hydrogen ions into the soil solution hence, causing soil acidity.

Question: How soil acidity affect soil properties

7) Use of acid forming fertilizers; excess application of mineral fertilizers especially with acid forming cations could lead to soil acidity if no lime is applied.

Importance of soil acidity:

1) Soil acidity affects availability of plant nutrients. The pH of any soil is a good guide in predicting which plant nutrient is likely to be deficient.

2) Soil pH affects the growth activities of soil microorganism for example bacteria and actinomycetes are known to function well at a pH of 5.5 while fungi function well on acidic medium i.e at a pH below 5.5 - The most favourable pH for micro organism in the soil is from 5.5 to 7.5

) Soil pH affects some diseases and pathogens in the soil. Increase in soil pH has shown to favourable potato scab which is controlled by application of elemental sulphur.

) Soil acidity especially hydrogen concentration has some buffering effect in maintaining ionic balance in soils. If the leaching of cations is greater than the anions in the soil, there is net positive charge hydrogen ion that is released from exchange sites, to soil solution to maintain the ionic balance.

5) Soil pH affects soil structure. Soil with pH 8.5 will have high porosity and thus will make the soil to be eroded. Na causes dispersion of soil resulting into physical problem such as dispersion of clay particles by wind.

Factors affecting/controlling soil reactions.

Soil reaction varies due to the following factors;

1) Nature of soil colloids - When hydrogen ion form the predominant absorbed cations on clay colloids the soil reaction becomes acidic

2) Soil solution - The more dilute the soil solution is, the higher the pH value. Hence, the pH drops as soil gets dry or concentrated

3) Climate - Rainfall plays an important role in determining the soil reaction. Soils formed in regions of high rainfall are usually acidic while soil formed in regions of low rainfall are alkaline or basic.

4) Soil management practices - such as cultivation makes soil more acidic due to leaching of basic cations and also improve crop harvest.

5) **parent material** – soils formed from parent material or basic rocks usually have higher pH than those formed from acid rocks such as granite.

6) **precipitation** – As water moves into the soil basic cations such as calcium, magnesium are leached out. These basic cations are replaced by acidic element such as hydrogen and aluminium. Therefore, soil formed under high precipitation are usually acidic

7) **Flooding** – It makes soil pH to be high and could lead to micro nutrient deficiency such as zinc.

8) **Soil depth** – Acidity increases with depth except when the ~~top~~ soil is leached out by erosion.

Influence of soil reaction on availability of nutrients

Soil nutrients affects nutrient availability in the following ways;

1) In highly acidic soil, the availability of some nutrients like Al, Fe and Mg is increased to a point when they become toxic to plants

2) At low pH, the supply of availability of Ca, P, K, N etc

3) At high pH, most plant nutrients such as N, P, K are unavailable to plants.

4) Most microorganisms function well at a pH of 5.5 to 7.5. If soil reaction is changed below or above this range, microorganisms that helps to decompose organic materials will be affected.

Soil colloids.

A colloidal state refers to two-phase system in which one material in a very finely divided state is dispersed through a second phase. For example, dispersion of clay particles in water is an example of a colloidal state. This is a solid in liquid state. Another example is fog or clouds in the atmosphere. In ~~this~~ this stage, it is a liquid in gas state. clay particles contains particles less than 0.002mm and particles less than 0.001mm are said to possess colloidal properties and are called soil colloids

properties of soil colloids

1.) They have small sizes and cannot be seen with naked eyes except with microscope

2) They have large surface area due to their small sizes

3) They carry both positive and negative

charges but electronegative charges dominate in most colloids.

4) Due to negative charges on soil colloids they attract ions of opposite charges to the colloidal surface through the process called isomorphous substitution.

5) They have cohesive and adhesive ~~adhe~~ attraction.

6) They absorb water molecules and this water determines the physical and chemical properties.

7) They possess brownian movement when viewed under the microscope.

8) Soil colloids swells or shrinks. Example of soil with this property is smectites, vertisols and vermiculites.

Types of soil colloids

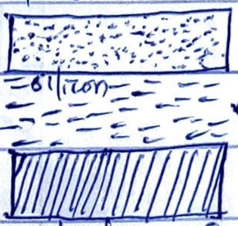
There are four major types of soil colloids namely; (1) Layer silicate clays
(2) Iron & Aluminium oxide (sesquioxide)
(3) Allophane & Amorphous clays.
(4) Humus.

(1), (2) and (3) are Inorganic soil colloids, while (4) is an organic colloid.

Layer silicate clays – These are the most important silicate clays and are called phyllo silicate because of their leaf-like or plate like structure. They are made of two horizontal sheets - one is dominated by silicon and the other is dominated by aluminium or magnesium. The one dominated by silica is called **silica tetrahedron** while the other dominated by aluminium or magnesium is called **alumina octahedron**. The following are the different types of silicate clays;

1) 1:1 type-clay mineral
2) 2:1 type-clay mineral.
3) 2:1:1 type-clay mineral.

Example of 1:1 type clay mineral are;
– Kaolinites which includes hallosites, nacrites and dickites.

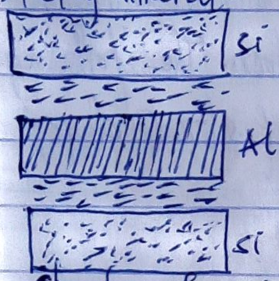


The gap is held by H_2 bond and so no H_2O can enter because the clay is hard and cannot break.

Structure of 1:1 clay mineral.

Example of 2:1 type clay mineral are;
– This type of minerals are the expanding type and examples are; Smectite and Vermiculites. Apart from these two expanding type, we have; non-expanding types of 2:1 clay minerals which are mica and illites. Unlike 1:1 clay mineral the expanding type of 2:1 swells and cracks when

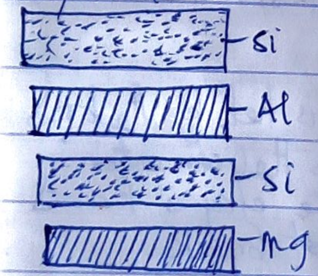
west and dry respectively. This is because water enters in between gaps of layers. A typical member of 2:1 clay mineral is a clay mineral called **montmorilonites**. The non expanding clay type mineral do not swell or crack but are not as strong as 1:1 clay minerals.



They are held together vanderwal forces which are heavy and water breaks in.

structure of 2:1 clay mineral.

Example of 2:1:1 clay mineral which includes; chlorites.



Iron and Aluminium Oxide clay

These types of clay are called **Sesquioxide**. They are the mix up of aluminium hydroxide, iron oxides and iron hydroxides.

Examples of iron and aluminium oxide clay. Gibbing and geothites

Allophane and amorphous

These are clay minerals which are formed from volcanic ashes which are allophane. They have high cation and anion exchange capacity. They are very reactive which under oxidation and reduction process.

Humus (Organic Colloids).

Humus is amorphous dark brown to black nearly insoluble in water but most soluble in dilute alkali (sodium hydroxide or potassium hydroxide solution). It is a product left after decomposition of plant animal remains.

The humus is often considered as organic colloids because it consists of various chains and loops of linked carbon atoms.

Humus consists of H, C and O unlike other colloids that are made up of Si, Al or Mg

Soil Organic Matter (SOM)

SOM consists of partially disintegrated and decomposed plant and animal residue and other organic compound synthesized by soil micro organism upon decay.

Sources of SOM; - Plant root / plant biomass
- Soil organisms.
- Waste product of animals and remains of plants after completing life cycle

Factors affecting soil organism / organic matter

- **Climatic conditions**; SOM decomposition varies in variation in temperature and rainfall. Warmer climate increases soil organic matter decomposition than cooler regions. Increase in rainfall increase SOM in soil than dry seasons.
- **Nature of vegetation**; soil organic matter is higher in soils developed under grassland than those under forest land (Reason); the higher the grasses decompose, the more the organic matter.
- **Drainage**; poorly drained soils usually are low organic matter than well drained soils (Reason? Read up).
- **Texture**; Fine texture soils generally are higher organic matter than coarsed texture soil (Reason?)
- **Cropping and tillage**; Crop lands have lower organic matter than virgin soils. Also, conservational tillage have higher SOM than conventional tillage (Reason?)

Decomposition of Soil Organic Matter.

This starts by the action of soil organisms such as worms, microbes, insects under favourable soil conditions. i.e H_2O or air is present. Some components of SOM are decomposed very fast while others decompose slowly e.g sugar, starch and simple protein decomposes fast while lignin fats, waxes, resins, cellulose and crude protein do not decompose fast. During decomposition of SOM, some biochemical reaction such as ammonification, nitrification and denitrification occurs. The transformation of organic nitrogenous compound into ammonia is called ammonification. The conversion of ammonia to nitrides (NO_2) and then to nitrate is called nitrification

$$NH_3 \xrightarrow[\text{Bacteria}]{\text{Nitrosomonas}} NO_2 \xrightarrow[\text{Bacteria}]{\text{Nitrobacter}} NO_3$$

The conversion of SOM nitrate into gaseous nitrogen or nitrous oxide is called denitrification. In decomposition of protein, the conversion of protein to amino acids is called aminization.

Factors affecting decomposition of SOM

- Temperature
- Soil moisture
- Lack of nutrients (Nitrogen)
- Soil pH
- Soil texture.

Functions of SOM

- Organic matter creates granular conditions of soil which increases soil H_2O p^H and aeration
- It increases the water holding capacity of the soil and reduces erosion and run off
- It reduces wind erosion and lowers soil temp
- It serves as a source of energy or food to soil micro organism
- Organic matter reduces soil acidity and improves soil alkalinity
- Organic matter acts as a store house for exchangeable and available cations
- It serves as a buffering agent which checks rapid chemical changes in p^H and soil reactions

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* Soil is an unconsolidated mineral matter of the earth surface

Functions of soil; - source of food (esophagi)
- It acts as a recycler of nutrients
- Soil supports growth of plants
- Habitat for organism
- Used for engineering purposes

Factors of soil formation
- Temperature Time
- Parent materials
- Biotic factors
- Climate
- Topography

Soil texture; This is the relative proportion of sand, silt and clay in the soil

ped; This is the smallest particle of a soil when it occurs in groups, its called polypedons

Soil texture is determined by particle size analysis

Textural triangle; - Sand is gritty
- clay is soft & smooth
- Silt is floury

Very coarse sand:- 2 - 1mm
Coarse sand:- 1 - 0.1mm
Medium sand:- 0.5 - 0.2mm
Fine sand:- 0.25 - 0.1mm
Very fine sand:- 0.1 - 0.5mm
Silt:- 0.05 - 0.002mm
Clay:- less than 0.002mm

Soil texture affects the following
- Porosity
- plant available water
* clay soil retains water and does not dry fa[st]
* Sandy soil absorbs water

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Soil structure: This is the arrangement of soil in aggregate or peds. Soil structure diagram

Soil structure

Shape	Grade of structure	Class
- Platy	- Structureless	- Very fine
- Blocky	- Weak	- Fine
- Prismatic	- Moderate	- Medium
- Granular	- Strong	- Coarse
- Structureless		- Very coarse

Formation of soil structure:

1) Freezing and thawing
2) Wetting and drying
3) Root pressure
4) Micro organism
5) Cementing agents e.g organic matter, clay, sesquioxide (oxide of aluminium & Iron).

Importance of soil structure:

- It increases infiltration of water through thereby reducing run-off and erosion
- Increases seed emergence
- Improves root growth
- Improves soil porosity

Munsell's colour chart contains hue, value and chroma. Hue is the dominant spectacular colour of the soil. Value is the degree of darkness or brightness of the soil. Chroma is relative intensity purity of the soil.

20/08/18

Soil pores are holes or bores in the soil. are important because air and water moves through them. Bulk density is the oven dry we of the given soil to the volume of the soil.

$$\text{Bulk density} = \frac{\text{Mass of soil}}{\text{vol of soil sample}}$$

Volume is that of a core sampler ($\pi r^2 h$)

Assuming the weight of the soil is 25g an the volume is 98.5cm³

$$B.D = \frac{25}{98.5} = 0.25 g/cm^3$$

Standard volume of the core sampler is 2.625

A standard soil bulk density ranges from 1- 1.8g/cm³. Soil density of 0.6–0.8 is not go for agricultural purposes due to wide pores

$$\text{Total porosity} = 1 - \frac{\text{bulk density}}{\text{Particle density}}$$

$B.D = 1.3$ and $1.6 g/cm^3$, $Pd = 2.654$

$$\text{Total } P = 1 - \frac{1.3}{2.654} = 0.51$$

* the higher the pore space, the lower the B.D.

Factors affecting Bulk Density
- Types of mineral present
- Texture of the soil
- Amount of organic matter

Soil permeability - This is the speed of movement of water and air in the soil. It is affected by:
- Soil structure.
- Soil texture.
- Drainage
- Pore sizes
- Root and worm channels
- Organic matters

Soil consistency - It is described as the resistance of the soil to mechanical stress or manipulation under different moisture content