

The Essentials of Soil Science in Environmental Science

Sailaja P

Research Scholar, Lovely Professional University

Email: tenalisailaja@yahoo.com

Abstract:

In order to survive, soil plays a crucial role as our mother. The soil is a natural resource that forms over long periods of time. All food on the planet is derived from soil, which is the planet's foundational resource. As 70% of the earth is covered by water, 30% is covered by land. The soil is the limited resource on earth that provides all of our food. Today people has to attempt to understand nature's limitations as environmental science awareness is becoming an increasingly global issue. To keep the agricultural sector healthy, soil must be treated and managed carefully. Soil is essential to the survival of most living things on earth, as it contains all the nutrients that are needed for their growth. Humans, birds, and animals all depend on soil to survive. Approximately 45% of the soil surface consists of minerals, 5% organic matter, 20% to 30% gases, and 20% to 30% water. In this paper, the soil formation, chemical elements properties of soil, and chemical reactions in soil are provided. This is a theoretical paper that provides essential information on soil science in environmental science. Any soil science researcher will benefit from reading this paper.

Keywords: Banana pulp, Ohmic heating, Conventional heating, Chemical preservatives, Physiochemical properties, Shelf life studies.

I. INTRODUCTION

Our solar system's planets can be divided into three groups based on their density, size and chemical nature. The very first group includes the huge and low density "gas giants" that are Jupiter and Saturn. Mercury, Venus, Earth, Moon, and Mars, as well as asteroids and satellites, are included in the second group of medium-sized, highly denser "rocky" planets. The 'icy' giants Uranus and Neptune are in the final group. Even though Pluto is only the size of Neptune's satellite "Triton", it is considered a planet [1].

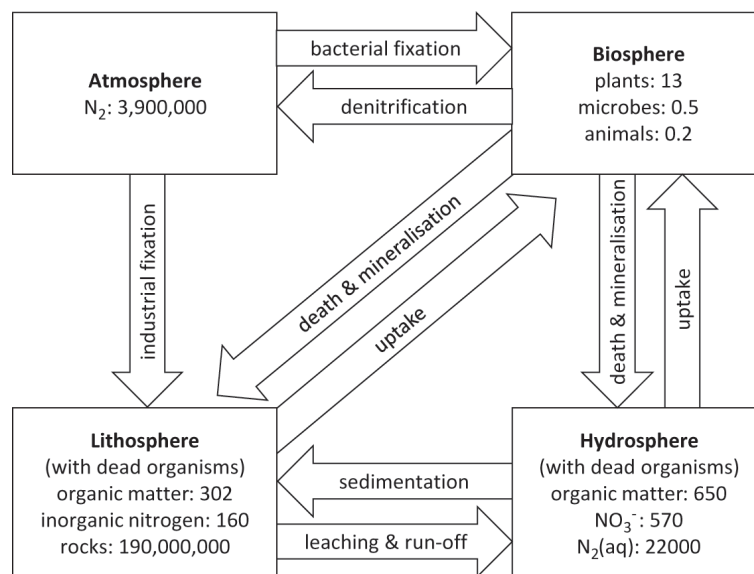
There are four segments to the Earth's environment, which we cannot fully comprehend because it is too large and very complex:

Atmosphere: Around the earth, the atmosphere consists of a protective blanket of the gases. The atmosphere contains nitrogen and oxygen, as well as argon, carbon dioxide, and trace gases. The atmosphere is what sustains life on earth. It protects it from unfriendly environment of the outer space. It absorbs a large amount of cosmic rays and electromagnetic radiation which is coming from the Sun. Only visible, ultraviolet, radio waves and near infrared (300 to 2500 nm) are transmitted here.

Hydrosphere: It contains all kinds of water resources, such as oceans, lakes, seas, rivers, reservoirs, streams, glaciers, polar icecaps and groundwater. Oceans make up 97% of Earth's water supply. About 1% of the water resources are available as fresh surface water which includes rivers, streams, lakes and groundwater suitable for human drinking and other uses. Only 2% of the earth's water supply is trapped in glaciers and polar icecaps.

Lithosphere: It is the outer mantle of the solid earth. It is made up of minerals and organic material that occur in the crust and the soil of the earth.

Biosphere: Living organisms and their interactions with the environment are described as the biosphere, which consists of the atmosphere, lithosphere and hydrosphere. The biosphere is sustained by microorganisms that maintain a chemical balance between metabolic waste yields and nutrients. They also contribute to the preservation of the natural environment because of their important role in soil elemental cycles.



Approximately 70% of the earth is covered by water, while 30% is covered by land. As the earth's outermost layer is thin layer, soil is primarily composed of organic materials, mineral particles, water, air and living organisms which act together slowly but constantly. The soil is the limited resource on the earth for all of our food. To ensure the health of the agricultural sector, soil must be cared and managed carefully. Almost all living things on land depend on soil for their survival, as it contains the nutrients they need to grow. Humans, birds, and animals all rely on soil for their survival. In order to ensure the sustainability of our food system, it is necessary to understand and manage soil properly. This will avoid damaging one of the most precious resource of the environment and as well able to maintain the quality of our air and water.

II. WHAT IS THE PROCESS OF SOIL FORMATION?

There is a complex assembly of gases, liquids and solids in a typical soil and this ideal for plants growth. This soil surface represents about 45% minerals and 5% organic matter, gases (air) about 20% to 30% and remaining is water i.e., 20% to 30%.

Anyway, water and gases percentage can change quickly and it is relying on weather situations and other factors in the environment [2]. As a result of weathering, rocks break down to form soil particles over a period of millions of years. There are three types of weathering: physical, chemical and biological. A variety of factors contribute to the weathering process, such as heat, water, cold, rain and wind as well as microbes, rodents and insects. Tree roots also play a role in weathering. Interactions among these factors result in an infinite variety of soils on earth's surface. These processes can be very slow, requiring many tens of thousands of years to complete. In the soil formation, there are five main factors that interact with each other. They are parent material, weathering, living organisms, topography and time.

Parent material: Mostly weathered rock makes up soil. It might be igneous rock or sedimentary rock. Its type depends on its parent material. If granite rocks are weathered, they become sand. Granite contains quartz, which is a silicate mineral that is resistant to weathering.

Exchangeable cations: Ca^{2+} , Mg^{2+} , Na^+ , K^+ , NH_4^+ , Al^{3+}

Soluble anions: NO_3^- , SO_4^{2-} , Cl^- , H_2CO_3 , HCO_3^- , SeO_4^{2-}

Poorly soluble anions: H_2PO_4^- , HPO_4^{2-} , H_3BO_3 , H_4BO_4^- , $\text{Si}(\text{OH})_4$, MoO_4^{2-} , HSeO_3^-

Poorly soluble metal cations: Al^{3+} , Fe^{3+} , Mn^{4+} , Mn^{2+} , Cu^{2+} , Zn^{2+} , Ni^{2+} , Co^{2+}

Toxic ions: Al^{3+} , H_3AsO_4 , H_3AsO_3 , Cd^{2+} , CrO_4^{2-} , Hg^{2+} , Pb^{2+}

Biogeochemical cycling elements: C, N, O, S

Weathering:- The rocks may break down into smaller pieces as a result of physical weathering without experiencing any changes to its molecular structure. Physical weathering is influenced by air and water. The natural breakdown of rock into sediments, which eventually turn into soil, this natural process can be done by windblown rock particles, torrential rain, and sea waves.

Rocks can also break down due to frost or temperature changes when rocks collide with each other. Chemical weathering involves the change in mineral composition caused by chemical reactions within rocks. An example of chemical weathering is hydrolysis, oxidation, carbonation and hydration, which lead to changes in the mineral composition of rocks. It occurs when minerals in rocks react with air, water or other chemicals, causing them to break down. Rain water leaches through hydrogen ions (H^+) and rocks, that react with ions of metal in the rocks to dissolve rock minerals. For example, during carbonation, CO_2 from the air it dissolves in water to produce H_2CO_3 (carbonic acid). Consequently, water in the rocks is acidified, causing more chemical reactions with the rock minerals. Iron in rocks is reacted with oxygen in the air to generate iron oxide, which gives rusty brown color materials. Biological weathering occurs when living organisms break down rock minerals. Rock fragmentation is the result of biological weathering. Mosses grow and tree roots enter rocks and create pores that gradually pull rocks apart. Also water and air can enter rock through burrowing animals and plant roots can grow into cracks, causing the rock to split.

Living organisms: The formation of soil is heavily influenced by living organisms. Humus, which is created when soil bacteria dissolve dead plant material and fallen leaves, is typically common in areas with high vegetation. Wax and fats are left in the soil after microbes consume the carbohydrates and sugars in organic matter. This is where humus comes from.

Topography: The shape of a land's surface area is referred to as the topography of that location. Sloped land becomes more vulnerable to erosion by wind and water, resulting in rock sediments moving downward and mineral washing downward into valleys. The soils mostly in valleys of these areas are richer in organic matter and darker, making them more beneficial for plant growth, whereas the soils on the hillsides are thicker, more eroded, and unsuitable.

Time: There are many factors that influence soil formation, but time is the most important. In areas where weathering conditions are favorable, such as climatic conditions, topography, or biology, soil formation is more rapid. Time also shows how long various soil-forming components have really been present. The mineral contents remain high in regions with young parent material because it hasn't undergone much weathering. Additionally, soils with old parent material that has undergone more severe weathering will have less minerals.

III. THE PROPERTIES OF SOIL CHEMICAL ELEMENTS

The Earth's crust contains only a few elements: oxygen, silicon, iron, aluminum, calcium, magnesium, sodium, and potassium. Minerals in Earth's crust consist mainly of oxygen atoms, which constitutes the majority by volume. The elements of primary concern in soil chemistry exhibit a wide range of chemical behavior, resulting in a wide range of mobility and bioavailability [3]. According to their general chemical characteristics and soil reactivity,

elements of common interest are grouped (give below) together in order to gain a better understanding of soil chemistry.

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Toxic ions: Al^{3+} , H_3AsO_4 , H_3AsO_3 , Cd^{2+} , CrO_4^{2-} , Hg^{2+} , Pb^{2+}

Biogeochemical cycling elements: C, N, O, S

Minerals and organic matter in soil have a negative charge that retains exchangeable cations. Anions that are poorly soluble are normally present in soil solutions at relatively low concentrations and are commonly found as minerals, salts, or sorbed to minerals. Typical soil solutions contain far lower concentrations of metal cations that are poorly soluble (such as transition metals), compared to alkali and alkaline earth cations. The soil contains a high concentration of toxic ions, including aluminum, which is highly toxic to plants in acidic soils. Nitrogen, Carbon, and sulfur are major biogeochemical cycling elements, which are heavily influenced by biological processes.

In summary, exchangeable cations are easily manipulated with irrigation, liming or acidifications. Soluble anions are present in the lower concentrations. Poorly soluble anions are strongly retainable by soils, phosphate is more soluble at neutral or slightly acid pH. Poorly soluble metals availability increases along with the increasing of soil acidity. Toxic ions are not soluble readily.

Moreover, nitrogen, sulfur and carbon are categorized because

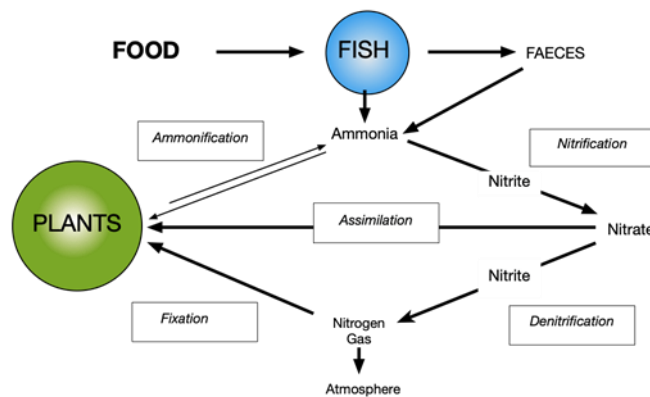
- They undergo rapid geochemical cycles in which the atmosphere is involved
- The oxidation state of these compounds changes cyclically and rapidly in soils and environment;
- A change in the oxidation state provides biological energy
- The processes of nitrogen, sulfur and carbon in soils have some common features, but they are not comparable.

In the nitrogen, carbon and sulfur cycle, oxidation and reduction are the most important chemical reactions.

Element	Example species of oxidation states*	Common occurrences in soil
Carbon	CH ₄ , glucose, CO, R-carboxyl, CO ₂	Soil organic matter, biota, calcite
Nitrogen	NH ₄ ⁺ , N ₂ , N ₂ O, NO ₂ ⁻ , NO ₃ ⁻	Adsorbed-NH ₄ ⁺ , proteins, DNA, N ₂ , nitrate
Sulfur	S ²⁻ , S, SO ₃ ²⁻ or SO ₂ , SO ₄ ²⁻	Sulfate, H ₂ S gas, metal sulfides, thiols, gypsum (CaSO ₄), sulfate in soil solution

As in temperate and humid regions, organic compounds constitute the majority of carbon, nitrogen, and sulfur in soil, resulting a mass ratio of C/N/S is about 100/10/1. Aridity increases the quantity of carbonate, sulphate, and nitrate anions in the soil solution when decreasing the amount of the organic matter in the soil [4]. Chemical and physical properties of elements change when their oxidation state changes. Several redox reactions produce volatile compounds (CH₄, CO₂, N₂O, NH₃, N₂, SO₂, H₂O, etc.) in the soil and atmosphere. As a result of their active movement between solid, solution, and gas states; carbon, nitrogen, and sulfur exhibit complex behavior compared to many other elements. Inorganic carbon can be found in soils through the dissolution of carbon dioxide gas into water, which produces carbonic acid.

For optimal plant yield, nitrogen is the most important substance after water. There are several species that contain nitrogen, and it has a challenging biochemical process in nature. Due to this, soil nitrogen has been extensively investigated for centuries, and it continues to be the most researched element in terms of soil chemistry, soil microbiology and soil fertility.

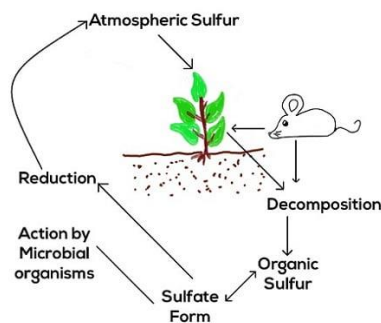


There are five general nitrogen cycle reactions in soil:

- Incorporation of nitrogen gas into soil (N₂-fixation)
- Conversion of ammonium to nitrate (nitrification)
- Conversion of nitrate to N-gases (denitrification)
- Nitrogen is consumed and converted to organic nitrogen by plants and microbes in the form of nitrate and ammonia (assimilation and immobilization).

- Organic nitrogen can be converted by organisms into inorganic nitrogen (ammonification or mineralization)

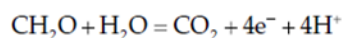
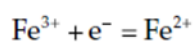
The sulfur cycle is very active, with reactions mediated by microorganisms, abiotic agents, animals and plants. An aerobic soil's stable oxidation state is sulfate, while an anaerobic soil's stable oxidation state is sulfide. Sulfur changes its oxidation state through microbial catalysis more readily than nitrogen or carbon. As an amendment, sulfur is sometimes added to soils. Elemental sulfur is rarely found naturally in soils. As a result of mining waste, wetlands and soils commonly contain sulfides. Sulfides oxidize to H_2SO_4 when exposed to oxygen. Acidity may persist until all sulfides are leached from soil.



IV. THE SOIL'S CHEMICAL REACTIONS

Introduction:-

A soil's chemical resistance is impressive, and it is a stabilizing influence on the three other compartments of the environment, the atmosphere, the hydrosphere, and the hyposphere. The hydrosphere, atmosphere, and biosphere are often affected by human activities by bypassing soil. Among all environmental compartments, the soil is the most robust. It is important to treat solid, liquid, and gaseous wastes in soil before releasing them into the hydrosphere or atmosphere, since soil is a source of most human waste. It is the largest reservoir of most essential elements. There are two branches of soil chemistry: inorganic chemistry and organic chemistry. Soil chemistry is closely related to geochemistry, colloid chemistry, soil mineralogy, soil fertility, and soil microbiology. It is important to emphasize that soil chemistry plays a role in both biological and inorganic processes, but it has traditionally been oriented primarily toward inorganic processes. Soil chemistry is also crucial to soil's non-agricultural applications [5].



Soil Solution:-

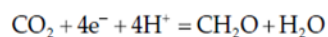
As a result of interactions with soil particles, roots, gases and microbes, soil water is an aqueous solution that lives in the pores of the soil. As a result of dissolved soil particles (solutes), water (bulk solution) is readily available for plant uptake in saturated soils or near saturated soils. Soil chemistry is primarily concerned with the soil solution, an aqueous solution between roots and soil microbes and how it reacts with the solid phase and between it. Most soil reactions occur at the soil solution, which is the interface between soil and other active environmental compartments such as the atmosphere, hydrosphere, and biosphere. Soil solution is electrically neutral, but usually contains more cations than the anions in comparison to other aqueous solutions. Plants require a variety of elements for growth, including solutes, electrolytes, and nonelectrolytes. All terrestrial organisms obtain their mineral nutrients from the soil solution. Both aqueous and solid solutions are involved in soil chemistry [6]. In both soil and water minerals, ions are dominating by O_2^- ions, which is the same as in soil solutions. A mineral's charge is countered by many other cations, whereas the charge of water, an oxide is neutralized by H^+ . Unlike O_2 , water reacts only weakly with cations. A soil solution's solute composition is determined by the competition between oxide groups in soil solids and H^+ , H_2O and OH^- in the soil solution.

Redox Reactions:-

Oxidation is the loss or donation of electrons by an element. Reduction is the gain or acceptance of electrons. For example, when Fe^{3+} is reduced to Fe^{2+} , the reaction is an oxidation reaction.

Here e^- represents free electron. Above mentioned reaction is simply half of a total reaction because it doesn't indicate where the electron is coming from. While half-reactions imply the existence of free electrons, an electron always connected with the atom and is immediately transported between molecules or ions instead of existing as a theoretical concept as suggested by half-reactions. As a result, in order to decrease one substance, another must be oxidised.

It is common for natural processes to involve reduction and oxidation in order to produce and utilize energy. Often, reduction reactions occur in wetlands or wherever limited oxygen in environment or in soils where microbial respiration is high and gas permeability is low. By capturing energy from the sun, chloroplasts in plants reduce CO_2 by fixing it into biological carbon compound.

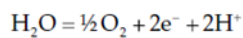
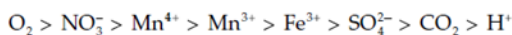


In order to complete the carbon cycle, animals, plants and microbes oxidize reduced carbon compounds and thereby release CO_2 and electrons needed to form ATP (Adenosine Triphosphate).

Element	Oxidation states	
	Most reduced	Most oxidized
Oxygen	2-	0
Nitrogen	3-	5+
Carbon	4-	4+
Sulfur	2-	6+
Iron	2+	3+
Manganese	2+	4+
Arsenic	3+	5+
Selenium	2-	6+
Mercury	0	2+
Chromium	2+	6+

There must be electron acceptors available in organic compounds in order for them to provide energy, and thus sustain life. In the absence of oxygen, soil microorganisms oxidize nitrogen, sulfur, iron, manganese, and other elements. In general, other elements are ranked based on the amount of energy produced.

The stability of water limits the range of redox potentials in soil. Water oxidized by high redox potentials produces oxygen.



It is possible to find nitrogen in multiple states within soil, including gaseous, liquid, and solid states. Ammonium adsorbs on mineral surfaces, organic nitrogen compounds (e.g., proteins), amine functional groups in soil organic matter, and nitrate salts in arid soils are some solid nitrogen species. The control of nitrogen species relies on redox reactions [7].

Common soil minerals:-

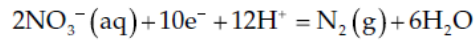
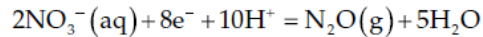
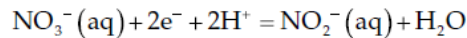
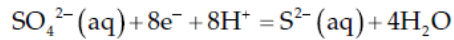
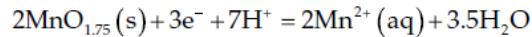
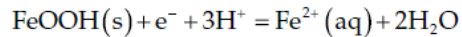
Solid–solution interfaces are the most reactive parts of soils, and they influence the amount and composition of nutrients and contaminants available in soil solution. As a result of composition and properties of the solids, the reactivity of the solid surface is highly variable. Organic solids are also very important for solid-solution interactions in soils.

The inorganic soil particles vary in size from colloidal (<2 μm) to gravel and rocks (>2 mm) and are made up of minerals, salts, and amorphous solids. Soil particles, such as sand and silt, are formed by physical breaking down of igneous and metamorphic rocks, resulting in primary minerals (minerals derived from melting). A soil's clay fraction is mainly composed of secondary minerals formed by weathering reactions at low temperatures [8].

A mineral is classified based on its chemical and structural characteristics. An anion group is one method of categorizing minerals into classes. Soil mineral classes include silicates, oxides, and carbonates, but phosphates, borates, chlorides, sulfates, and sulfides are less abundant. It is possible to categorize minerals according to their structural similarities. An atom can combine with another to form a mineral, but when they do, they form bonds between them that change the distribution of electrons. There are different types of bonds based on the electronic structure of the atoms combined. In the case of Si-O bond in the silicates 51% is ionic and 49% is covalent.

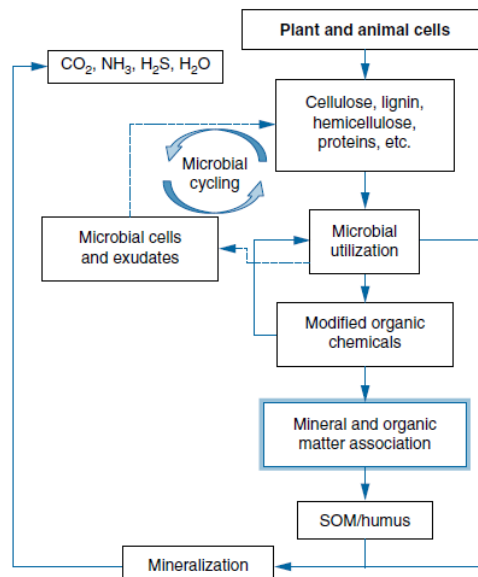
Carbonates accumulate in soils when there is little rainfall, especially CaCO_3 . Water flows downward through the soil profile will only remove weathering products that are highly soluble, such as Na^+ salts, where evapotranspiration exceeds precipitation. Although phosphorus is a minor constituent of soils, understanding the mineral phases of phosphorus in soils is important due to its importance to plant nutrition and surface water quality [9]. There are several phosphate minerals found in soil that limit its availability in the environment, but orthophosphate is the primary phosphorus molecule present in the environment, and it strongly adsorbs to mineral surfaces. In soils, calcium phosphate mineral formation and dissolution are influenced by organic matter, pH, ion composition, temperature, ionic strength and adsorbents.

As an inorganic component of soils, sulfur exists as sulfide and sulfate. Sulfate is a divalent compound containing S_6^+ in tetrahedral oxygen coordination. Hydrogen sulfide gas, and metal sulfide compounds are formed by S_2^- ions. Sulfate is the stable form of sulfur in oxidized soils (SO_4^{2-}). As the two most common iron oxides in soil, hematite (Fe_2O_3) and goethite (FeOOH), both occur in high weathered soils. Hematite is from pink to bright red in color, while goethite color is yellow to a dark yellowish brown. It is commonly found in soil and clay sediments that titanium oxides have the mineral formulas TiO_2 . When the water fluctuates, manganese oxides form concretions and nodules in soils. They are naturally poorly crystalline mixtures of Mn(IV) and Mn(III) [13]. The manganese oxide found in soils typically occurs as coatings or as fine poorly crystalline nanoparticles (along with iron oxides).



Organic Matter in Soil:-

Soil microbial activity that degrades soil organic matter and plant species are all affected by climate. The soils in forests and grasslands contain more SOM than soils in deserts and semi-deserts, which contain very little. Compared to soils on south-facing slopes, north-facing slopes have moister, cooler temperature and are higher in organic matter. In addition to slowing microbial activity, low temperatures enhance SOM accumulation. A higher temperature leads to a higher rate of organic carbon along with more degradation. The molecular properties of SOM are determined by the types of organic chemicals present in it.



Microbes and plant roots are important sources of SOM compounds, which are formed as a result of degradation and reaction of plant matter. Nitrogen and sulfur are reduced (fixation) using carbon, which provides the energy as well as the matrix to incorporate nitrogen and sulfur into compounds. In turn, nitrogen and sulfur are amongst the elements that regulate plant growth and photosynthesis. Under natural conditions, the C/N/S ratio of SOM remains relatively constant due to the interdependence of these nutrients.

Plants and microbes create organic nitrogen compounds from soil solution. Organic nitrogen compounds are an important nutrient source for soil and can come from plant debris, root exudates, microbial cells, or microbial exudates. Some of the organic nitrogen compounds degrade and complex with minerals via electrostatic interactions, such as cation associations with clay minerals, or interaction with mineral surfaces. In order to prevent degradation and mineralization of organic nitrogen compounds, they can be associated with minerals [10]. Microbes will mineralize organic nitrogen to form ammonium, nitrate, or nitrogen gas, which is absorbed by plants and microbes, or lost to the soil.

The aeration capacity, permeability of soils and water holding capacity are improved by SOM. Pesticide adsorption by SOM greatly influences their performance in soils, including effectiveness against targets, phytotoxicity, leachability, volatility, and biodegradability. A major area of soil chemistry research involves the behavior of organic chemicals. The organic matter in soils absorbs a large amount of water, up to 80–90% of its weight. In addition to holding water, micropores within organic-mineral aggregates increase soil water that is available to plants. One of the major advantages of organic matter additions is the ability to retain water.

Nanoparticles in soils:-

A nanoparticle is an organic or inorganic particle that has a dimension less than 100 nm. It is distinguished from larger particles due to the unique surface characteristics compared to molecules or atoms of the same composition. A variety of nanoparticles are found in soil, including minerals like nanoball allophane, as well as organic macromolecules such as root exudates and microbes. It is not all clay particles that are nanoparticles, but nanoparticles are clay particles. Clay minerals naturally occurring in nature are nanoparticles, for example, montmorillonite. In nature, nanoparticles are found in soils, lakes, rivers, and the atmosphere. Very small particles possess unique surface properties when compared with larger particles with the same composition. Increasing use of engineered nanoparticles in products raises concerns about their effects on the environment. For example, researchers are researching whether nanoparticles taken up by plant tissues or absorbed by animals can negatively impact them.

There are many nanoparticles in soil. For example, iron oxide nanoparticles are often found in soil grains, such as sand and silt. It is critical to understand and predict soil and ecosystem processes by understanding the behavior of nanoparticles, including engineered nanoparticles, given their unique reactivity and abundance, and this is an area of active research.

Adsorption Process in Soils:-

It is one of the most important soil processes as it describes the behavior of chemicals with soil solids. Sorption is the removal of chemicals from aqueous solutions through partitioning onto mineral surfaces or soil organic matter. A desorption reaction is the opposite of sorption - releasing a chemical from a solid into solution. As soil particles maintain a distribution between

their solid surfaces and solutions, they facilitate the regulation of chemical concentrations in soil pore water, allowing plants, microorganisms, and animals to utilize the chemicals.

The majority of chemical uptake in soil comes from adsorption reactions. Adsorption reactions can be divided into two types.

Outer - sphere adsorption. At least one water molecule remains between a chemical and its surface. There are adsorbed ions located on mineral surfaces, but the ions do not form direct chemical bonds with the surface functional groups. Instead, they maintain a separate hydration sphere. A large number of plant nutrients are held electrostatically in the outer sphere of soil, including Ca^{2+} , Mg^{2+} , Na^+ , NO_3^- , K^+ .

Inner - sphere adsorption. There is a direct ionic or covalent bond between the chemical and the mineral surface. Adsorption occurs between chemicals and a mineral or soil organic matter surface through the formation of covalent bonds. Transition metal cations, Al^{3+} , Be^{2+} , Pb^{2+} , lanthanides, actinides, and oxyanions such as borate, phosphate, arsenate, and selenite form innersphere bonds with the functional groups found on aluminosilicate edges and oxides, as well as soil organic matter.

Adsorption of ions onto soil surfaces is a major focus of soil chemistry. Desorption reactions, on the other hand, are just as important to the availability of chemicals as adsorption reactions [11]. Chemicals bonded to solid surfaces are released into soil solutions during desorption reactions. In this regard, desorption reactions are very similar to dissolution reactions. However, desorption reactions usually occur much more quickly than dissolution reactions, so they are often responsible for maintaining soil solution chemical concentrations. In the case of plant roots absorbing ions from soil solution or leaching out of soil profile, adsorbed ions will desorb to maintain equilibrium between the solid and solution. Desorption is facilitated by exchange reactions between protons and hydroxides released by plants.

As part of soil chemistry, cation adsorption has historically been emphasized over anion adsorption. A soil is characterized by exchangeable cations (salt solutions contain dissolved ions) when they undergo a salt solution. Anions can also exchange with soils in a salt solution, and permanent charge soils tend to have mineral charges that are generally negative, so cations tend to interchange more often than anions. $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+ > \text{Na}^+$ are the most exchangeable cations, in decreasing order. Plant productivity is heavily dependent on exchangeable cations and soil solution salts, which can be controlled by irrigation, liming, fertilization and leaching. In soil chemistry, cation exchange is therefore very important. Based on the anions' characteristics, the mineral composition of soil, and the pH of the soil, anions adsorb differently. Anions adsorb on positively charged mineral surfaces by electrostatic adsorption, forming chemical bonds with surface functional groups. Agriculture is concerned about Cl^- , HCO_3^- , H_3SiO_4^- , NO_3^- , H_2PO_4^- , SO_4^{2-} , HPO_4^{2-} , OH^- , $\text{B}(\text{OH})_4^-$ and F^- .

There are many important soil processes, including adsorption and desorption on soil particle surfaces. Mineralogy, solid surface area, organic matter and pH levels influence these processes. In soil solids with charged surfaces, such as clay minerals, oxides, and soil organic matter, electrostatic surface potential is created between ions and the surface [12]. Clay soils with a large amount of permanent charge have a high cation exchange capacity (CEC). Cation and anion adsorption reactions i.e., particularly outer sphere exchange reactions are controlled by the electrostatic potential in soils. At low pH, oxide minerals favor anion adsorption, while at high pH, they favor cation adsorption; therefore, adsorption and exchange capacity vary with pH.

Soil Acidity:-

A farmer has known for centuries that crushed seashells or powdered limestone can neutralize soil acids. There are species that react with soil acidification by contributing protons to the solution when it is titrated, which means that the soil neutralizes bases added to it as a result of soil acidification. In the context of soil acidification, protons can be directly produced, as well as exchangeable acids can be produced. Among the causes for exchangeable acidity in soil is leaching of base cations (Ca^{2+} , K^+ , Mg^{2+} , Na^+) and weathering of minerals [14] which enriches exchangeable Al^{3+} in the soil and causes it to become acidic.

The process of acidification occurs when soils are acidified or depleted of bases. Acidification is caused by several processes in soils. These processes include natural processes (for example, weathering and leaching) and human-induced processes (fertilization and harvesting). There are many sources of soil acidification, including natural and anthropogenic H_2SO_4 , HNO_3 , and other organic compounds. Soil acidification can include changes in the biogeochemical cycling of carbon, nitrogen, or sulfur, depending on whose concentration or species has changed.

As soil acidity changes, nutrient availability may increase or decrease, which may influence plant growth. Although there are no generalizations regarding pH and plant growth, some generalizations must be made. The plants that can utilize ammonium forms of nitrogen in acid soils have a significant advantage because nitrogen nitrification occurs slowly below pH 5.5. Since organic nitrogen can be mineralized into ammonia more easily than nitrate by microorganisms, ammonium ions may accumulate in acid forest soils.

V. CONCLUSION

Approximately 70% of the earth is covered by water, while 30% is covered by land. As the earth's outermost layer is thin layer, soil is primarily composed of organic materials, mineral particles, water, air and living organisms which act together slowly but constantly. The soil is the limited resource on the earth for all of our food. To ensure the health of the agricultural sector, soil must be cared and managed carefully. Almost all living things on land depend on soil for their survival, as it contains the nutrients they need to grow. Humans, birds, and animals all rely on soil for their survival. There are many factors that influence soil formation, but time

is the most important. In areas where weathering conditions are favorable, such as climatic conditions, topography, or biology, soil formation is more rapid. The Earth's crust contains only a few elements: oxygen, silicon, iron, aluminum, calcium, magnesium, sodium, and potassium. Minerals in Earth's crust consist mainly of oxygen atoms, which constitutes the majority by volume. It is important to treat solid, liquid, and gaseous wastes in soil before releasing them into the hydrosphere or atmosphere, since soil is a source of most human waste. It is the largest reservoir of most essential elements. This theoretical paper has provided essential information on soil science in environmental science. There are many nanoparticles in soil. It is critical to understand and predict soil and ecosystem processes by understanding the behavior of nanoparticles, including engineered nanoparticles, given their unique reactivity and abundance, and this is an area of active research.

Reference:

- Bowen, H.J.M. 1979. Environmental Chemistry of the Elements Academic Press, London; New York.
- Markert, B. 1992. Presence and Significance of Naturally-Occurring Chemical-Elements of the Periodic System in the Plant Organism and Consequences for Future Investigations on Inorganic Environmental Chemistry in Ecosystems. *Vegetatio* 103:1–30.
- Laird, B.D., D. Peak, and S.D. Siciliano. 2011. Bioaccessibility of metal cations in soil is linearly related to its water exchange rate constant. *Environmental Science & Technology* 45:4139–4144.
- Nightingale, E.R. 1959. Phenomenological theory of ion solvation – effective radii of hydrated ions. *Journal of Physical Chemistry* 63:1381–1387.
- Richens, D.T. 1997. *The Chemistry of Aqua Ions*. John Wiley and Sons, New York.
- Rodríguez Eugenio, N., M.J. McLaughlin, D.J. Pennock, Food, N. Agriculture Organization of the United, and P.Global Soil. 2018. Soil pollution: a hidden reality. Food and Agriculture Organization of the United Nations, Rome.
- Baas Becking, L.G.M., I.R. Kaplan, and D. Moore. 1960. Limits of the Natural Environment in Terms of pH and Oxidation-Reduction Potentials. *Journal of Geology* 68:243–284.
- Jorgensen, C.J., and B. Elberling. 2012. Effects of flooding-induced N₂O production, consumption and emission dynamics on the annual N₂O emission budget in wetland soil. *Soil Biology & Biochemistry* 53:9–17.

- McBride, M.B. 1994. Environmental Chemistry of Soils. Oxford University Press, New York.
- Wilson, M.J., L. Wilson, and I. Patey. 2014. The influence of individual clay minerals on formation damage of reservoir sandstones: a critical review with some new insights. Clay Minerals 49:147–164.
- Scharlemann, J.P.W., E.V.J. Tanner, R. Hiederer, and V. Kapos. 2014. Global soil carbon: understanding and managing the largest terrestrial carbon pool. Carbon Management 5:81–91.
- Bear, F.E. 1964. Chemistry of the Soil. 2nd ed. Reinhold Pub. Corp., New York.
- Hingston, F.J., J.P. Quirk, and A.M. Posner. 1972. Anion adsorption by goethite and gibbsite .1. Role of proton in determining adsorption envelopes. Journal of Soil Science 23:177–192.
- Osborne, L.R., L.L. Baker, and D.G. Strawn. 2015. Lead Immobilization and Phosphorus Availability in phosphate-amended, mine-contaminated soils. J Environ Qual 44:183–190.