Chapter 1

Soil, Earth and Environment

Asif Naeem, Muhammad Sabir, Saifullah and Sadia Bibi*

Abstract

The chapter "Soil, Earth and Environment" discusses soil as a natural medium for plant growth as well as explains its other functions including nutrient cycling, regulation of water and carbon dioxide supplies and a medium for landscaping. Approaches to the study of soil i.e., soil science and its branches, have been elaborated in detail. Elemental composition of Earth crust, types of rocks (igneous, metamorphic and sedimentary), their mineralogical composition and occurrence in Earth's crust have been described. The term "mineral" has been defined, and different minerals, their properties and their role in soil genesis have been described. Classification of minerals is based on their physical properties, like crystal structure and habit, hardness, luster, diaphaneity, color, streak, cleavage and fracture, and specific gravity. This chapter also describes the four spheres of Earth, namely atmosphere, lithosphere, hydrosphere and biosphere in terms of their properties and effects on environmental conditions. In addition to that, geology and its branches (physical geology, mineralogy, petrology, mining geology and hydrology), environment and its elements, and environmental science and its branches (ecology, atmospheric science, environmental chemistry, environmental engineering and geosciences) have been covered in detail.

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*Asif Naeem
Soil Science Division, Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan.
For correspondance: scoutuaf@gmail.com

Muhammad Sabir, Saifullah and Sadia Bibi
Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.

Managing editors: Iqrar Ahmad Khan and Muhammad Farooq
Editors: Muhammad Sabir, Javaid Akhtar and Khalid Rehman Hakeem
University of Agriculture, Faisalabad, Pakistan.

Keywords: Soil, Rocks and Soil Minerals, Geology, Spheres of Earth, Environmental Science.

1.1. Soil

In its traditional meaning, "soil" is the natural medium for plant growth, whether it has well defined layers, i.e., the soil horizons. This is the common meaning for the term "soil" and the greatest interest is aligned to it. Since soil supports plants that provide food and cater other human needs, filters water and recycles all sort of wastes, it is essential for life on earth. Excluding bare rocks, deep water, areas of everlasting frost, or the sterile ice of glaciers, soil covers the surface of Earth as a continuum. Soil, in this context is a natural body comprising of solids, liquid, and gases occurring on the surface of land and is characterized by the presence of one or both of following: i) horizons, that are discernible from the original material as a result of additions, losses and transformations of energy and matter; ii) the ability to support the rooted plants in a natural environment (Soil Survey Staff 1999). Thus, soil may be defined as "The unconsolidated mineral material on the immediate surface of the Earth that functions as a natural medium for plant growth on land surface". There are two approaches to study of soil: First approach considers soil as a natural body, weathered and synthesized product, while the other treats soil as a medium for growth of plants.

1.1.1. Pedological approach

Pedology (from Greek "pedon", means soil or Earth) is the study of origin, classification and description of soils as they occur in their natural environment. A pedologist examines and classifies soil as a natural body and does not emphasize on its practical use.

1.1.2. Edaphological approach

The properties of soil in relation to plant growth, reasons for variation in soil productivity and methods to improve soil productivity are studied in Edophology (from Greek word "edaphos", means soil or ground). Edaphologists are more practical and their ultimate goal is to study soils in relation to their production of food and fiber.

1.2. Functions of Soils

Soils perform many agricultural and non-agricultural functions in the global ecosystem which are described as follows:

1.2.1. Medium for plant growth

As an anchor for plant roots and as a water holding tank, soil provides a hospitable place for a plant to take root. Soil properties those affect plant growth include its texture (coarse or fine), aggregate size, pH, salt concentration, porosity, and water holding capacity. The ability to store and supply nutrients to plants is an important function of soil and is referred to as soil fertility. Soil fertility is influenced by the amount of clay and organic matter content in the soil. High clay and organic matter contents generally lead to a highly fertile soil.

1.2.2. Nutrient recycling

Being the major "switching yard", soil stores and regulates the transformation of plant nutrients and other elements in the ecosystem. A generalized explanation of nutrient cycling is shown in Fig. 1.1. These biological and geochemical processes are governed by nutrients' transformation into forms available for plant absorption, adsorption onto soil, and loss into air or water. Decomposition of organic matter by soil microorganisms liberates elements from the complex materials, drives them back into rotation and hence is pivot of all the transformations. During the decomposition of organic matter, generally but not always, complex compounds are converted into simpler ones.

Cycling of nutrients can be assessed from soil fertility status, organic matter content and soil reaction (pH) indicators. Soil fertility indicators are mineral nitrogen and plant available phosphorus, potassium, sulfur, calcium, magnesium, zinc and boron. Organic matter indicators are soil organic matter content, carbon to nitrogen ratio, particulate organic matter, microbial biomass carbon and activity of soil enzymes.

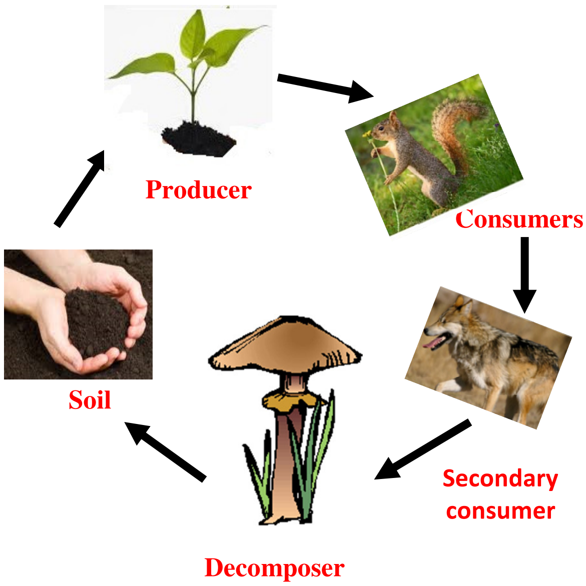

Fig. 1.1 Schematic diagram of nutrient cycling

1.2.3. Regulation of water supplies and environmental interactions

Water falling on land in the form of snow or rain is absorbed and stored by soil for later use. The stored pool of water remains available for plant absorption and use by soil organisms to sustain their life between precipitation or irrigation happenings. This ability of soil to hold a specific amount of water against the pull of gravity is known as its water holding capacity (WHC). Upon soil saturation, some of water will drain down into its profile and the leftover will be held in the soil until it evaporates or is drawn into plant roots, which ultimately transpire it through leaves. Infiltration of water into a soil profile is influenced by its texture, structure and the amount of vegetative cover on it. Coarse textured (sandy) soils have lesser water retention ability and therefore allow its rapid infiltration, whereas fine textured soils have an abundance of micro-pores causing low rate of infiltration and allowing the soil to retain a lot of water. Thus, some salient soil properties can regulate drainage and storage of water and its dissolved solutes, including plant nutrients, pesticides and other compounds. In short, soil's function is to partition water for groundwater recharge and use by plants and animals.

Qualities of soil and water are strongly linked to each other, and, to a large extent, soil properties are governed by the quality of water. When water passes through a soil profile, dissolved nutrients and other compounds are retained in it and the water gets filtered and purified. Consequently, aquifer recharge takes place with clean water and risk of eutrophication (a process whereby presence of excess nutrients in water bodies stimulates growth of algae and other aquatic plants) of lakes and other water bodies is reduced.

1.2.4. Landscaping and engineering medium

Soil serves as foundation for all civil structures including houses, buildings, roads and other structures which are set upon it but there is great variation in physical properties of different soil types. Landscape applications range from the gardens and lawns of residential houses to the bridge and roadway construction around highway interchanges. Both the physical and ecological functions of soils must be considered in all these instances. Soil properties including compressibility, bearing strength, shear strength, consistency and shrink-swell potential of soil are of concern in engineering and construction works. These engineering properties in turn are governed by the most basic soil physical properties including type of clay minerals, texture and structure.

1.2.5. Carbon storage and maintenance of gaseous balance in air

Organic carbon is an extremely important component of soil which is originally created through photosynthesis by plants. It plays significant roles in improving nearly all properties of soil including moisture retention, soil structure, drainage and nutrient storage. Storage of carbon in soil is essential in decreasing the amount of carbon dioxide (CO_2) in the atmosphere, thereby regulating climate change. Complex organic molecules are continually broken down by soil organisms into simpler organic and inorganic molecules/elements. Some of them are released into atmosphere as gases such as CO_2. However, humification, a biological transformation whereby more complex and stable organic matter is formed, is also carried out by some soil microorganisms. The amount of organic carbon in a soil is determined by the balance between input and loss of carbon. Globally, soil contains about three times as much carbon as vegetation cover on it and twice as much as in the atmosphere. Land use practices such as the conversion of grasslands to arable lands, arable lands to commercial ones and cultivation of organic soils are the major source of CO_2 emission from soil.

1.3. Soil Science

Soil science may be defined as "The branch of science dealing with soil as a natural resource on surface of the Earth, including pedology (soil genesis, classification and mapping) and the physical, chemical, biological and fertility properties of soil and their relation to crop production.

Soil Science is further divided into six well defined and developed disciplines which reflect its scope.

1.3.1. Soil mineralogy

Soil mineralogy deals with the primary and secondary minerals and their contribution to chemical, physical and biological properties, and fertility of soils.

1.3.2. Soil fertility

It addresses the ability of soil to supply essential nutrients and water to plants in sufficient amounts and proportions for their growth and development in the absence of toxic substances. Nutrient supplying power of a soil primarily depends on how much of the nutrients are inherently present, in which forms these are present, organic matter content and reaction (pH) of the soil and the rate of organic matter mineralization.

1.3.3. Soil chemistry

Soil chemistry primarily deals with chemical reactions in soil contributing to soil development and those affecting plant growth. Since concerns have grown about soil health risks, the recent emphasis in soil chemistry has shifted from agricultural soil science to environmental soil science. Soil pH, anion and cation exchange capacity, clay mineralogy, sorption and precipitation reactions, oxidation-reduction and soil chemical equilibria are the key areas studied under soil chemistry.

1.3.4. Soil physics

Soil physics deals with physical properties and processes in soils. It deals with the dynamics of physical soil components by drawing on the principles of physics, physical chemistry, engineering, and meteorology. Soil physics applies these principles to address practical problems of agriculture, ecology, and engineering.

1.3.5. Soil microbiology

Soil microorganisms include bacteria, fungi, actinomycetes, algae and protozoa. Microorganisms in soil are important because they affect the structure and fertility of soils. Soil microbiology deals with microorganisms, their population, classification and role in soil transformations and how they affect soil properties. The soil organisms have different characteristics which determine their role in the soil they live in.

1.3.6. Soil conservation

It involves how to safeguard the soil against physical loss by erosion (by water and wind) or chemical deteriorations. Thus, soil conservation is concerned with a combination of all management and land-use methods that protect the soil from deterioration caused by human or natural factors.

1.3.7. Pedology

Pedology deals with soil genesis, classification and its survey for different land uses. Soil genesis deals with weathering of rocks and minerals and factors affecting the weathering process.

1.4. Earth

Earth can be described as a sum total of land, air, water and its organisms. The land includes valleys and mountains, while air is a mixture of different gases with nitrogen (N_2) and oxygen (O_2) being the dominant ones. Water occurs as oceans, lakes, rivers, streams, rain, snow and ice. The mass of Earth, approximately 5.98×10^{24} kg, is mostly composed of iron (32 %), oxygen (30 %), silicon (15 %) magnesium (14 %), sulfur (3 %), calcium (1.5 %) and aluminum (1.4 %) and 3.2 % of trace elements (of which 2% is nickel). Due to mass segregation, primarily the core region of Earth is composed of iron (88.8%), sulfur (4.5%) and minor amounts (6.8%) of trace elements (including 5.8% nickel). Since more common rocks of the Earth's crust are nearly all oxides, oxygen constitutes more than 47% of it. Silica, alumina, iron oxides, lime, magnesia, potash and soda are principal oxides in the Earth Crust (Morgan and Anders 1980).

1.4.1. Minerals

Any naturally occurring abiogenic solid substance that is stable at room temperature, has a chemical formula and ordered atomic structure, is known as mineral (Dyar and Gunter 2008). Exceptions to the rule of stability at room temperature include mercury and water which are liquid at room temperature. Similarly, the criteria of being abiogenic and with a structured arrangement are also controversial and some organic compounds have been assigned a separate class. Therefore, many scientists proposed to amend the definition of mineral so that biogenic or amorphous substances may also be considered as minerals. That's why, International Mineralogical Association (IMA) now defines a mineral as "an element or chemical compound that is normally crystalline and has been formed because of geological processes" (Nickel 1995). In the light of this definition, organic class of minerals has again been included in both of Dana and the Strunz mineral classification schemes (Skinner 2005). Over 60 biominerals had been published prior to the listing of IMA (Veis 1990).

Minerals that persisted or changed little in their chemical composition since they were formed from molten lava are called primary minerals, e.g. quartz, micas and feldspar. They are dominant in sand and silt fractions of soil. Secondary minerals are those which were formed by breakdown of less persistent primary minerals and tend to dominate in clay and to lesser extent in silt fraction of soil, e.g., silicate clays and iron oxides (Weil and Brady 2016).

1.4.1.1. Physical properties of minerals

In classification, minerals range from simple to complex ones. Some minerals can be fully identified based on their physical properties only while others require complex methods, for their identification, like X-ray diffraction analysis. Physical properties used in classifying the minerals include crystal structure and habit, hardness, luster, diaphaneity, color, streak, cleavage and fracture, and specific gravity.

i. Crystal structure and habit

Every mineral has a regular and geometric internal arrangement of atoms or ions resulting in a specific crystal structure. Crystal structure is always periodic in nature even when the mineral grains are indiscernible and irregular in shape. Crystals are classified into six families based on relative lengths of the crystallographic axes and the angles between them.

The six crystal families are restricted to 32 classes (point groups) which differ in their symmetry. Due to restriction of 32 classes, minerals of different composition may have identical crystal structure and are called isomorphic minerals. The examples are halite (NaCl), galena (PbS), and periclase (MgO) which all are isometric (hexaoctahedral) minerals. Polymorphs, on the other hand, is group of minerals having same chemical formula but different structure. Pyrite and marcasite, for example, are isometric and orthorhombic forms of iron sulfides (FeS_2). The behavior of minerals to have same chemical formula but different crystal structure is named as polymorphism (Dyar and Gunter, 2008).

Minerals differing in crystal structure greatly differ in other physical properties. The common example is diamond and graphite allotropes of carbon, the former is the hardest mineral, has adamantine luster and crystallizes in the symmetry, whereas the later is very soft, has greasy lustre and belongs to hexagonal crystal family.

Crystal habit defines the overall shape of a crystal. Common shapes include bladed, acicular (needle like common in natrolite), equant, (typical example is garnet), dendritic (tree-pattern, as in native copper), tabular, prismatic (Chesterman and Lowe 2008).

ii. Hardness

Resistance of a mineral towards scratching is named as its hardness and it is determined by the chemical composition and crystalline structure of the mineral. All sides of a mineral do not necessarily show the same hardness. Crystallographic strength renders some directions harder than others as in kyanite, which has a Mohs hardness of 5½ parallel to [001] but 7 parallel to [100]. The ordinal Mohs scale is the most common scale of hardness measurement. It is defined by ten minerals so that a mineral with a higher index scratches those below it (Table 1.1) (Dyar and Gunter 2008).

iii. Luster and diaphaneity

How light reflects from the mineral's surface regarding its quality and intensity is known as luster. It may either be metallic/sub-metallic which is identified by high metal like reflectivity, as in galena and pyrite or non-metallic which may be vitreous (a glassy luster, in silicate minerals), adamantine (in diamond), pearly (in apophyllite and talc), silky (in fibrous minerals like asbestiform chrysotile) and resinous (in members of the garnet group).

The diaphaneity is defined as the ability of a mineral to pass light through it. Mineral may be transparent (muscovite), translucent (nephrite) and opaque (graphite) (Busbey et al. 2007; Dyar and Gunter 2008).

Table 1.1 Mohs hardness scale

Mohs hardness	Mineral	Chemical formula
1	Talc	$Mg_3Si_4O_{10}(OH)_2$
2	Gypsum	$CaSO_4 \cdot 2H_2O$
3	Calcite	$CaCO_3$
4	Fluorite	CaF_2
5	Apatite	$Ca_5(PO_4)_3(OH, Cl, F)$
6	Orthoclase	$KAlSi_3O_8$
7	Quartz	SiO_2
8	Topaz	$Al_2SiO_4(OH, F)_2$
9	Corundum	Al_2O_3
10	Diamond	C

Source: Dyar and Gunter (2008)

iv. Color and streak

Color of minerals is the most obvious and usually, not always, a non-diagnostic property. The minerals in which color is diagnostic property e.g. malachite (green) and azurite (blue), have dichromatic elements in their composition. In contrast, allochromatic elements are present in colorless minerals in trace amounts. Examples of such minerals are ruby and sapphire varieties of corundum mineral. The colors of pseudochromatic minerals (opal, bornite) are due to of interference of light waves. Play of color when the mineral is turned, as in opal, is due to variation in reflection of different colors. The phenomenon of change in color as light passes through a mineral in a different orientation is known as pleochroism (Busbey et al. 2007; Dyar and Gunter 2008).

The color which a mineral give in powder form is known as its streak. Streak plate made of porcelain and colored either black or white is most commonly used for testing this property. Streak may be different or identical to the body color of mineral. The body color of hematite is black, silver or red but its streak is cherry-red to reddish-brown (Busbey et al. 2007; Dyar and Gunter 2008).

v. Cleavage, fracture and tenacity

The breakage of a mineral along the planes of weakness of crystal structure is known as cleavage. The quality of cleavage is determined by how clean and easy mineral breakage takes place. In decreasing order of quality, "perfect", "good", "distinct", and "poor" are common descriptors of cleavage. Cleavage can be seen as series of parallel lines marking the planar surfaces in transparent mineral or in thin-section. Cleavage is not a universal to all minerals, for example, quartz does not cleave due to absence of crystallographic weakness. Contrarily, in micas, weekly bounded silica tetrahedra sheets perfectly cleave along basal line. Since cleavage is a function of crystallographic weakness, cleavage may be one, two, three, four, or six directional cleavage (Chesterman and Lowe 2007; Dyar and Gunter 2008).

Fracture is breakdown of mineral that does not follow the cleavage plan. There are several types of fracture including conchoidal (whereby rounded surfaces are formed as in quartz), splintery, fibrous, and hackly (Dyar and Gunter 2008).

Resistance of a mineral towards both cleavage and fracture is known as tenacity. Minerals can be ductile, malleable, brittle, sectile, flexible, or elastic in tenacity (Dyar and Gunter 2008).

vi. Specific gravity and other properties

Specific gravity is defined as the ratio of the mass of the mineral to the difference between its weight in air and water. Specific gravity of rock forming minerals - especially silicates and sometimes carbonates ranged from 2.5 to 3.5. Due to having elements with higher atomic mass in composition, oxides and sulfides have a higher specific gravity. Various other properties such as effervesce, magnetism, smell, radioactivity can be used as diagnose to minerals (Dyar and Gunter 2008).

1.4.2. Rocks

Geologically, a rock is coherent assembling of minerals or mineraloids of variable composition by the action of heat and water into a solid aggregate that forms a part of the Earth crust. For example, granite (a common rock) is composed of quartz, feldspar and biotite minerals. Rocks form nearly whole of the outer solid layer of Earth crust, i.e., lithosphere.

1.4.2.1. Types of rocks

The minerals forming the rocks are held together by chemical bonds in an orderly manner. Rock forming processes determine the types and abundance of minerals in a rock. Since most of the rocks contain silica, its proportion determines the properties and name of a rock (Wilson 1995). In addition to chemical composition, rocks are geologically classified according to texture and size of the constituent particles (Blatt and Tracy 1996). Geological model, also called as the rock cycle, explains the transformation of one type of rock into another with the course of time. Based upon the mode of formation, rocks are categorized into three major types, i.e. igneous, sedimentary and metamorphic which are explained in Chapter 2.

1.4.3. Spheres of Earth

The Earth's environment comprises of atmosphere, lithosphere, hydrosphere and biosphere.

1.4.3.1. Atmosphere

A layer of gases held around the Earth by force of gravity is known as atmosphere. The first 32 km above the Earth's surface contain about 99% of the total atmospheric mass. Atmosphere is divided into several concentric strata or layers, because of variations in temperature which result mainly from differential absorption of solar radiations.

Troposphere is the atmospheric layer closest to the Earth and due to vigorous convective air currents within this stratum, it is named so which mean the "region of mixing". It contains about 80 % of the total atmospheric mass. Troposphere retains about 99 % of atmospheric water vapors which play a major role to regulate air temperature owing to their ability to absorb solar radiations and heat energy from the Earth's surface. The stratosphere extends after the troposphere to an altitude of about 50 km above the Earth's surface. Water vapors in this region are very low and ozone gas, about 90 % of which resides within 15-25 km of this layer. Ozone absorbs solar ultraviolet radiation ranging in wavelength from 290-320 nm and, thus, regulates thermal regime of the stratosphere.

The mesosphere extends from approximately 50 to 85 km above the surface and is characterized by low temperature. The stratosphere and mesosphere jointly are sometime referred to as the middle atmosphere. The thermosphere is located above the mesosphere. Above this altitude, atmosphere becomes too thin to support aircraft and vehicles. Beyond about 160 km altitude, atomic oxygen becomes the major atmospheric component. The most distant atmospheric region from Earth's surface is the exosphere. The exosphere is a transitional zone between atmosphere and space (Skinner and Porter 1987).

1.4.3.2. Lithosphere

The term lithosphere is derived from two Greek words: lithos, means rocky, and sphaira, means sphere. It is the rigid shell of Earth and can be identified based on its mechanical properties (Skinner and Porter 1987). The upper part of the lithosphere chemically interacts with hydrosphere, atmosphere and biosphere, and is called as the pedosphere. The difference in response to stress between the lithosphere and the underlying asthenosphere defines the boundary between these two layers. There are two types of lithosphere; the one which underlies the ocean basin, named as oceanic lithosphere, and the other is continental lithosphere lying below continental crust.

1.4.3.3. Hydrosphere

Hydrosphere (from Greek word - hydōr, "water" and - sphaira, "sphere") defines the whole amount of water over and under the Earth's surface. There are 1.386×10^9 km^3 of water on Earth with a total mass of 1.4×10^{18} tons (0.23 % of Earth's mass). About 20×10^{12} tones of total water is in the Earth's atmosphere. Of the total ware, saline water is 97.5 % and rest is freshwater. About 68.7% of freshwater is in the "form of ice whereas the remaining 29.9% is found as groundwater. Only 0.26% of the fresh water is concentrated in lakes, reservoirs and rivers which is accessible for our economic use. Approximately 75% of the Earth's surface is covered by ocean. Transfer of water from one state or reservoir to another, known as Hydrological cycle (Fig. 1.2), is driven by solar energy and force of gravity (de Villiers 2003).

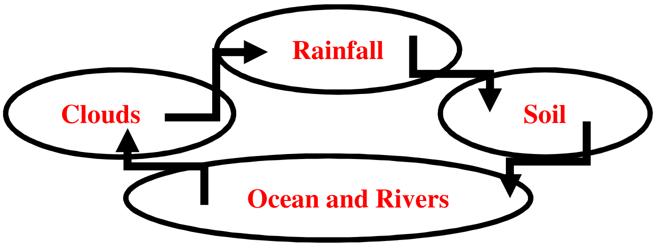

Fig. 1.2 Schematic diagram of water cycle

1.4.3.4. Biosphere

The term "biosphere" was introduced by geologist Eduard Suess in 1875, which he described as "the place on Earth's surface where life dwells". The biosphere, the global sum of all ecosystems, is referred to as a self-regulating zone of life on Earth and it is a closed system. So, it is the global ecological system in which all organisms integrate with each other and with other elements of the system such as atmosphere, hydrosphere and lithosphere. The biosphere is hypothesized to have been evolved at least 3.5 billion years ago, either from non-living matter (biopoesis) or by biogenesis, i.e., creation of life from living matter (Campbel et al. 2006).

1.5. Geology

Geology (from Greek "Geo", means Earth, and Logos means Science) is known as the Earth Science and it deals with the study of origin, structure, composition and history of Earth which includes the development of life and nature of the processes occurring on Earth. Geologists discover new deposits of rocks and minerals of economic value and thus play a significant role in the development of a nation. For ease of studying, science of Geology has been categorized into different branches as detailed below:

1.5.1. Physical geology

The study of the processes occurring on Earth by the action of physical agents, including water, wind, glaciers and sea waves, is known as physical geology. Physical geology contributes a significant role in civil engineering through revealing constructive and destructive processes driven by physical agents such as erosion, transportation and deposition of particulate matter. It helps in selecting a suitable site for different types of projects to be undertaken at a specific site.

1.5.2. Mineralogy

Mineralogy deals with the study of chemical composition, crystal structure and physical properties of minerals. More specifically, scientific studies of the processes of mineral formation and classification, geographical distribution and utilization of minerals are undertaken in mineralogy. Mineralogy with emphasis on minerals of economic importance is known as economic geology.

1.5.3. Petrology

Petrology is the branch of geology which deals with the study of rocks. It is further subdivided into: (i) Structural geology also named as tectonics, deals with identification and arrangements of structures found in rocks. It plays an important role in the selection of suitable sites for dams, tunnels, multistoried buildings, etc.; (ii) Stratigraphy deals with stratified rocks.

1.5.4. Paleontology

The branch of geology which involves the study of fossils, the prehistoric remains of organisms, is called as paleontology. Study of fossils describes how animals and plants had evolved and migrated through ages and climate of an area.

1.5.5. Mining geology

Mining geology deals with study of application of geological principles to mining engineering for selection of sites suitable for quarrying and making mines.

1.5.6. Hydrology

Both the qualitative and quantitative study of water which is present under and/or above the surface of Earth and in the atmosphere, is known as hydrology.

1.6. Environment

In literal sense, environment refers to external conditions or stimuli influencing development of people, animals or plants. By this definition, environment consists of intellectual, physical, economic, social, cultural, political, moral and emotional forces acting upon an organism from its conception to its death. Thus, environment has great influences on behavior, nature, growth, development and maturity of organisms.

Environment is a system of physical, biological and cultural elements inter-related to each other both individually as well as collectively in various ways. Physical elements include space, climate, water bodies, landforms, rocks, minerals and soils. These determine the character and opportunities as well as limitations of humans. Biological elements include micro-organisms, plants, animals, and people whereas cultural elements are artificial features such as social, economic and political values.

1.6.1. Environmental Sciences

As a branch of science, environmental science examines physical and natural environments of Earth and their complex interactions with humans. It is a multidisciplinary approach whereby it involves integrated application of atmospheric and Earth science, ecology, biology and chemistry to study the environment.

In the recent scenario, environmental pollution may be defined as the study of environmental pollutants, their sources and channels to various environments and remediation of the contaminated environments. The branches of environmental science include atmospheric science, ecology, environmental chemistry, environmental engineering and geosciences.

1.6.1.1. Ecology

Ecology is study of the interactions among organisms and with their environment. The concept of ecology is well explained by biodiversity, population of living organisms and competition between organisms and components of ecosystems. Ecosystems consist of interactions among biotic and abiotic components of the ecosystem and their environment.

1.6.1.2. Atmospheric science

Atmospheric science deals with the study of atmosphere, its processes, the effects of other systems on the atmosphere, and vice versa. It includes meteorology, climatology, aeronomy and planetary science. Meteorology makes use of atmospheric chemistry and atmospheric physics for weather forecasting while climatology addresses the changes in atmosphere that define change in climate over time and, hence, the average climate. The study of the upper atmospheric layers is known as aeronomy. Planetary science deals with the study of atmospheres of the planets of the solar system.

1.6.1.3. Environmental chemistry

Environmental chemistry is an interdisciplinary approach that makes use of atmospheric, aquatic, soil and analytical chemistry to study chemical and biochemical processes occurring in the environment and are impacted by humans.

1.6.1.4. Environmental engineering

Environmental engineering is the integration of environmental science and engineering principles to provide healthy natural environments, including air, water and land by cleanup of pollution sites for safe living of humans and animals. It can also be defined as the branch of applied science and technology that focuses on issues of energy preservation and control of waste productions by human and animal activities. The major areas addressed under environmental engineering are management and control of wastewater and air pollution, disposal and recycling of various wastes, radioprotection and public health, industrial hygiene and environmental sustainability.

1.6.1.5. Geoscience

Geoscience is a special branch of planetary science dealing with planet Earth. The reductionism approach (a complex system is a collection of its parts) of Earth sciences includes the study of biosphere, hydrosphere and atmosphere as well as the solid Earth. Typically, Earth scientists build a quantitative understanding of how the Earth system works, and how it had evolved to its current state by applying principles of mathematic, physics, chemistry, biology and chronology.

1.7. Conclusions

In this chapter, we have discussed the soil as a natural medium for plant growth. Soil is characterized by the presence of well-developed profile consisting of soil horizons. Soil supports plants, filters percolating water and recycles organic waste by serving as a sink. Origin of parent material, soil minerals, development of soil profile, soil formation, physical, chemical and biological properties of soils, nutrient availability to plants and problem soils studied under the umbrella of different branches of soil science are explained in this chapter. The origin of rocks from lava, different types of the rocks and their properties greatly influence the soil formation processes and different biogeochemical properties the soils thus formed. Geology and its different braches which provide insight to all these processes are also discussed in this chapter. Environment being sum of all the factors influencing life cycle of a living organism is greatly influenced by different processes being occurred in soil and geological perspectives. After studying this chapter, students would be able to understand the nexus between soils, rocks and the environment.

References

Blatt, H. and R.J. Tracy (1996). Petrology, 2nd Edition. W.H. Freeman Company, New York, USA.

Weil, R.R. and N.C. Brady (2016). The Nature and Properties of Soils, 15th Edition. Pearson Education Inc., Upper Saddle River, New Jersey, USA.

Busbey, A.B., R.E. Coenraads, D. Roots and P. Willis (2007). Rocks and Fossils. Fog City Press, San Francisco, USA.

Campbell, N.A., B. Williamson and R.J. Heyden (2006). Biology: Exploring Life. Pearson Prentice Hall Boston, Massachusetts, USA.

Chesterman, C.W. and K.E. Lowe (2008). Field Guide to North American Rocks and Minerals. Toronto, Canada.

de Villiers, M. (2003). Water: The Fate of Our Most Precious Resource. McClelland and Stewart, Toronto, Ontario, Canada.

Dyar, M.D. and M.E. Gunter (2008). Mineralogy and Optical Mineralogy. Mineralogical Society of America, Chantilly, Virginia, USA.

Morgan, J.W. and E. Anders (1980). Chemical composition of Earth, Venus, and Mercury. Proc. Nat. Acad. Sci. 77: 6973–6977.

Nickel, E.H. (1995). The definition of a mineral. Can. Minerol. 33: 689–690.

Skinner, B.J. and S.C. Porter (1987). Physical Geology. John Wiley and Sons, USA.

Skinner, H.C.W. (2005). Biominerals. Mineral Manage. 69: 621-641.

Soil Survey Staff (1999). Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys, 2nd Edition. Natural Resources Conservation Service, U.S. Department of Agriculture, Washington D.C., USA.

Veis, A. (1990). Biomineralization. In: Simkiss, K. and K.M. Wilbur (Eds.), Cell Biology and Mineral Deposition. Academic Press, San Diego, CA, USA.

Wilson, J.R. (1995). A Collector's Guide to Rock, Mineral and Fossil Localities of Utah. Utah Geological Survey, Utah, USA.