Indexed, Abstracted and Cited: **ISRA Journal Impact Factor, International Impact Factor Services (IIFS), Directory of Research Journals Indexing (DRJI), International Institute of Organized Research and Scientific Indexing Services, Cosmos Science Foundation (South-East Asia), Einstein Institute for Scientific Information {EISI}, Directory of Open Access Scholarly Resources,**

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Directory Indexing of International Research Journals

World Journal of Biology and Medical Sciences

Published by Society for Advancement of Science®

ISSN 2349-0063 (Online/Electronic)

Volume 2, Issue- 4, 89-99, October to December, 2015

WJBMS 2/04/45/2015

www.sasjournals.com

A Double Blind Peer Reviewed Journal / Refereed Journal

wjbmedsc@gmail.com/wjbms.lko@gmail.com

REVIEW ARTICLE

Received: 03/07/2015 Revised: 03/09/2015 Accepted: 05/09/2015

Study of Desert Soil Horizons: A Review

Sadaf Kheyrodin and *Hamid Kheyrodin

Islamic Azad University, Mashhad Branch, Iran

*Faculty of Desert Science, Semnan University, Iran

ABSTRACT

Horizons are defined in most cases by obvious physical features, chiefly color. Desert soils form in areas where the demand for water by the atmosphere (evaporation) and plants (transpiration) is much greater than precipitation. Deserts cover 20 to 33% of the Earth's land surface, and can be found in the tropics, at the poles, and in between. Most desert soils are called Aridisols (dry soil). However, in really dry regions of the Sahara and Australian outback, the soil orders are called Entisols. Entisols are new soils, like sand dunes, which are too dry for any major soil horizon development. They also occur in floodplains after a spring flood, which is why they can occur in the desert. The deserts are very fertile, which means that, if provided with water, they can grow a lot of food. This can be done by providing water with irrigation technology. The Central Valley in California produces 250 types of fruits and vegetables, and does so with river water, aquifers, and streams. Six master soil horizons are commonly recognized and are designated using the capital letters O, A, E, B, C, and R. O horizon definition, the layer of loose leaves and organic debris at the surface of soil. A-horizons may also be the result of a combination of soil bioturbation and surface processes that winnow fine particles from biologically mounded topsoil. B horizons: are commonly referred to as the subsoil. They are a zone of accumulation where rain water percolating through the soil has leached material. The C

horizon (parent material) is below the B Horizon. This layer is little affected by soil-forming.
The R horizon is basically the deepest soil horizon in the soil profile. Unlike the horizon above, this horizon does not comprise rocks or boulders, but instead is made of continuous mass of bedrock. It is very difficult to dig through this layer.
Key words: Desert Soil, Horizons, Aridisols, Entisols and Soil Farming.

INTRODUCTION

A soil horizon is a layer generally parallel to the soil surface, whose physical characteristics differ from the layers above and beneath. Each soil type usually has three or four horizons. Horizons are defined in most cases by obvious physical features, chiefly color and texture. These may be described both in absolute terms (particle size distribution for texture, for instance) and in terms relative to the surrounding material (i.e., "coarser" or "sandier" than the horizons above and below). The differentiation of the soil into distinct horizons is largely the result of influences, such as air, water, solar radiation and plant material, originating at the soil-atmosphere interface. Since the weathering of the soil occurs first at the surface and works its way down, the uppermost layers have been changed the most, while the deepest layers are most similar to the original parent material.
Identification and description of the horizons present at a given site is the first step in soil classification at higher levels, through the use of systems such as the USDA soil taxonomy or the Australian Soil Classification. The World Reference Base for Soil Resources lists 40 diagnostic horizons. **Isbell Raymond, (2002).** Soil scientists often dig a large hole, called a soil pit (usually several meters deep and about a meter wide) to expose soil horizons for study. The vertical section exposing a set of horizons, from the ground surface to the parent rock, is termed a soil profile. Most soils, especially in temperate climates, conform to a similar general pattern of horizons, often represented as "ideal" soil in diagrams. Each main horizon is denoted by a capital letter, which may then be followed by several alphanumerical modifiers highlighting particular outstanding features of the horizon. While the general O-A-B-C-R sequence seems fairly universal, some variation exists between the classification systems in different parts of the world. In addition, the exact definition of each main horizon may differ slightly – for instance, the US system uses the thickness of a horizon as a distinguishing feature, while the Australian system does not. It should be emphasized that no one system is more correct – as artificial constructs, their utility lies in their ability to accurately describe local conditions in a consistent manner. Also, many subtropical and tropical areas have soils such as oxisols or aridisols that have very different horizons from "ideal" soil or no horizons at all.

Main Profile

Six master soil horizons are commonly recognized and are designated using the capital letters O, A, E, B, C, and R. The following horizons are listed by their position from top to bottom within the soil profile. Not all of these layers are present in every location. For instance, P horizons only form in areas which have been waterlogged for long periods of time. Soils with a history of human interference, for instance through major earthworks or regular deep ploughing, may lack distinct horizons almost completely. When examining soils in the field, attention must be paid to the local geomorphology and the historical uses to which the land has been put in order to ensure that the appropriate names are applied to the observed horizons. The horizon not listed is the O horizon which is grass and animal/plant life.

Layers: Soil generally consists of visually and texturally distinct layers, also called profiles, which can be summarized as follows from top to bottom:

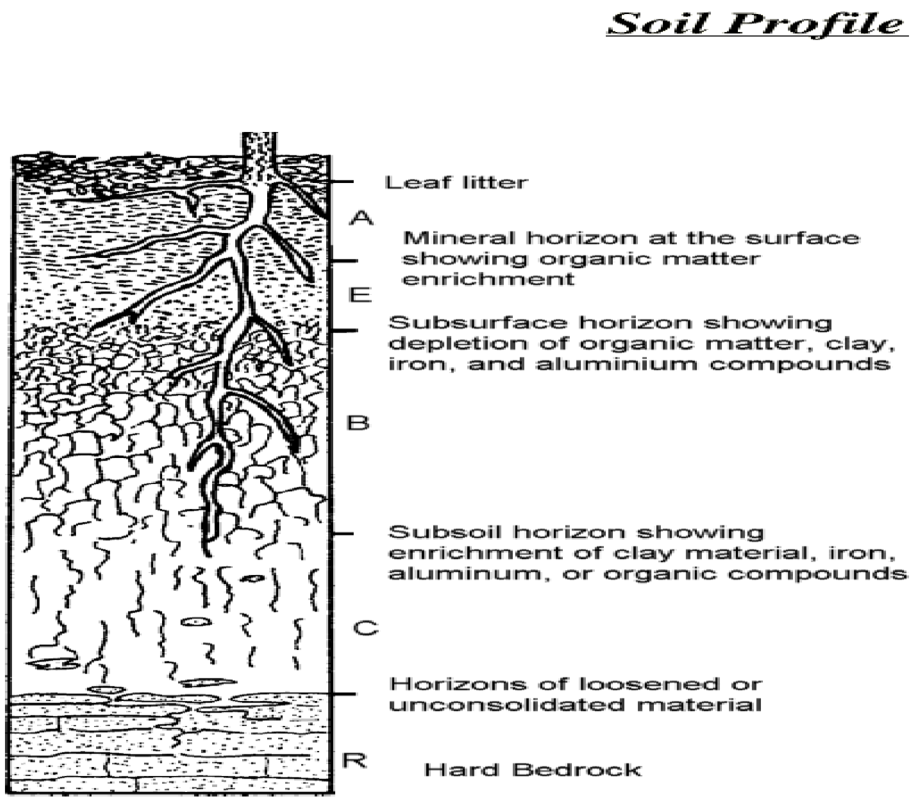

Figure 1. Soil Profile.

O) Organic matter: Surficial organic deposit with litter layer of plant residues in relatively non-decomposed form.
A) Surface soil: Organics mixed with mineral matter. The Layer of mineral soil with the most organic matter accumulation and soil life. This layer eluviates (is depleted of) iron, clay, aluminum, organic compounds, and other soluble constituents. When eluviation is pronounced, a lighter colored "E" subsurface soil horizon is apparent at the base of the "A" horizon. A-horizons may also be the result of a combination of soil bioturbation and surface processes that winnow fine particles from biologically mounded topsoil. In this case, the A-horizon is regarded as a "biomantle".
B) Subsoil: Subsurface layer reflecting chemical or physical alteration of parent material. This layer accumulates iron, clay, aluminum and organic compounds, a process referred to as illuviation.
C) Parent rock: The parent material in sedimentary deposits. Layer of large unbroken rocks. This layer may accumulate the more soluble compounds .
R) Bedrock: The parent material in bedrock landscapes. This layer denotes the layer of partially weathered bedrock at the base of the soil profile. Unlike the above layers, R horizons largely comprise

continuous masses of hard rock that cannot be excavated by hand. Soils formed in situ will exhibit strong similarities to this bedrock layer. These areas of bedrock are under 50 feet of the other profiles.

O Horizon

This layer generally forms above the mineral soil or occurs in an organic soil profile. The "O" stands for organic matter. It is a surface layer dominated by the presence of large amounts of organic material derived from dead plant and/or animal residues which is in varying stages of decomposition. The O horizon is generally absent in grassland regions. The O horizon usually occurs in forested areas and is commonly referred to as the forest floor. The O horizon should be considered distinct from the layer of leaf litter covering many heavily vegetated areas, which contains no weathered mineral particles and is not part of the soil itself. O horizons may be divided into O1 and O2 categories, whereby O1 horizons contain decomposed matter whose origin can be spotted on sight (for instance, fragments of rotting leaves), and O2 horizons contain only well-decomposed organic matter, the origin of which is not readily visible. O horizons may also be divided into three subordinate O horizons denoted as: Oi, Oe, and Oa.

P Horizon

These horizons also heavily organic, but are distinct from O horizons in that they form under waterlogged conditions. The "P" designation comes from their common name, peats. They may be divided into P1 and P2 in the same way as O Horizons. This layer accumulates iron, clay, aluminium and organic compounds, a process referred to as illuviation **(Johnson, D.L., J.E.J. Domier, and D.N. Johnson 2005)**.

A Horizon

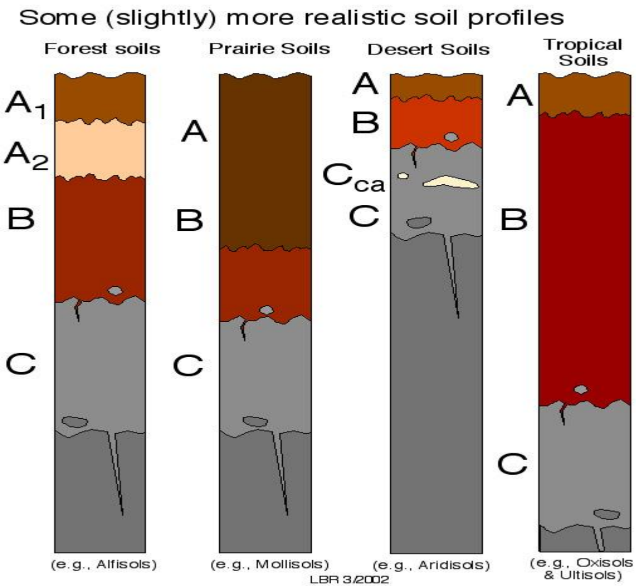

Figure 2. Show some realistic soil profiles.

The A horizon is the topmost mineral horizon, often referred to as the 'topsoil'. This layer generally contains enough partially decomposed (humified) organic matter to give the soil a color darker than that of the lower horizons. The A horizons are often coarser in texture, having lost some of the finer materials by translocation to lower horizons and by erosion. This layer is known as the zone in which the most biological activity occurs. Soil organisms such as earthworms, potworms (enchytraeids), arthropods, nematodes, fungi, and many species of bacteria and archaea are concentrated here, often in close association with plant roots. Thus the A horizon may be referred to as the biomantle (**McDonald, R. C. 1990 and Wilkinson, M.T. and G.S. Humphreys 2005)**. However, since biological activity extends far deeper into the soil, it cannot be used as a chief distinguishing feature of an A horizon.

E Horizon

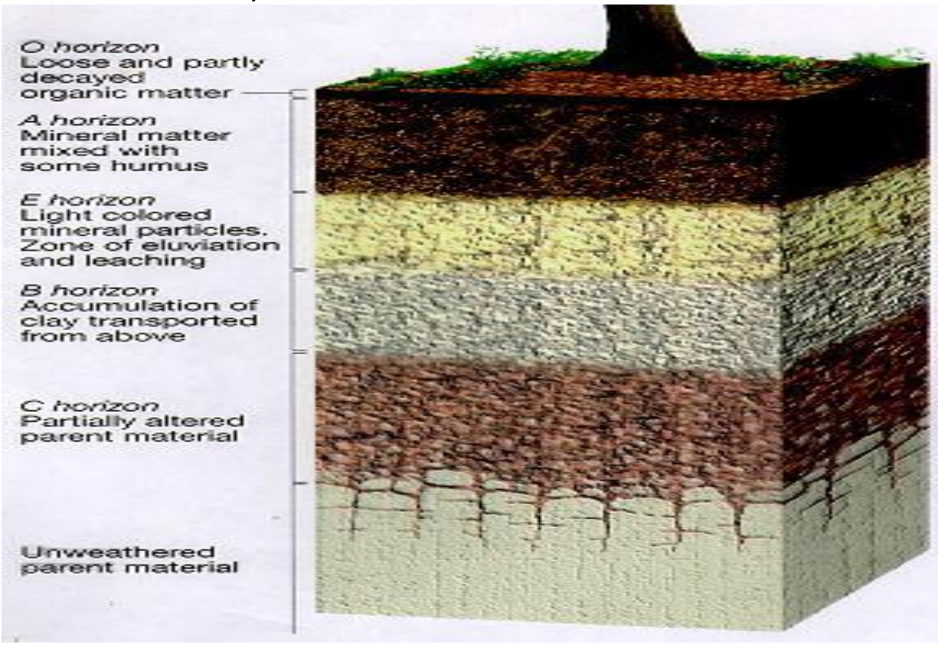

Figure 3. Show soil horizons in forest.

Albeluvisol – dark surface horizon on a bleached subsurface horizon (an albic horizon) that tongues into a clay illuviation (Bt) horizon

Main article: Eluvium

"E", being short for eluviated, is most commonly used to label a horizon that has been significantly leached of clay, iron, and aluminum oxides, which leaves a concentration of resistant minerals, such as quartz, in the sand and silt sizes. These are present only in older, well-developed soils, and generally occur between the A and B horizons. The E horizon often has a pale color that is generally lighter in color than either the horizon above or below it. E horizons are commonly found in soils developed under forests, but are rare in soils developed under grasslands. In regions where this designation is not employed, leached layers are classified firstly as an A or B according to other characteristics, and then appended with the designation "e" (see the section below on horizon suffixes). In soils that contain gravels, due to animal bioturbation, a stonelayer commonly forms near or at the base of the E horizon.

The above layers may be referred to collectively as the "solum". The layers below have no collective name but are distinct in that they are noticeably less affected by surface soil-forming processes.

B Horizon

B horizons form below an O, A, or E horizon and they have undergone sufficient changes during soil genesis, such that the properties of their original parent material are no longer discernible. The B horizon is commonly referred to as the "subsoil". In humid regions, B horizons are the layers of maximum accumulation of materials such as silicate clays, iron (Fe) and aluminum (Al) oxides, and organic material. These materials typically accumulate through a process termed illuviation, wherein the materials gradually wash in from the overlying horizons. Accordingly, this layer is also referred to as the "illuviated" horizon or the "zone of accumulation". In addition, it is defined as having a distinctly different structure or consistency than the horizon(s) above and the horizon(s) below. The B horizon may also have stronger colors (higher chroma) than the A horizon. In arid and semiarid regions, calcium carbonate or calcium sulfate may accumulate in the B horizon.

As with the A horizon, the B horizon may be divided into B1, B2, and B3 types under the Australian system. B1 is a transitional horizon of the opposite nature to an A3 – dominated by the properties of the B horizons below it, but containing some A-horizon characteristics. B2 horizons have a concentration of clay, minerals, or organics and feature the highest soil development within the profile. B3 horizons are transitional between the overlying B layers and the material beneath it, whether C or D horizon.

The A3, B1, and B3 horizons are not tightly defined, and their use is generally at the discretion of the individual worker.

Plant roots penetrate through this layer, but it has little humus. It is usually brownish or reddish due to residual clay and iron oxides.

C Horizon

The C horizon (parent material) is below the B Horizon. This layer is little affected by soil-forming processes and they thus have a lack of pedological development. In other words, the C horizon is the unconsolidated material underlying the solum (A and B horizons). It may or may not be the same as the parent material from which the solum formed. The C horizon forms as the R horizon weathers and rocks break up into smaller particles. The C horizon is below the zones of greatest biological activity and it has not been sufficiently altered by soil genesis to qualify as a B horizon. In dry regions, carbonates and gypsum may be concentrated in the C horizon. While loose enough to be dug with a shovel, C horizon material often retains some of the structural features of the parent rock or geologic deposits from which it formed. The A and B layers usually originated from the C horizon. The upper layers of the C horizon may in time become a part of the solum as weathering and erosion continue. The C Horizon may contain lumps or more likely large shelves of unweathered rock, rather than being made up solely of small fragments as in the solum. It contains rocks with cracks and crevices.

6.26 Soil profiles

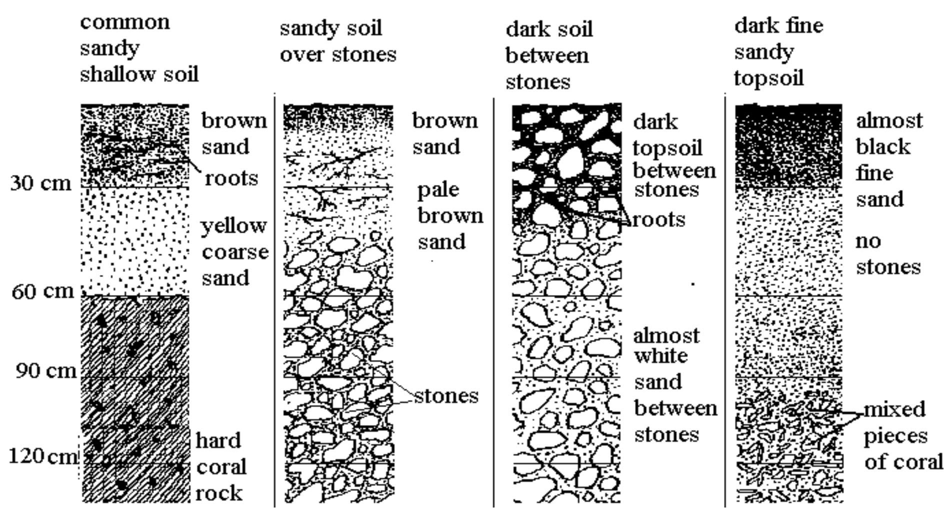

Figure 4. Show soil profiles in 120 cm.

D Horizon

D horizons are not universally distinguished, but in the Australian system are "any soil material below the solum that is unlike the solum in general character, is not C horizon, and cannot be given reliable designation… [it] may be recognized by the contrast in pedologic organization between it and the overlying horizons" (MacDonald et al., 1990, p. 106).

R Horizon

R horizons are the layers of partially weathered bedrock at the base of the soil profile. Unlike the above layers, R horizons are composed largely of consolidated masses of hard rock that cannot be excavated by hand. Soils formed in situ will exhibit strong similarities to this bedrock layer.

L Horizon

L (limnic) horizons or layers indicate mineral or organic material that has been deposited in water by precipitation or through the actions of aquatic organisms. Included are coprogenous earth (sedimentary peat), diatomaceous earth, and marl; and is usually found as a remnant of past bodies of standing water.

Subdivisions within master horizons

Often, distinctive layers exist within a given master horizon, and these are indicated by a numeral following the letter designation. For example, if three different combinations of structure and colors can be seen in the B horizon, then the profile may include a sequence such as B1-B2-B3. If two different geologic parent materials (e.g., loess overlying glacial till) are present within the soil profile, the numeral 2 is placed in front of the master horizon symbols for horizons developed in the second layer of parent material. For example, a soil would have a sequence of horizons designated O-A-B-2C if C horizon developed in a different parent material. Where a layer of mineral soil material was transported by humans from a source outside the pedon, the caret symbol (^) is inserted before the master horizon designation.

Transition Horizons

Master horizon letter combinations with a slash in between, such as E/B, are used to designate transition horizons where distinct parts of the horizon have properties of E while other parts have properties of B. Transitional layers between the master horizons may be dominated by properties of one horizon but also have characteristics of another. The two master horizon letters are used to designate these transition horizons (e.g., AE, EB, BE, and BC), wherein the dominant horizon is placed before the non-dominant horizon. For example, BE is a transition to B that is more like B than E, while EB is a transition to B that is more like E than B.

Subordinate Distinctions

Subordinate horizons may occur within a master horizon and these are designated by lowercase letters following the capital master horizon letter (e.g., Ap, Bt, or Oi). Since the nature of a master horizon is only generally described by the capital master horizon letter, the lowercase letter symbols following the master horizon designation is often used to indicate more specific horizon characteristics. Subordinate distinctions include, but are not limited to, special physical characteristics and the accumulation of particular materials.

Table 1. Lowercase Letter Symbols to Designate Subordinate Distinctions within Master.

Horizons			
Letter	**Distinction**	**Letter**	**Distinction**
a	Organic matter, highly decomposed	b	Buried soil horizon
c	Concretions or nodules	d	Dense unconsolidated materials
e	Organic matter, intermediate decomposition	f	Frozen soil
g	Strong gleying (mottling)	h	Illuvial accumulation of organic matter
i	Organic matter, slightly decomposed	j	Jarosite (yellow sulfate mineral)
jj	Cryoturbation (frost churning)	k	Accumulation of carbonates
m	Cementation or Induration	n	Accumulation of sodium
o	Accumulation of Fe and Al oxides	p	Plowing or other disturbance
q	Accumulation of silica	r	Weathered or soft bedrock
s	Illuvial organic matter and Fe and Al oxides	ss	Slickensides (shiny clay wedges)
t	Accumulation of silicate clays	u	Presence of human-manufactured materials (artifacts)
v	Plinthite (high iron, red material)	w	Distinctive color or structure without clay accumulation
x	Fragipan (high bulk density, brittle)	y	Accumulation of gypsum
z	Accumulation of soluble salts		

Buried Soils

While soil formation is generally described as occurring in situ, as rock breaks down and is mixed with other materials, the process is often far more complicated. For instance, a fully formed profile may have developed in an area only to be buried by wind- or water-deposited sediments which later formed into another soil profile. This sort of occurrence is most common in coastal areas, and descriptions are modified by numerical prefixes. Thus, a profile containing a buried sequence could be structured O, A1, A2, B2, 2A2, 2B21, 2B22, 2C with the buried profile commencing at 2A2.

Diagnostic surface horizons of mineral soils

The diagnostic horizons at the soil surface are called epipedons (from the Greek 'epi, "over", and pedon, "soil"). The presence or absence of these particular diagnostic surface horizons help soil scientists determine the place of a soil within the Soil classification system. The epipedon includes the upper part of the soil darkened by organic matter and/or the upper eluvial horizons. It may also include the B horizon if the eluvial horizons are sufficiently darkened by organic matter. All soils must have one epipedon. Eight epipedons are recognized, but only five occur naturally over wide areas. The five naturally-occurring epipedons are called the mollic epipedon, umbric epipedon, ochric epipedon, melanic epipedon, and histic epipedon.

The mollic epipedon is a mineral surface horizon that is distinguished by its dark color, an associated accumulation of organic matter (>0.6% throughout), for its thickness (>25 cm), and for its softness even when dry. The mollic epipedon also has a high base saturation (>50%). The umbric epipedon has the same general characteristics as the mollic epipedon except it has a low base saturation (<50%). The umbric epipedon commonly develops in areas with slightly higher rainfall than mollic epipedon, and forms where the parent material has lower content of calcium and magnesium, The ochric epipedon is a mineral horizon that is either too thin, too light in color, or too low in organic matter to be considered a mollic or umbric horizon. The melanic epipedon is a mineral horizon that is very dark in color due to its high organic matter content (>0.6%). It is characteristic of soils high in such minerals as allophane, developed from volcanic ash. Melanic epipedon is extremely fluffly for a mineral soil. Histic epipedon is a 20 to 60 cm thick layer of organic soil materials (>20%) overlying a mineral soil. It is formed in wet areas, and has a layer of peat or muck with a black to dark brown color and a very low density.

Surface horizons are usually characterized by roundish granular structure that exhibits a hierarchy in which relatively large macroaggregates (0.25 to 5 mm in diameter) are composed of smaller microaggregates (2 to 250 µm). The latter, in turn, are composed of tiny packets of clay and organic matter only a few µm in size. You may easily demonstrate the existence of this hierarchy of aggregation by selecting a few of the largest aggregates in a soil and gently crumbling them into many smaller-sized pieces. You will find that even the smallest specks of soil usually are not individual particles but can be rubbed into a smear of still smaller particles of silt, clay, and humus. At each level in the hierarchy of aggregates, different factors are responsible for binding together the subunits.

Diagnostic subsurface horizons

Many subsurface diagnostic horizons are used to characterize different soils in soil taxonomy. Each diagnostic horizon provides a characteristic that helps place a soil in its proper class in the system. A soil may or may not have a subsurface diagnostic horizon. There are approximately 20 subsurface diagnostic horizons, of which include the argillic horizon, natric horizon, kandic horizon, oxic horizon, spodic horizon, and albic horizon. The argillic horizon (designated as Bt) is characterized by a thick accumulation of silicate clays that have moved downward from the upper horizons or have formed in place. The argillic horizon often contains clays with shiny coatings termed "argillans" or "clay skins", and accompanied by less than 15% exchangeable sodium on the colloidal complex. The natric horizon (designated as Btn) similarly has silicate clay accumulation with clay skins, but the clays are accompanied by more than 15% exchangeable sodium on the colloidal complex and by columnar or prismatic soil structural units. The natric horizon is most commonly found in arid and semiarid regions. The kandic horizon (designated as Bt, Bts), sometimes referred to as "old" clays, has an accumulation of Fe and Al oxides as well as low-activity silicate clays (e.g., kaolinite), but clay skins need not be evident. The clays are low in activity as shown by their low cation-holding capacities.

CONCLUSION

Soil is made of a number of distinct, horizontal layers placed one above the other, which are known as soil horizons. Most soils conform to a general pattern consisting of six horizons. A vertical cross section of the soil, which is known as the soil profile, is your best bet if you intend to get well-versed with different horizons. The oxic horizon (designated as Bo) is a very weathered horizon with a high content of Fe/Al oxides and low-activity silicate clays. It is generally physically stable, crumbly, and not very sticky, despite its high clay content. It is found most commonly in humid tropical and subtropical regions. The spodic horizon (designated as Bh, Bhs) is an illuvial and dark-colored horizon that is characterized by the accumulation of colloidal organic matter and aluminum oxide with or without iron oxide. It is commonly found in highly leached forest soils of cool humid climates, typically on sandy-textured parent materials. The albic horizon (designated as E) is an eluvial and light-colored horizon that is characterized by a low content of clay and Fe/Al oxides.

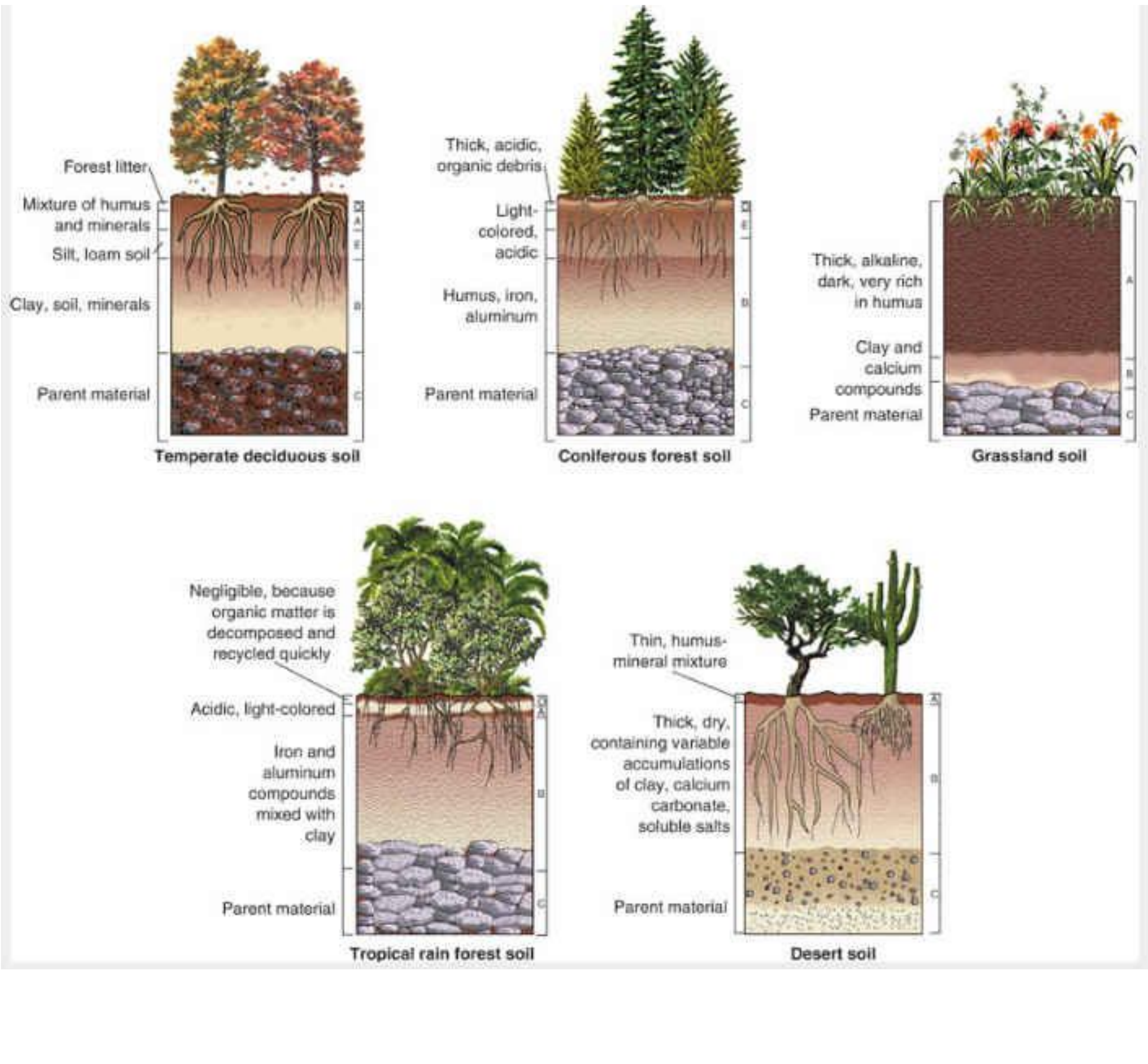

Figure 5. Show variation of soils horizon.

ACKNOWLEDGEMENTS

Research conducted and supported by Semnan University for help with the manuscript.

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Corresponding author: Dr. Hamid Kheyrodin, Faculty of Desert Science, Semnan University, Iran
Email: hkhyrodin@yahoo.com