AgriCos e-Newsletter
ISSN: 2582-7049

AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 02 Issue: 10 October 2021 Article No: 01

Pedogenic Evaluation of Soil and its Composition

S. Arunkumar

Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, School of Agriculture, Lovely Professional University, Jalandhar, Punjab, India

SUMMARY

Pedology is defined as the science that studies the genesis, nature, distribution and use potentiality of soil resources. It uses an empirical scientific methodology, which is the topic of this paper. The role of systems, models, data and theories as key concepts of this scientific methodology is discussed within a pedological framework. Soil is an open system because it loses and receives material and energy at its boundaries. Examples are given of how the soil system may be subdivided into subsystems suited to various types of pedological research. The natural soil system is very complex. Therefore pedologists build models as convenient devices for scientific research.

INTRODUCTION

Humans tend to classify and categorize almost everything we encounter in our natural world. From rocks to soils, from landscapes to living things on the land and in the water, we have systems of classification to describe these things in uniform terms. The nature and properties of soils can vary widely from one location to the next, even within distances of a few meters. These same soil properties can also be found to exhibit similar characteristics over broad regional areas of like climate and vegetation. The soil forming factors of parent material, climate, vegetation (biota), topography, and time tend to produce a soil that describes the environment in which it is formed. By surveying properties of soil colour, texture, and structure; thickness of horizons; parent materials; drainage characteristics; and landscape position, soil scientists have mapped and classified nearly the entire contiguous United States and much of the rest of the world.

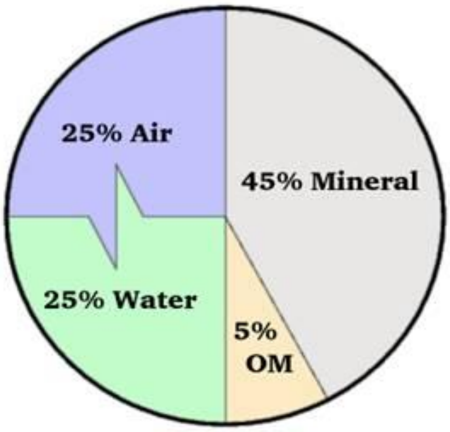

Fig.01: Soil Composition

USDA Soil Classification System

Soil taxonomic classifications reflect the dominant Soil Forming Factors active during soil formation at a particular location. The USDA system of Soil Taxonomy (soil naming) consists of a hierarchy of six levels. These levels, in order from most general to most specific, are:

- Order
- Suborder
- Great Group
- Subgroup
- family
- Series

This system of Soil Taxonomy is comparable to the Linnean system used in biology to classify living things (kingdom, phylum, class, order, family, genus, and species).

This system of soil classification provides information that can be used by land managers to make inferences regarding a particular soil's utility for plant production, urban/residential usages, waste management, and construction sites.

Taxonomic Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories. Beginning with the broadest, these categories are the Order, Suborder, Great Group, Subgroup, family, and Series**.**

These categories are defined in the following paragraphs.

Order – Twelve soil orders are recognized. The differences among orders reflect the dominant soil forming processes and the degree of soil formation. Each order is identified by a word ending in 'sol.' An example is Alfisols.

Suborder - Each order is divided into suborders primarily on the basis of properties that influence soil formation and/or are important to plant growth.

Great Group – Each suborder is divided into great groups on the basis of similarities in horizons present, soil moisture or temperature regimes, or other significant soil properties.

Subgroup – Each great group has a 'typic' (typical) subgroup which is basically defined by the Great Group. Other Subgroups are transitions to other orders, suborders, or great groups due to properties that distinguish it from the great group.

Family – Families are established within a subgroup on the basis of physical and chemical properties along with other characteristics that affect management.

Series – The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

Soil Orders

The most general level of classification in the USDA system of Soil Taxonomy is the Soil Order. All of the soils in the world can be assigned to one of just 12 orders. Soil orders are frequently defined by a single dominant characteristic affecting soils in that location, e.g., the prevalent vegetation (Alfisols, Mollisols), the type of parent material (Andisols, Vertisols), or the climate variables such as lack of precipitation (Aridisols) or the presence of permafrost (Gelisols). Also significant in several soil orders is the amount of physical and chemical weathering present (Oxisols, Ultisols), and/or the relative amount of Soil Profile Development that has taken place (Entisols). This lesson will examine each of these 12 soil orders in turn: Entisols, Inceptisols, Andisols, Mollisols, Alfisols, Spodosols, Ultisols, Oxisols, Gelisols, Histosols, Aridisols, and Vertisols. To get the most out of this lesson, the student should carefully study each soil order, including the supplementary material provided by the embedded links.

Entisols

This is a very diverse group of soils with one thing in common, little profile (horizon) development. Includes the soils of unstable environments, such as floodplains, sand dunes, or those found on steep slopes. Entisols are commonly found at the site of recently deposited materials (e.g., alluvium), or in parent materials resistant to weathering (e.g. sand). Entisol soils also occur in areas where a very dry or cold climate limits soil profile development. Productivity potential of Entisols varies widely, from very productive alluvial soils found on floodplains, to low fertility/productivity soils found on steep slopes or in sandy areas.

Inceptisols

These soils are in the beginning stages of soil profile development. The differences between horizons are just beginning to appear. Some color changes may be evident between the emerging horizons, and the beginnings of a B horizon may be seen with the accumulation of small amounts of clay, salts, and organic material. These soils show more profile development than Entisols, but have not developed the horizons or properties that characterize other soil orders. Inceptisols are commonly found throughout the world, and are prominent in mountainous regions. The natural productivity of these soils varies widely, and is dependent upon clay and organic matter content, and other edaphic (plant-related) factors.

Aridisols

Dry soils with $CaCO_3$ (lime) accumulations, common in desert regions. The extent of Aridisol occurrence throughout the world is widespread, second in total ice-free land area only to the Entisols. Extensive areas of Aridisols occur in the major deserts of the world, as well as in Southwestern North America , Australia , and many Middle Eastern locations. Aridisols are commonly light in color, and low in organic matter content. Lime and salt accumulations are common in the subsurface horizons. (For details on horizon development see Lesson 3.3 and Lesson 4.2.) Some Aridisols have an argillic (clay accumulation) B horizon, likely formed during a period with a wetter climate. Water deficiency is the dominant characteristic of Aridisols with adequate moisture for plant growth present for no more than 90 days at a time. Crops cannot be grown in these soils without irrigation. Productivity of Aridisols is generally low, and there is potential for land degradation due to overgrazing by livestock. If irrigation water is available, Aridisols can be made productive through use of fertilizers and proper management.

Mollisols

The Mollisol order takes its name from the Latin word mollis, meaning soft. These mineral soils have developed on grasslands, a vegetation that has extensive fibrous root systems. The topsoil of Mollisols is characteristically dark and rich with organic matter, giving it a lot of natural fertility. These soils are typically well saturated with basic cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) that are essential plant nutrients. These characteristics of Mollisols place them among the most fertile soils found on Earth.

Alfisols

Alfisols are found in cool to hot humid areas, and in the semiarid tropics; they are formed mostly under forest vegetation, but also under grass savanna. Extensive areas of Alfisols are found in the Mississippi and Ohio River valleys in the USA, through Central and Northern Europe into Russia, and in the South-central region of South America. Alfisols generally show extensive profile development, with distinct argillic (clay) accumulations in the subsoil. Extensive leaching often produces a light-colored E horizon below the topsoil. Generally fertile and productive, these soils typically have a high concentration of nutrient cations (Ca, Mg, K, and Na) and form in regions with sufficient moisture for plants for at least part of the year. Natural fertility and productive capacity of Alfisols is considered to be greater than that of Ultisols, but less than that of Mollisols.

Spodosols

Spodosols commonly form in sandy parent materials under coniferous forest vegetation. As a consequence of their coarse texture, they have a high leaching potential. They are characterized by high acidity, and have a subsoil accumulation of organic matter, along with aluminum and iron oxides, called a spodic horizon. Typically low in natural fertility (basic cations, Ca^{2+}, Mg^{2+}, and K^{+}) and high in soil acidity (H^{+}, Al^{3+}), these soils require extensive inputs of lime and fertilizers to be agriculturally productive. This order are most commonly associated with a cool and wet climate, but also occur in warmer climes such as in Florida, USA. Large areas of Spodosol are found in northern Europe, Russia, and northeastern North America.

Ultisols

Ultisols are intensely weathered soils of warm and humid climates. They are typically formed on older geologic locations in parent material that is already extensively weathered. Ultisols have accumulated clay minerals in the **B horizon**. While generally low in natural fertility (basic cations, Ca^{2+}, Mg^{2+}, and K^{+}) and high in soil acidity (H^{+}, Al^{3+}) the clay content of Ultisols gives them a nutrient retention capacity greater than that of Oxisols, but less than Alfisols or Mollisols. Ultisol soils can be agriculturally productive with inputs of lime and fertilizers. Large areas of Ultisol are found in the southeastern USA, China, Indonesia, South America, and equatorial regions of Africa.

Oxisols

Oxisols are the most weathered of the 12 soil orders in the USDA soil classification system. (See Lesson 2 -- Processes of Weathering.) They are composed of the most highly weathered tropical and subtropical soils, and are formed in hot, humid climates that receive a lot of rainfall. Oxisols are located primarily in equatorial regions. These soils are extensively leached, and the clay size particles are dominated by oxides of iron and aluminum, which are low in natural fertility (Ca^{2+}, Mg^{2+}, K^{+}) and high in soil acidity (H^{+}, Al^{3+}). While Oxisols are typically physically stable, with low shrink-swell properties and good erosion resistance, these soils require extensive inputs of lime and fertilizers to be agriculturally productive.

Andisols

Soils form in volcanic ash and cinders near or downwind from volcanic activity. Generally lacking in development, they are not extensively weathered, forming in deposits from geologically recent events. Usually of high natural fertility, they tend to accumulate organic matter readily and are of a ‘light’ nature (low bulk density) that is easily tilled. These soils generally have a high productiv

Gelisols

Gelisols are soils with permafrost within 2 meters of the surface. These soils generally have limited profile development. Most of the soil forming processes in these soils occur near the surface, sometimes resulting in significant accumulation of organic matter. Large areas of this soil occur in the Northern regions of Russia, Canada, and Alaska. These areas become boggy wetlands in the summer, and support large numbers of migratory birds and grazing mammals. The permafrost of Gelisols tends to become unstable (melt) if disturbed, leading to a waterlogged soil condition that poses problems for engineering uses.

Histosols

Histosols are soils without permafrost that are predominately composed of organic materials in various stages of decomposition. They generally consist of at least half organic materials (by volume). They are usually saturated with water which creates anaerobic conditions and causes organic matter accumulation at rates faster than that of decomposition. Little soil profile development is present, due to their saturated and **anaerobic** condition, however layering of organic materials is common. Histosols can form in wetland areas of any climate where plants can grow such as bogs, marshes, and swamps, but are most commonly formed in cool climates.

Vertisols

Vertisols are soils with a high content of clay minerals that shrink and swell as they change water content. The clay minerals adsorb water and increase in volume (swell) when wet and then shrink as they dry, forming large, deep cracks. Surface materials fall into these cracks and are incorporated into the lower horizons when the soil becomes wet again. As this process is repeated, the soil experiences a mixing of surface materials into the subsoil that promotes a more uniform soil profile. Vertisols are usually very dark in color, with widely variable organic matter content (1 – 6%). They typically form in Ca and Mg rich materials such as limestone, basalt, or in areas of topographic depressions that collect these elements leached from uplands. Vertisols are most commonly formed in warm, subhumid or semi-arid climates, where the natural vegetation is predominantly grass, savanna, open forest, or desert shrub. Large areas of Vertisols are found in Northeastern Africa, India, and Australia , with smaller areas scattered worldwide.

Soil Composition

The basic components of soil are minerals, organic matter, water and air. The typical soil consists of approximately 45% mineral, 5% organic matter, 20-30% water, and 20-30% air as seen in Fig.1. These percentages are only generalizations at best. In reality, the soil is very complex and dynamic. The composition of the soil can fluctuate on a daily basis, depending on numerous factors such as water supply, cultivation practices, and/or soil type. The solid phase of soil, which includes minerals and organic matter, are generally stable in nature. Yet, if organic matter is not properly managed, it may be depleted from the soil. The liquid and gas phases of the soil, which are water and air respectively, are the most dynamic properties of the soil. The relative amounts of water and air in the soil are constantly changing as the soil wets or dries.

CONCLUSION

The complex natural system is replaced by a simpler or more abstract model, which can be more easily handled either manually or mentally. These systems then enable us to communicate with each other about these subjects in terms that are understandable and consistent. Classification systems and taxonomic conventions allow us to describe a thing or phenomenon in a way that can then be understood by those in remote locations and without direct experience of the subject. The nature, function and design are explained from the field of pedology. Soil composition is an important aspect of nutrient management. While soil minerals and organic matter hold and store nutrients, soil water is what readily provides nutrients for plant uptake. Soil air, too, plays an integral role since many of the microorganisms that live in the soil need air to undergo the biological processes that release additional nutrients into the soil.

REFERENCES

Buol, S. W.; Hole, F. D. & McCracken, R. J. (1973). *Soil Genesis and Classification* (First ed.). Ames, IA: Iowa State University Press. ISBN 978-0-8138-1460-5.

Jenny, Hans (1994). *Factors of soil formation: A System of Quantitative Pedology*(PDF). New York: Dover. ISBN 978-0-486-68128-3. Archived from the original (PDF) on 25 February 2013. Retrieved 4 September 2014.

Scalenghe, R., Territo, C., Petit, S., Terribile, F., Righi, D. (2016). "The role of pedogenic overprinting in the obliteration of parent material in some polygenetic landscapes of Sicily (Italy)". *Geoderma Regional*. **7**: 49–58. doi:10.1016/j.geodrs.2016.01.003