Chapter 21

Soil Systems

OVERVIEW

This chapter is the first chapter of Part Five, which looks at the life layer where physical and biological processes interact. It examines soil characteristics, the processes of soil formation, and the global pattern of the distribution of soil that develops as the interface between the lithosphere, the biosphere, and the atmosphere.

- **Soil** is a complex mixture of solids, liquids, and gases. It contains mineral material derived from the **parent material** and **organic matter** derived from living plants and other organisms in the soil.
- The major **soil-forming factors** are parent material, climate, vegetation, and time. Soil characteristics develop over very long periods of time.
- **Soil color** is the most obvious characteristic of soil. Color may be inherited from parent material, but it is often a result of soil forming processes.
- **Soil texture** refers to the proportion of soil particles that fall into each of three size grades: sand, silt, and clay.
- **Soil colloids** are the smallest particles in soils. They are important because they hold plant nutrients in the soil in the form of ions.
- **Soil pH** can range from acid to alkaline.
- **Soil structure** refers to the way in which the soil grains are bound together by colloids into peds.
- Chemical and organic processes in soils change primary minerals into **secondary minerals** such as oxides and clay minerals.
- The nature of the clay minerals determines a soil's **base status,** which, in turn, affects its **fertility** or ability to retain nutrients.
- The **storage capacity** of a soil is the maximum amount of water that it can retain by capillary tension when it is allowed to drain. The **wilting point** is the water storage level below which plants cannot access water. The difference between the storage capacity and the wilting point is the **available water capacity** for plants which varies with soil texture.
- Water stored within a soil is depleted by **evaporation** and **transpiration** until it is recharged by precipitation.
- The **soil water balance** describes the inter-relationship between **water need** (potential evapotranspiration), **water use** (actual evapotranspiration), precipitation, and storage in the soil water zone.

- A **soil water budget** is a numerical accounting, usually done on a monthly basis, of the soil water balance components. It determines the amount of water plants need for optimal growth.
- Most soils have distinct horizontal layers, known as **soil horizons**, that develop by the processes of enrichment, removal, translocation, and transformation.
- **Soil forming processes include:**
- **Enrichment -** the addition of organic and mineral material to the soil by sedimentation and biological activity.
- **Leaching** - the removal of dissolved material in percolating soil water, and by erosion.
- **Translocation -** the removal of material from upper horizons (**eluviation**) and its accumulation in lower horizons (**illuviation**).
- **Humification** - an important transformation process in which organic material is decomposed to **humus**.
- **Soil classification systems** are used to study the distribution of soils and their relationship to a variety of environmental factors.
- The U.S. Comprehensive Soil Classification System groups the soils of the world into 11 **soil orders** that are distinguished primarily by the presence of diagnostic horizons.
- Seven soil orders (**Oxisols**, **Ultisols**, **Vertisols**, **Alfisols**, **Spodosols**, **Mollisols**, and **Aridisols**) have well-developed horizons and can often be associated with particular climatic regimes.
- One soil order, **Histosols**, includes soils with a large proportion of organic matter.
- Three soil orders (**Entisols**, **Inceptisols,** and **Andisols**) have poorly developed horizons or are capable of further mineral alteration.

KEY TERMS

soil	soil horizons	Alfisols
parent material	soil profile	Spodosols
soil texture	eluviation	Histosols
soil colloids	illuviation	Entisols
bases	soil orders	Inceptisols
secondary minerals	Oxisols	Andisols
water use	Ultisols	Mollisols
water need	Vertisols	Aridisols

STUDY QUESTIONS

1. What is soil, and how is it distinguished from regolith?
2. What are the major factors that affect the properties and formation of soils?

3. What is soil texture, and why is it considered an important soil property?
4. Colloids play an important role in determining soil base status and fertility. Why is this?
5. Identify two important classes of secondary minerals produced by mineral alteration, and give an example of each.
6. How does the ability of a soil to retain moisture vary with soil texture? Why?
7. Sketch a diagram to illustrate the concept of the soil water balance. Your diagram should show the important inputs, outputs, and storage components of the soil column.
8. Define water use and water need, and discuss how they affect the soil water balance.
9. What are soil horizons, and how do they form?
10. What are the four classes of soil forming processes? Describe each of them.
11. Define calcification and decalcification. Under what conditions does each prevail? List and describe the eleven soil orders of the U.S. Comprehensive Soil Classification System.
12. Which soil order dominates the landscape of the area in which you live? Why?
13. Sketch a schematic diagram to show how soil order and soil profile characteristics would change along a transect across North America from a cool, dry desert in the west to a cool, moist climate in the east.

CHAPTER QUIZ

Multiple Choice Questions

1. The texture class that includes soils with approximately equal parts of sand, silt, and clay is:
   a) sandy loam
   b) clay loam
   c) silt loam
   d) loam
2. The amount of water that a soil will hold when it is fully wetted and allowed to drain is its:
   a) wilting point
   b) storage capacity
   c) soil water recharge
   d) potential evapotranspiration
3. Which of the following soil-forming processes is a transformation process?
   a) elluviation
   b) calcification
   c) humification
   d) salinization
4. Which of the following soil orders include soils that lack horizon development?
   a) Histosols
   b) Ultisols
   c) Mollisols

d) Entisols

5. Which of the following soil orders dominates the rainforests of the Amazon River Basin?
   a) Oxisols
   b) Vertisols
   c) Spodosols
   d) Aridisols

True/False Questions

1. In soil water balance, the difference between water use and water need is called the deficit. (T/F)
2. Soils that lack colloids and clay minerals usually have a high base status. (T/F)
3. Soil consists of matter in solid, liquid, and gaseous forms. (T/F)
4. In moist, hot climates, rates of decomposition are so rapid that very little organic matter is present in the soil. (T/F)
5. Soils that form under forest vegetation tend to be acidic. (T/F)

Short Answer Questions

1. What is the essential difference between soil and regolith?
2. What is soil structure, and how does this property affect the suitability of soils for agriculture?
3. Sketch a diagram showing the relationship between soil storage capacity, wilting point, and soil texture. Discuss the physical basis of this relationship.
4. A moist, midlatitude climate with nearly constant monthly precipitation will typically have a water budget with a strong seasonal cycle of water surplus and water shortage. Why is this?
5. How does soil pH affect the storage of plant nutrients?

Short Essay Questions (1 - 2 paragraphs)

1. Sketch a simple diagram to show the soil orders and climate types that occur along two transects across North America: one along the thirtieth parallel and one along the fiftieth parallel. Discuss the relationship between climate and soils illustrated by these transects.

2. Define soil colloids, describe their origin, and discuss their impact on soil fertility.

Internet Resources

1. Global soils maps: <http://www.nhq.nrcs.usda.gov/WSR/mapindx/maps.htm>
2. NEED INTRO: <http://quarles.unbc.edu/nres/soc/ggroup/ggroups.html>
3. US Department of Agriculture Keys to Soil Taxonomy: <http://www.statlab.iastate.edu/soils/keytax/content.html>

4. A good review of soils and their properties: <http://interactive.usask.ca/skinteractive/modules/agriculture/soils/index.html>
5. Soil landscapes of Canada – great photographs and access to interactive mapping tools: <http://sis.agr.gc.ca/cansis/nsdb/slc/intro.html>
6. Soils of Alberta – Introduction: <http://www.soils.rr.ualberta.ca/soa/intro.cfm>
7. Soil Development Processes and Global Soils Learning Modules: http://www.uwsp.edu/geo/faculty/ritter/geog101/modules/soils/soils_module_contents.html