6.2 - Functions of Soil

Functions of Soil in the Global Ecosystem

Soils perform five key functions in the global ecosystem. Soil serves as a:

1. medium for plant growth,
2. regulator of water supplies,
3. recycler of raw materials,
4. habitat for soil organisms, and
5. landscaping and engineering medium.

Soil Function: Medium for plant growth

As an anchor for plant roots and as a water holding tank for needed moisture, soil provides a hospitable place for a plant to take root. Some of the soil properties affecting plant growth include: soil texture (coarse of fine), aggregate size, porosity, aeration (permeability), and water holding capacity.

Figure 2. Impact of soil physical properties on plant growth. The exposed roots of this corn plant show evidence of preferential growth to the right, away from where soil compaction has occurred in the wheel track area on the left. *Image courtesy of John Doran*

An important function of soil is to store and supply nutrients to plants. The ability to perform this function is referred to as soil fertility. The clay and organic matter (OM) content of a soil directly influence its fertility. Greater clay and OM content will generally lead to greater soil fertility. The soil in figure 2 has a dark brown to black color, indicating abundant OM accumulation, and a highly fertile soil.

Question 1: An important function of soil is to store and supply necessary nutrients to plants. The ability of a soil to perform this function is referred to as the soil fertility. Which of the following soil properties will most influence soil fertility?

- **A.** soil aggregate size
- **B.** porosity and aeration
- **C.** soil texture (fine or coarse)
- **D.** clay and organic matter content

- **E.** water holding capacity

Check It

Soil Function: Regulator of Water Supplies

As rain or snow falls upon the land, the soil is there to absorb and store the moisture for later use. This creates a pool of available water for plants and soil organisms to live on between precipitation or irrigation events. When soils are very wet, near saturation, water moves downward through the soil profile unless it is drawn back towards the surface by evaporation and plant transpiration.

Figure 3. Eroded soil muddies runoff water after a spring thunderstorm in China. Soils are at risk of erosion when directly exposed to the impacts of raindrops and runoff. Surface erosion reduces the overall ability of soil to absorb and retain water. *Image courtesy of John Doran*

The amount of water a soil can retain against the pull of gravity is called its water holding capacity (WHC). This property is close related to the number of very small mircro-pores present in a soil due to the effects of capillarity.

The rate of water movement into the soil (infiltration) is influenced by its texture, physical condition (soil structure and tilth), and the amount of vegetative cover on the soil surface. Coarse (sandy) soils allow rapid infiltration, but have less water storage ability, due to their generally large pore sizes. Fine textured soils have an abundance of micropores, allow them to retain a lot of water, but also causing a slow rate of water infiltration. Organic matter tends to increase the ability of all soils to retain water, and also increases infiltration rates of fine textured soils.

Question 2: Which of the following soil conditions would likely have the greatest water holding capacity?

- **A.** Fine texture, low organic matter
- **B.** Fine texture, high organic matter
- **C.** Coarse texture, low organic matter
- **D.** Coarse texture, high organic matter
- **E.** Fine or coarse texture with high organic matter

Check It

Soil Function: Recycler of raw materials

As a recycler of raw materials, soil performs one of its greatest functions in the global ecosystem. Decomposition of dead plants, animals, and organisms by soil flora and fauna (e.g., bacteria, fungi, and insects) transforms their remains into simpler mineral forms, which are then utilized by other living plants, animals, and microorganisms in their creation of new living tissues and soil humus.

Many factors influence the rate of decomposition of organic materials in soil. Major determinants of the rate of decomposition include the the soil physical environment, and the chemical make-up of the decomposing materials. The activity levels of decomposing organisms are greatly impacted by the amount of water and oxygen present, and by the soil temperature. The chemical makeup of a material, especially the amount of the element nitrogen present in it, has a major impact on the 'digestibility' of any material by soil organisms. More nitrogen in the material will usually result in a faster rate of decomposition.

Figure 4. New life springs from remains of the old. Plants, fungi, and insects utilize the remains of formerly living tissues to create new living tissues as a source of energy and to create new living tissues. This process recycles the dead back into the living. As dead organisms decompose, carbon dioxide gas is released, and essential nutrients contained within their remains are returned to the soil to be taken up in the creation of new living tissues. *Image courtesy of USDA-NRCS*

Through the processes of decomposition and humus formation, soils have the capacity to store great quantities of atmospheric carbon and essential plant nutrients. This biologically active carbon can remain in soil organic matter for decades or even centuries. This temporary storage of carbon in the organic matter of soils and biomass is termed carbon sequestration. Soil organic carbon has been identified as one of the major factors in maintaining the balance of the global carbon cycle. Land management practices that influence soil organic matter levels have been extensively studied, and are often cited as having the potential to impact the occurrence of global climate change.

Question 3: Which of the following soil properties have the LEAST influence on the ability of the soil to recycle dead plants, insects, and animals into the simple raw materials necessary for plant growth?

- **A.** soil textural class (% of sand, silt and clay)

- **B.** soil porosity and aeration
- **C.** tchemical composition of the material
- **D.** soil water content
- **E.** temperature

Check It

Soil Function: Habitat for soil organisms

Soil is teeming with living organisms of varied size. Ranging from large, easily visible plant roots and animals, to very small mites and insects, to microscopically small microorganisms (e.g. bacteria and fungi.) Microorganisms are the primary decomposers of the soil, and perform much of the work of transforming and recycling old, dead materials into the raw materials needed for growth of new plants and organisms.

Figure 5. An earthworm in its burrow excretes its waste 'middens' on the soil surface, where it will be further broken down by bacteria and other soil organisms. Organic materials in soil are consumed and digested repeatedly by different organisms on their path to becoming humus. *Image courtesy of USDA-NRCS*

Most living things on Earth require a few basic elements: air, food, water, and a place to live. The decomposers in soil have need of a suitable physical environment or 'habitat' to do their work. Water is necessary for the activities of all soil organisms, but they can exist in a dormant state for long periods when water is absent. Most living organisms are 'aerobic' (requiring oxygen), including plant roots and microorganisms, however some have evolved to thrive when oxygen is absent (anaerobes). Greater soil porosity and a wide range of pore sizes (diameter) in the soil allows these organisms to 'breathe' easier. Soil textural type has a great influence on the available habitat for soil organisms. Finer soils have a greater number of small 'micro-pores' that provide habitat for microorganisms like bacteria and fungi. In addition to the need for suitable habitat, all soil organisms require some type of organic material to use as an energy and carbon source, that is to say they require food. An abundant supply of fresh organic materials will ensure a robust population of soil organisms.

Question 4: Soil is home for an enormous variety of living organisms (plants, insects, microorganisms,

etc.). Which of the following soil properties will have the greatest influence on the ability of the soil to provide a suitable habitat for these organisms?

- **A.** textural class (% of sand, silt and clay)
- **B.** porosity (aeration)
- **C.** organic matter type and composition
- **D.** soil water content
- **E.** All of the above

Check It

Landscaping and engineering medium

Soils are the base material for roads, homes, buildings, and other structures set upon them, but the physical properties of different soil types are greatly variable. The properties of concern in engineering and construction applications include: bearing strength, compressibility, consistency, shear strength, and shrink-swell potential. These engineering variables are influenced by the most basic soil physical properties such as texture, structure, clay mineral type, and water content. Landscaping applications range in scale from bridge and roadway construction around highway interchanges to courtyards and greenspaces around commercial sites to the grading and lawns of residential housing developments. In all these instances, both the physical and ecological functions of soils must be considered.

Figure 6. Exposure of soil at a construction site creates potential for soil erosion by water, wind, or both. Eroded soil pollutes waterways and causes sedimentation of ponds and reservoirs. *Image courtesy of Tim Kettler*

Question 5: Soil physical properties have a profound influence on their behavior and function within an ecosystem. The type of solid soil particles (textural class) and the amount and size of the empty spaces between them (porosity and structure) determine how a soil will behave when used as foundations for buildings and roads. Which of the

following soil properties will be of greatest interest to an engineer designing a roadway or building foundation?

- **A.** textural class (% of sand, silt and clay)
- **B.** structure and porosity (aeration)
- **C.** clay mineral type and amount
- **D.** water content
- **E.** All of the above

Check It