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The Soil and Me: A Perspective on Soil Health

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Soil is the foundation upon which our natural living world depends; it is otherwise known as the dynamic material that civilization is built on (Lindbo, Kozlowski, and Robinson 2012). Soil serves diverse functions that are critical to the survival of humanity; without the soil, life on earth is inconceivable. It represents the critical zone of the earth where life, water, minerals, and air intersect and interact (fig. 1) because the soil constantly relates with other parts of nature. The soil is considered a living, dynamic resource at the earth's surface and has been defined as "the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants" (SSSA 2015). The thickness or depth of this surface or layer varies with the type and environment of the soil.

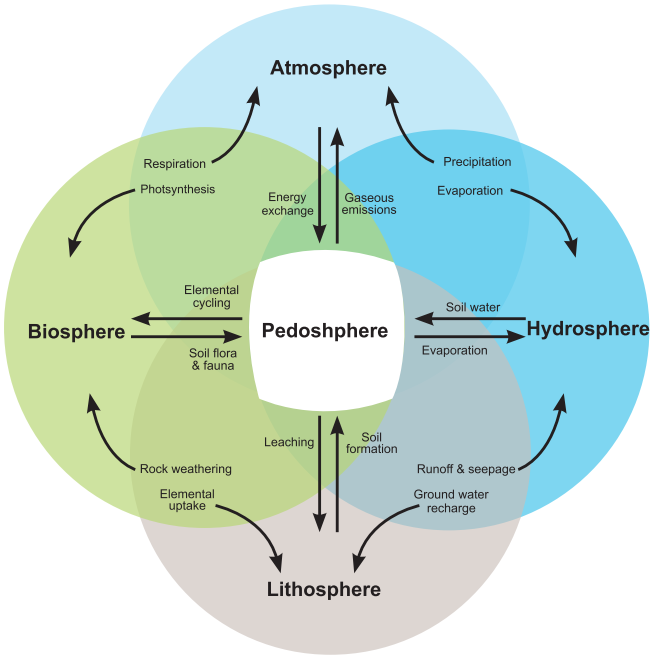

Figure 1. Soil (pedosphere) in interactive processes.
Reprinted from Fortuna (2012).

For as long as humanity has existed on the Earth's surface, the soil has been used for different things by different people. In practically every continent — Africa, Asia, North and South America, Australia, and Europe — people have depended on soil for survival. While soil can serve different purposes, such as a foundation for buildings and a filter for human and industrial wastes, the major focus in this publication is how soil can benefit the agricultural production of food and fiber. Together with sunlight and water, soil is our fundamental terrestrial asset that provides the basis for all terrestrial life, the biodiversity around us, the field crops harvested for food and fiber, and other useful animal products. In addition, soil provides ecosystem services, enables plant growth, resists erosion, stores water, retains nutrients, and is an environmental buffer in the landscape, among other things (fig. 2). Soil supplies nutrients, water, and oxygen to plants and is populated by soil biota essential for decomposing and recycling the soil organic materials. This means that soil is life — soil sustains life — soil is not "dirt."

The terrestrial life supported by soil continues to grow as the world's population increases, while the land available for agricultural production has been decreasing through civilization and resultant degradation. As was credited to Franklin D. Roosevelt in a 1937 letter to state governors, "The nation that destroys its soil destroys itself." This necessitates the maintenance and management of this nonrenewable essential resource.

The art of soil management is as old as civilization (Brady and Weil 2007), but the challenges of this century require new technologies and understanding of what is relevant for maintaining and sustaining the soil resources. If humans depend on soil for life, can they relate better to soil management if it is compared to

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management and maintenance of human health? Can a somewhat comparative analysis of steps to sustain human health be translated to soil health?

What Is Soil Health?

Soil health is the continued capacity of a soil to function as a vital living system within ecosystem and land-use boundaries, to sustain biological productivity, maintain the quality of air and water environments, and promote plant, animal, and human health (Doran et al. 1994). It is the condition of the soil in relation to its inherent (or potential) capability to function within ecosystem and land-use boundaries. A healthy soil is productive, sustainable, and profitable.

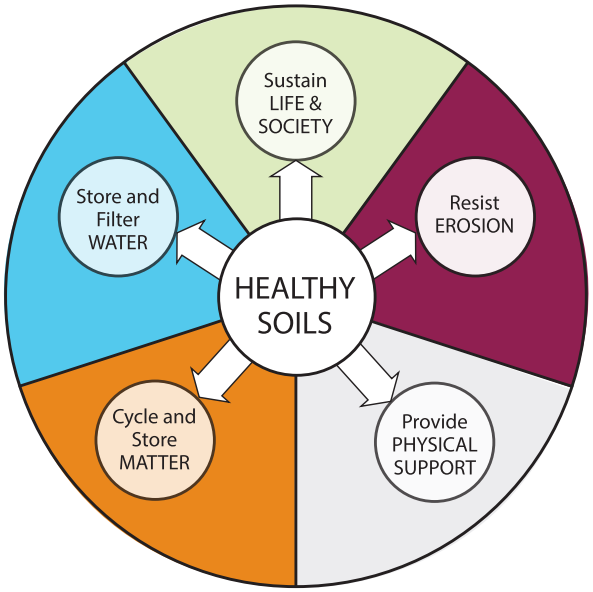

Figure 2. Major functions of a healthy soil.
Reprinted from Victorian Resources Online (2015).

Soil health is analogous to the concepts of environmental health, human health, plant health, and animal health because human health is a functional concept that describes our capacity to function, to interact with each other and our environment, and to do this into the future (Victorian Resources Online 2015).

Understanding Soil Health

The soil consists of four major components, namely, air, water, mineral, and organic matter (fig. 3) that describe the different aspects of the physical, chemical, and biological properties of soil. Each aspect of these properties focuses on specific parts of the soil; however, soil health emphasizes the integration of these properties (fig. 4). Evaluating soil health will therefore depend on the exploration of a range of physical, chemical, and biological properties. Since soil health fundamentally links to land productivity and environmental sustainability, understanding, protecting, improving, and maintaining soil health is critical.

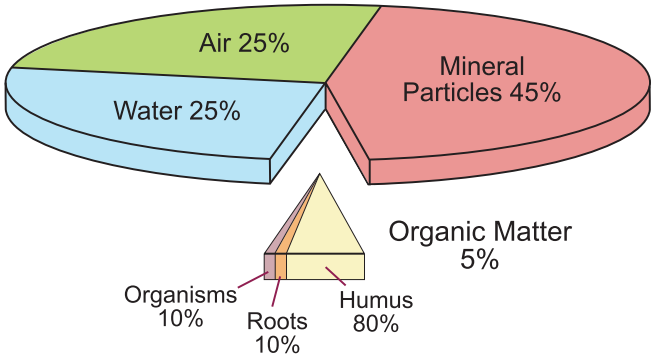

Figure 3. Components of the soil.
Reprinted from Pidwirny (2006).

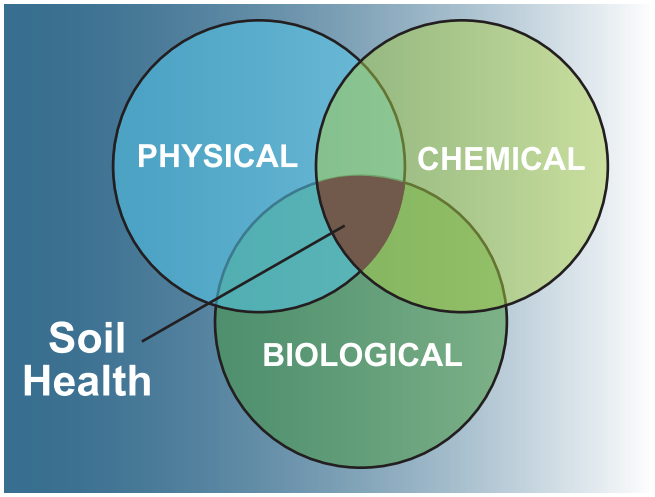

Figure 4. Soil health as an integrated concept (Sarrantonio 1994). Reprinted with permission from Rodale Institute, Rodaleinstitute.org, ©2015.

Soil Health Indicators

Soil health indicators provide an assessment of how well the soil functions. Though the properties that constitute a healthy soil are not the same in all situations and locations, there are some important soil properties that indicate soil health. Soil health indicators could be physical, chemical, or biological properties, which in turn influence the processes or characteristics of the soils (fig. 5). Soil quality

attempts to integrate all three types of indicators. The categories do not neatly align with the various soil functions, so integration is necessary (Doran and Parkin 1996). Out of all the properties, the soil organic component (system) is the most important because of the profound influence it has on the soil's physical, chemical, and biological properties (Brevik 2009). Therefore, many of the steps taken to improve soil health focus on improving the soil organic matter status.

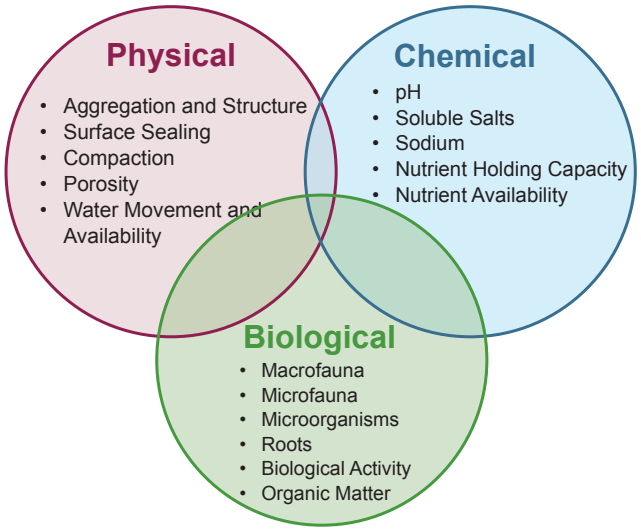

Figure 5. Major soil health indicators.
Reprinted from North Dakota State University (2015).

Soil Health Management and Applications

Management practices that improve soil health, increase productivity, and sustain profitability are crucial. Soil health management includes maintaining suitable habitat for the myriad of creatures that constitute the soil food web. Figure 6 showcases a schematic representation of the interactions of the soil's biology.

Soil health management concerns everyone who benefits from food and other resources from the soil. Improving and managing soil health can generally be accomplished by practices that disturb the soil as little as possible, growing as many different species of plants as practical, keeping living plants in the soil as often as possible, and keeping the soil covered throughout the year, amongst other things. These applications specifically include the following.

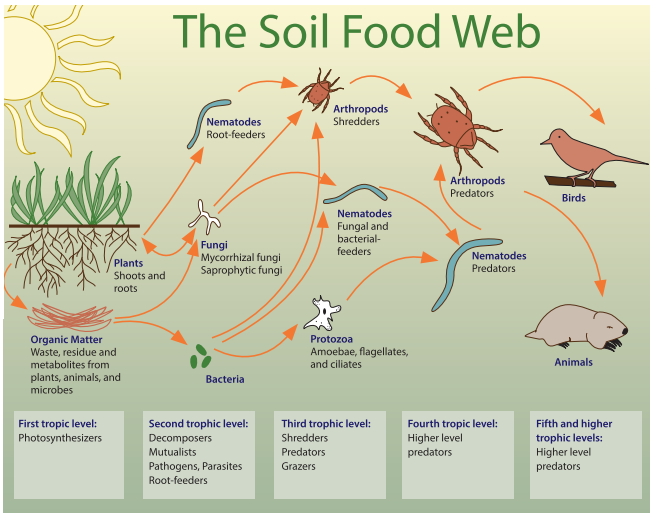

Figure 6. The soil food web (diversity and interactions of soil life). Reprinted from Tugel, Lewandowski, and Happe-vonArb (2000).

No/Reduced Tillage

Adopting a no-till or reduced tillage option increases the soil organic matter, reduces the cost of land preparation, and encourages earthworm populations. These outcomes invariably improve soil structure, water-holding capacity, soil biodiversity, and infiltration, as well as reduce runoff.

Cover Crops

Cover crops keep the soil covered between crop productions. The use of cover crops helps to prevent erosion, suppress perennial and winter annual weeds, and alleviate soil compaction. Cover crops can also reduce nutrient leaching by serving as catch crops and can ultimately add organic matter to the soil. Cover crops have been shown to benefit a wide range of soils and climatic conditions (Clark 2007). With several varieties of cover crops to choose from, including ryegrass, forage radish, hairy vetch, rye, clover, mustard, oats, and wheat, those chosen should depend on the goals and objectives of use as well as the crop being produced or the field conditions.

Crop Rotation

Crop rotation is one of the oldest and most-effective cultural control strategies; it systematically changes the crop family to be planted in succession within a given field. Crop rotation prevents soil depletion, maintains soil fertility, reduces soil erosion, controls insect pests, and breaks disease cycles. Rotation also enhances soil biological diversity and sustainable cropping systems, reduces reliance on synthetic chemicals, and helps control weeds.

Compost and Organic Amendments

Composting is the aerobic biodegradation of selected organic materials, mixed together in the right proportion under controlled conditions, resulting in a rich humus-like material. Compost is an important supplement in both organic and traditional (nonorganic) production. Compost can add organic matter to the soil and deliver beneficial nutrients. Composted material is more uniform than noncomposted materials and has less odor, a better carbon-to-nitrogen ratio, and reduced pests, diseases, and weed seeds. Compost, when properly prepared, improves the structure and fertility of the soil as well as its water-holding capacity.

Agroforestry and Others

Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits. It has been practiced in the United States and around the world for centuries (USDA 2015). The intensive and interactive nature of agroforestry operations combine agricultural and forestry technologies to sustain and restore the soil.

Organic Matter

Organic matter is considered the single most important property that determines and maintains soil health. Organic matter has a profound and positive influence on the physical, chemical, and biological properties of any soil. Organic matter helps recycle and reuse nutrients, builds structure, maintains tilth, increases water-holding capacity, and minimizes erosion. Soil organic matter also improves the soil biology as it affects the number and diversity of the organisms in the soil.

Organic matter originates from three primary sources: plant tissues, which include production crops/ plant residues; animal tissues including microbial populations; and waste materials such as manures and the organic components of garbage (Brevik 2009). Almost all the management practices discussed above, such as cover cropping, reduced tillage, and compost, when applied properly, will eventually build the soil organic matter, which in turn will benefit agricultural yields and allow for sustainable cropping of the land. Organic matter builds soil aggregates and improves the soil physical structure, and it impacts soil chemical properties because essential plant nutrients are released during the decomposition of soil organic matter.

How to Start Managing for Soil Health

Soil health, just like human health, results from the overall management of several resources rather than from a single fix. Knowledge of soils, soil differences, and soil condition needs to be translated into action. A relevant, ongoing question should be, "What management actions are required to maintain or improve soil condition and get the best from the soil?" The following steps, though not exclusive, are useful in achieving and maintaining soil health.

Assessment and Monitoring

- Identify your current situation as a farmer or landowner/-user and determine the need of your land.
- Assess your land and check for common problems like erosion, compaction, high pest pressure, drought-prone soils, low organic matter, loss of biodiversity, etc.
- Sample your soil and submit it for a laboratory analysis of nutrients, organic matter, etc.
- Use the laboratory analysis to determine the condition of your land. What are the initial management options?
- Monitor your land's performance plan periodically.

Plan According to Your Situation

- What do you intend to use the land for — plants (what kind?), livestock, mixed planting?
- Are you a beginning farmer or an established one? A beginning farmer would easily plan with soil health in mind, while an established farmer could methodically incorporate soil health into existing production practices. This is because the new farmer could follow the guidelines necessary for soil health from the beginning without jeopardizing the production setup, as might an established farmer.

Soil Health Guidelines

Soil health guidelines are the specific soil health steps necessary for each farmer and their farm. After the initial assessment and planning, develop soil health guidelines for your field. These guidelines will depend on your soil type, crop production interests and budget.

- Do a regular check on your soil samples to monitor for nutrients and soil pH. Virginia Cooperative Extension recommends that soil samples be tested at least every three years, with more frequent sampling for problem fields and to obtain further information.
- Pay attention to the soil health indicators discussed.
- Keep your soil covered at all times.
- Do not disturb your soil. Use tillage only when necessary.
- Invest in your soil conditions and soil health.
- Know your soil and translate that knowledge into managing your soil properly for optimal soil health.
- Periodically update your soil health guidelines according to the needs of your soil.

Seek Help

Do not hesitate to seek help from numerous soil educators around your region. The Virginia Cooperative Extension website (www.ext.vt.edu) has contact information for each region and county.

Conclusion

Soil health affects human health because soil is an important global resource for both agriculture and the environment. Soil health is fundamentally linked to land productivity and environmental sustainability. Many reasons have been outlined here for improving and maintaining the health of the soils. It is important to note that the best methods for improving and maintaining soil health are different for each particular situation; hence, there is no single approach to soil health. However, a variety of practices are available for improving soil health. Such practices generally include reducing tillage, adding organic amendments, cover cropping, and crop rotation. It is critical to understand the state of the soil through soil health assessment and to develop both short- and long-term strategies to address soil health issues in your field. A centuries-old notable quote beautifully summarizes this: "To be a successful farmer one must first know the nature of the soil." — Xenophon, from "Oeconomicus" (400 B.C.)

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