Soil Health Fact Sheets – Ocean County

New Commercial and Residential Developments

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What are New Commercial and Residential Developments?

New commercial and residential developments are new developments that are established upon land with no existing building or pavement or physical preparation for construction of buildings or pavement. These new development areas occur on forestland, pastureland, or agricultural land areas that may or may not be adjacent to existing new developments.

What is Soil?

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface. It consists of mineral particles of different sizes (sand, silt, and clay), organic matter, water, air, and numerous living organisms. Soil has biological, chemical, and physical properties. It is not an inert, lifeless medium but rather a living matrix of solid, liquid, and gas, with microorganisms, earthworms, fungi, bacteria, insects, living and decayed organic matter, water, air, and nutrients, all engaged in a biological and chemical give-and-take of energy and elements.

What is Soil Quality?

Soil Quality is simply how well soil does what we want it to do. More specifically, soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystems, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. For people active in production agriculture, it may mean highly productive land, sustaining or enhancing productivity, maximizing profits, or maintaining the soil resource for future generations. Soil Quality is the integration of the physical, chemical and biological properties of the soil.

Why is Soil Health Important in Planning New Developments?

A healthy soil provides a link to plant, animal, and human health. Soil provides essential ecosystem services that benefit all of us. Soil supports the growth and diversity of plants and animals by providing a physical, chemical, and biological environment where the exchange of water, nutrients, energy and air occurs. Soil regulates and partitions rainfall, regulates flow and storage of water and solutes, including nitrogen, phosphorus, pesticides and other nutrients and compounds that are in dissolved water. Soil stores, moderates the release of, and cycles plant nutrients and other elements. Soil acts as a living filter that serves to protect and enhance our entire ecosystem.

Construction activities can be major contributors to poor water and air quality from sedimentation and dust in new developments. Changes in water quality in adjacent streams and wetlands commonly indicate poor management of new developments. For example, a lower abundance of organisms, such as crayfish and dragonflies, in streams can be an indicator of poorly managed new developments nearby. Runoff is water that cannot infiltrate the soil and flows across the land surface, picking up soil particles and any other objects that can be moved as sediment during rainstorms and periods of flooding. Sediment can clog streets and storm drains with mud, and floodwater can carry excess phosphorus, nitrogen, and other contaminants to streams or lakes. Excess nutrients, attached to soil particles in sediment may cause algae blooms and poor underwater visibility. Algae blooms are sometimes health hazards and impact swimming and fishing. Algae blooms and sedimentation also decreases water quality, usually by reducing the oxygen content.

Many common development practices severely damage the long-term ability of soil to function. Often, large tracts of land are cleared of vegetation and left bare and unprotected for extended periods. The valuable topsoil erodes away or may be deliberately removed. Heavy equipment is driven over much of the soil, causing long-term deep compaction that reduces the ability of soil to absorb and hold water, and the ability of roots to penetrate through the soil. The layer of topsoil and sod placed on top of the compacted subsoil may be too thin to support healthy turf and landscape plants. The plantings require frequent fertilizer applications and irrigation because the soil cannot hold adequate water and nutrients.

Much of this damage can be prevented by preserving existing soil and vegetation if it is healthy (functioning well), limiting construction traffic to as small a portion of the development tract as possible, and ensuring adequate topsoil quality and depth.

Changes in soil health that occur as a result of management affect:

- The amount of water from rainfall and snowmelt that is available for plant growth;
- Runoff, water infiltration, and the potential for erosion; the availability of nutrients for plant growth;
- The conditions needed for germination, seedling establishment, vegetative reproduction, and root growth;
- The ability of the soil to act as a filter and protect water and air quality.
- Carbon sequestration

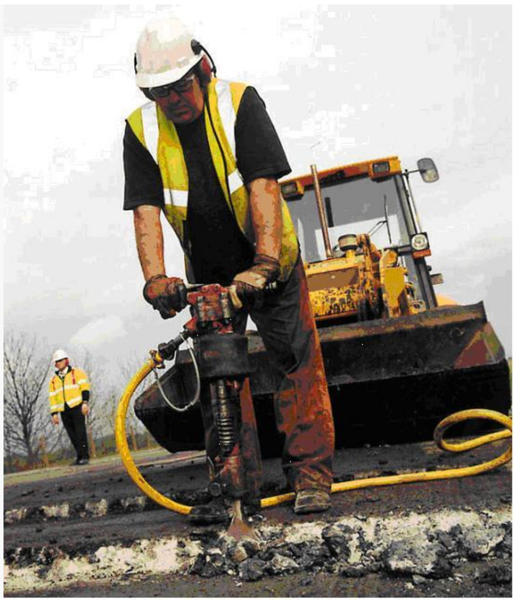
Many contractors and developers are unaware of or disinterested in the significant long-term economic impacts of common construction practices. Therefore, any effort to improve urban hydrology and soil quality must include a persistent educational component. Homebuyers need to learn that careful construction can substantially reduce long-term maintenance costs associated with irrigation, fertilizer, and plant replacement. Planners need to understand that preserving soil function will pay off in more effective and less expensive stormwater management systems. Builders need to know the direct cost savings of applying these practices such as easier planting, better initial plant growth, and fewer call-backs to replace dead plants, not to mention happier customers who will sell the next job. Site inspectors should be present to ensure the correct implementation of key processes, including sub-soiling and topsoil installation.

Natural Condition: notice 0.3% runoff and 36% groundwater recharge.

Developed Condition: notice 30% runoff and 15% groundwater recharge.

What Happens When Soil is Disturbed?

Soils on new developments have been disturbed by human activity in some manner and to some degree. This disturbance has changed the properties of the soil, and the soil should now be managed in a different manner. Some soils have to be altered before they are suitable for certain uses. Topsoil commonly is piled up and then spread on top of the altered soil after construction. In some strongly sloping areas, soil may be moved from one area to another to fill low-lying areas and level the site for construction.



After disturbance, the surface layer of new developments should have the characteristics needed for good plant growth. Management includes overcoming physical and chemical root restrictions, providing nutrients by managing soil fertility and acidity (pH), and reducing the likelihood of contamination or disease problems. In areas where the climate is dry, a water supply for the site also is needed.

Improperly planned development and subsequent construction activity can disrupt natural soil profiles, increases impervious surfaces and decreases vegetative cover. These disruptions increase stormwater runoff at the expense of groundwater recharge thus degrading water quality and impairing aquatic habitats. The repercussions of this non-point source pollution are being felt worldwide. Creative Best Management Practices (BMPs) that harness the ability of vegetation and soils to mitigate urban and suburban runoff are needed.

What are Inherent and Dynamic soil properties?

Soil has both inherent and dynamic qualities. *Inherent* soil quality is a soil's natural ability to function. For example, sandy soil drains faster than clayey soil. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics do not change easily. *Dynamic* soil quality describes the changes that result from management decisions. For example, soil compaction occurs from the use of heavy equipment under the wrong moisture conditions.

Compaction

Compaction is a familiar sight in areas of road and building construction, but it degrades soil for other important uses. It occurs when moist or wet soil particles are pressed together and the pore spaces between them are reduced. Adequate pore space is essential for the movement of water, air, and soil fauna through the soil. Restricted infiltration results in excessive runoff, erosion, nutrient loss, and potential water-quality problems. Compaction restricts penetration by plant roots and thus inhibits plant growth. Also, it can significantly reduce the rate of rainwater infiltration in new developments, thus increasing the volume of stormwater runoff. Soil is especially susceptible to compaction when it is moist or wet. A low content of organic matter, poor aggregate stability, and moist or wet conditions increase the likelihood of compaction.

Compacted subsurface layer causing stormwater basin not to function due to lack of infiltration.

Preventing soil compaction is important because all compaction is expensive to treat and deep compaction may have permanent, untreatable effects on plant growth. Certain strategies can minimize compaction.

A controlled traffic system can separate traffic zones from planting zones within a management area. Traffic is restricted to controlled zones between the rows. The soil should not be subject to traffic when it is wet!

Recognizing Compaction

Generally, compaction is a problem within the top 24 inches of the soil. There are several signs of compaction. Discolored or poor plant growth, especially in very wet or very dry years, may reflect the poor soil-plant-water relationships of compacted soils. Excessive runoff on sloping land and ponding on nearly level land are common in compacted areas because water does not infiltrate into the soil.

Surface ponding due to compacted soil.

Penetration resistance of the soil to a firm wire (survey flag) or stake increases in compacted areas. A shallow hole may reveal lateral root growth with little, if any, penetration of roots into compacted layers. Platy, blocky, dense, or massive layers may indicate compaction. Quantitative methods of detecting compaction include measuring penetration resistance with a commercially available cone penetrometer and measuring soil bulk density by other methods. Soil texture must be considered in evaluating bulk density values.

Alleviating Compaction

Shallow soil compaction generally can be alleviated by chisel plowing at shallow depths. Deep compaction requires sub-soiling, which refers to tillage at a depth of at least 14 inches. Chiseling and sub-soiling are expensive, and their benefits are generally not long lasting if traffic continues. Before these methods are implemented, the depth and extent of the compaction problem should be determined. Sub-soiling should occur when the soil is dry enough for the equipment to fracture the compaction zone properly but moist enough for the equipment to pull the shank. Sub-soiling when the soil is too dry will disturb more surface soil, and sub-soiling when it is too wet will not fracture the compacted layer. Deep-rooted perennials should be considered where compaction is not too severe and mechanical sub-soiling is not practical.

Organic Matter

Many soil properties impact soil health but organic matter is the most limiting factor. It affects several critical soil functions and can be manipulated by management practices. Organic matter enhances water and nutrient holding capacity and improves overall soil structure. Managing for soil carbon or organic matter enhances the productivity and environmental quality of our ecosystems. Soils high in organic matter content can typically reduce the severity and costs of natural disasters such as drought, flood and diseases. Moreover, increasing soil organic matter levels can reduce atmospheric CO_2 levels that contribute to climate change.

Organic residues on the soil surface and within the soil profile have been shown to cushion the effects of compaction. Organic matter acts like a sponge in that the organic matter is compressed and then springs back to its normal shape. Plant debris and residues attach to soil particles and keeps them from compacting. Organic matter binds micro-aggregates into macro-aggregates in the soil. Soil compaction has a biological component and the *root* cause of soil compaction is a lack of actively growing plants and active roots in the soil. Plant roots create voids and macro-pores in the soil for air and water movement. It is best to keep the soil covered in vegetation as much as practical.

Plant roots act like a biological valve to control the amount of oxygen in the soil to preserve soil organic matter. Plant roots supply food for soil microbes and soil fauna. Residual organic residues (plants, roots, microbes) are lighter and less dense than soil particles. Polysaccharides from plants and glomalin (soil glue) from fungus weakly hold the micro-aggregates together but are consumed by bacteria so they need to be continually reproduced in the soil to improve soil structure. Glomalin, is produced by a beneficial fungus that grows on plant roots. The glue comes off of the fungus and is deposited on soil particles. This process leads to build up and stabilization of soil aggregates. These glues are carbon containing compounds that protect the microorganisms from drying out. These fungi are beneficial to plants because of hyphae, hair like projections of the fungus. The hyphae extend further out into the soil profile from the plant roots, thus increasing the potential nutrient pool. Increasing the organic matter content in soil feeds the soil microorganisms that then in turn results in fungi creating more glomalin – this is the "glue" that holds soil particles together.

What are Soil Health Indicators that can help determine overall Soil Function?

Indicators of soil quality can be categorized into four general groups: visual, physical, chemical and biological. ***Visual indicators*** may be obtained from observation or photographic interpretation. Exposure of subsoil, change in soil color, ephemeral gullies, ponding, runoff, plant response, weed species, blowing soil and deposition are only a few examples of potential indicators. ***Physical indicators*** are related to the arrangement of solid particles and pores. Examples include topsoil depth, bulk density, porosity, aggregate stability, texture, crusting, and compaction. Physical indicators primarily reflect limitations to root growth, seedling emergence, infiltration, or movement of water within the soil profile. ***Chemical indicators*** include measurements of pH, salinity, organic matter, phosphorus concentrations, cation-exchange capacity, nutrient cycling, and concentrations of elements that may be potential contaminants or those that are needed for plant growth and development. The soil's chemical condition affects soil-plant relations, water quality, buffering capacities, the availability of nutrients and water to plants and other soil organisms, mobility of contaminants, and some physical conditions such as the tendency for a surface soil crust to form. ***Biological indicators*** include measurements of micro- and macro-organisms, their activity, or byproducts. Respiration rates can be used to detect soil microbial activity, specifically soil microbial decomposition of organic matter, which is the key to the formation and stability of soil aggregates.

How does Soil Structure and Bulk Density help determine Soil Health?

Soil structure is of particular importance in the absorption of water and the circulation of air. A desirable structure should have a high proportion of medium-sized aggregates and an appreciable number of large pores through which water and air can move. Good soil structure is crucial to proper drainage, infiltration, and productivity. In soils with poor structure, root penetration is limited thus reducing the plants access to water and nutrients. There are three very important aspects of soil structure. They are (a) the arrangement into aggregates of a desirable shape and size, (b) the stability of the aggregate, and (c) the configuration of the pores, that is, whether or not they are connected to the surface by channels or isolated. Aggregates that are stable in water permit a greater rate of absorption of water and greater resistance to erosion. Aggregates that are unstable in water tend to slake and disperse. These aggregates, when exposed to raindrops, are particularly subject to dispersion and the resultant crusting of soils. The stability of aggregates is due to the kind of clay, the chemical elements associated with the clay, the nature of the products of decomposition or organic matter, and the nature of the microbial population.

Bulk density Bulk density refers to the weight of the oven-dry soil with its natural structural arrangement. The pore space between the soil particles is a part of the volume of soil measured for bulk density. Bulk density is expressed as grams per cubic centimeter. The variation in bulk density is due largely to the difference in total pore space. Because finer textured soils have higher percentages of total pore space, it follows that finer textured soils have smaller bulk density values. Compacted soils have lower percentages of total pore space and therefore, higher bulk densities. High and low bulk densities have great influences on engineering properties, water movement, rooting depth of plants, and many other physical limitations for soil interpretations. Bulk density is a critical soil property in assessing proper soil function.

This rain garden helps water infiltrate into the soil rather than runoff.

Summary

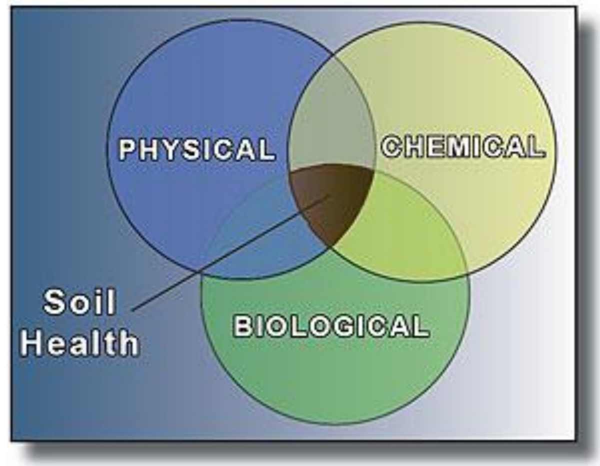
These facts help us begin to understand that new developments are very different from soils in natural areas. Even in undisturbed areas, no two soils are exactly alike. Thus, it is important to know all one can about a soil before it is used for any purpose, including urban and suburban projects. Most soil-related limitations can be overcome if you design, install and maintain a project properly. Costs to overcome project errors are often higher than the original project costs. Therefore, it is better to get it right the first time!

Where can I get more information on Soil Health?

For additional information go to the following websites:

- www.nj.nrcs.usda.gov
- www.soils.usda.gov/sqi
- www.soilhealth.org

The full series of Soil Quality Information Sheets is available at http://soils.usda.gov/sqi



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