The Nature of the Soil Environment

Mineral 44%
Water 25%
Air 23%
Organic Matter 2%

TURFGRASS SOIL PROPERTIES

- Physical Properties
- Chemical Properties
- Biological Properties
SOIL PHYSICAL PROPERTIES THAT INFLUENCE TURF PERFORMANCE AND FUNCTION

• Water flow in and through soils (drainage)
• Soil strength (root growth and stability)
• Temperature
• Aeration (root growth, microbial activity, chemical reactions)

SOIL CHEMICAL PROPERTIES:

• Nutrient amount and availability
• pH
• Toxic elements, salts and metals, etc.

SOIL BIOLOGICAL PROPERTIES:

• Pest reduction (diseases and insects)
• Nutrient cycling and availability
• Organic matter accumulation and decomposition (including thatch)
BASIC SOIL TERMINOLOGY

• Physical terms:
  - bulk density (g/cm³)
  - particle density (g/cm³)
  - infiltration rate (cm/hr or inches/hr)
  - saturated hydraulic conductivity (IR)
  - oxygen diffusion rate (µg O₂/cm²/sec)

BASIC SOIL TERMINOLOGY

• Physical terms:
  - total porosity
  - aeration porosity (at some water potential)
  - capillary porosity (″)

BASIC SOIL TERMINOLOGY

Physical terms for sand/gravel:

• Bridging factor: 15% of the largest sand particles bridge with the 15% of the smallest gravel particles
• Permeability factor: smallest 15% of gravel particles >/= five times the smallest sand particles
• Uniformity factors
What is a soil profile?

What is a soil profile like in a turf setting?
What is a soil profile like in a turf setting?

SOIL COLOR

DARK SOIL: associated with organic matter
BROWN-RED: adequate air + good drainage
YELLOW: imperfect drainage
MOTTLING/STREAKING: seasonal/periodic water problems
BLUE-GREEN GRAY: continuously wet/saturated

Soil Texture

amount of sand, silt and clay in a soil
SOIL TEXTURE

influences:

- drainage
- aeration
- water holding capacity
- nutrient holding ability

SOIL STRUCTURE

influences:

- soil moisture: infiltration, drainage
- aeration
- availability of nutrients
- microbial activity
Natural Activities that improve soil structure

- freezing and thawing
- wetting and drying
- root growth
- microbial activity

SOIL STRUCTURE

Aggregation depends on biological processes

- Gels produced by microbes
- Fungal hyphae
### Soil Physical and Chemical Properties

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Drainage</th>
<th>Susceptibility to Compaction</th>
<th>Water &amp; Nutrient Holding Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>excellent</td>
<td>little - none</td>
<td>limited</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>excellent</td>
<td>limited</td>
<td>limited</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>good</td>
<td>limited - moderate</td>
<td>moderate</td>
</tr>
<tr>
<td>Loam</td>
<td>good-fair</td>
<td>moderate</td>
<td>moderate - substantial</td>
</tr>
<tr>
<td>Silt loam</td>
<td>fair-poor</td>
<td>substantial</td>
<td>substantial</td>
</tr>
<tr>
<td>Clay loam</td>
<td>fair-poor</td>
<td>substantial</td>
<td>substantial</td>
</tr>
<tr>
<td>Clay</td>
<td>poor</td>
<td>substantial</td>
<td>substantial</td>
</tr>
</tbody>
</table>

### Chemical Properties of Soil: pH Affects

Nutrient availability microorganisms

### Chemical Properties of Soil-pH

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>pH at Maximum availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>6-8</td>
</tr>
<tr>
<td>phosphorus</td>
<td>6.5-7.5</td>
</tr>
<tr>
<td>potassium &amp; sulfur</td>
<td>&gt; 6</td>
</tr>
<tr>
<td>calcium, magnesium</td>
<td>7-8.5</td>
</tr>
<tr>
<td>iron</td>
<td>&lt;6</td>
</tr>
<tr>
<td>Mn, Cu, Zn</td>
<td>5-7</td>
</tr>
</tbody>
</table>

recommended range for turf?
Chemical properties of soil: Cation exchange

Nutrient reservoir:
Cation exchange capacity

Humus or clay

Soil solution

Where Do Soil Organisms Live?

- Microorganisms live as biofilms associated with plants (seeds and roots), other soil organisms, on soil particles, and embedded in organic matter.
- Larger organisms live in soil pores.
- Most organisms can be found in the upper few inches of the soil profile.
The Spermosphere

The Rhizosphere

Major Soil Microorganisms
- Bacteria
- Archaea
- Actinobacteria
- Fungi
- Algae/Cyanobacteria
- Protozoa
- Nematodes
- Microarthropods
  - Mites
  - Collembola
  - Rove Beetles
Bacterial Cells Root Surfaces

Predominant Activities of Bacteria in Turfgrass Soils
• Organic Matter Degradation
• Primary Nutrient Cycling Organisms
• Major Influences on Soil Structure
• Pesticide Degradation
• Produce Plant Hormones for Enhanced Plant Growth
• Biological Control of Pests

Predominant Activities of Actinobacteria in Turfgrass Soils
• Organic Matter Degradation
• Biological Control of Diseases
Fungi

Fungal Colonies on a Putting Green

Fungi and Bacteria on Plant Roots
Predominant Activities of Fungi in Turfgrass Soils
- Organic Matter Degradation
- Symbiotic Associations with Plants
- Improve Soil Structure
- Parasitic Interactions with Plants, Insects, and Fungal Pathogens
- Produce Antibiotics

Other Organisms in Soils

Protozoa
Components of Soil Organic Matter

- Decomposing organic residues constitute between 33 and 50% of the organic matter in soils
- Between 33 and 50% may be in the form of humus
- Fresh organic residues constitute <10%
- Organic matter in the form of microbial biomass is generally <5%

ROLE OF SOIL ORGANIC MATTER

Two major components:

- Effects of the organic matter itself
  - soil structure, chelation of micronutrients, pH buffering capacity
- Effects of decomposition of organic residues
  - aggregation, nutrient release, biological activity, disease suppression

SOIL ORGANIC MATTER CONTINUUM

- Easily decomposed
  - clippings
- Resistant to decomposition-thatch
- Compost, slow release fertilizers
What is thatch?

- layer of dead or dying organic matter composed of roots and stems (rhizomes, stolons and crowns) and little or no clippings
Properties of thatch

- well aerated having very large pores
- resists compaction
- little or no water and nutrient holding capacity
- acts as a bio-filter of pesticides
- greater temperature extremes than soil

Problems with thatch

- roots often limited to thatch layer
- more drought susceptible
- lower tolerance of high and low temperature
- more insect and disease problems
- scalping
- poor root zone pest control
- increase in pesticide phytotoxicity

Good points of thatch

- insulates soil from temperature extremes
- cushioning effect
- less pesticide leaching
Why does thatch accumulate?

- imbalance between production and degradation of organic material
- some species and cultivars produce more thatch (more lignin)
- too high or too low nitrogen applications
- late fall applied nitrogen (more root growth)

Why does thatch accumulate?

- high mowing heights (more roots)
- low soil pH ≪ 6
- temperature and moisture extremes (low microbial break down)
- some pesticides increase thatch by: increasing growth or reducing reduction

pH !!!!!

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Thatch (mm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td>12</td>
<td>4.7</td>
</tr>
<tr>
<td>lime</td>
<td>3</td>
<td>6.7</td>
</tr>
<tr>
<td>gypsum</td>
<td>4</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Principles of Water Movement and Drainage, Normal water flow

Preferential Flow-finger flow in sand

Principles of Water Movement and Drainage, Preferential Flow-Earthworm channels
Principles of Water Movement and Drainage, Water repellent soil

Principles of Water Movement and Drainage
Increase surface drainage-wetting agents
Principles of Water Movement and Drainage

Increase surface drainage with wetting agents

Typical turfgrass symptoms of soil problems

- shallow but extensive root system
- little or no roots below 4 inches
- little or no top growth (immediately after a major use)
- off-color, very chlorotic tissue

Typical turfgrass symptoms of soil problems

- wilts easily
- low turf density with weeds
- poor response to fertilization and soil related pesticides
- poorly drained, prolonged wet soils, making the site difficult to use
- water easily runs off the turf surface or collects in low spots
Causes of soil problems

• soil compaction during construction (often very deep compaction)
  
  big equipment syndrome
  
  hire contractors with turf construction experience

Causes of soil problems

Soil compaction from normal use such as

  games, golfing and normal maintenance

  often resulting in surface soil compaction (top 4 inches)

Causes of soil problems

• soil compaction from excess use
  - not enough fields
  - too many golfers
  - not enough pin placements or traffic is channeled into one area
Causes of soil problems

- Improper soil for the intended use of the site
- Poor construction techniques
  - Soils too wet
  - Used too much heavy equipment
  - Worked soil too much

Causes of soil problems

- Poorly drained sites or sites with no drainage outlet
- Use during wet conditions
  - Rutting (soil displacement)
  - More compaction with wet soils than dry soils, why?
- Thatch and other layers that impede water flow
  - (Perched water table concept and sand topdressing over fine texture soils)

Soil problem

**Situation:**
The sand based greens at the new Turning Stone Casino golf courses have high spots that are always dry. The greens are undulating, have a maximum of a 6% slope and are built to USGA recommendations with 12" of a 80% sand to 20% peat (by volume) over a 4 inch gravel layer. The layers are slope to match the surface topography.

**Analysis:** Analyze the situation from a scientific perspective. What do you feel is causing the dry areas on the high spots of the greens and why is this a problem?

**Strategies:** Give your ideas on how to cure this problem.