UNDERSTANDING TURF MANAGEMENT

The third in a series by
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SOIL STRUCTURE, DENSITY AND POROSITY

If the mixture of sand, silt and clay particles in the soil remained separated as individual particles the smaller particles of clay and silt would migrate into the holes between the larger sand fragments to create a dense material such as found at depth in the subsoil of a normal soil. An analogy would be to take a bin of softballs, fill the bin with marbles, shake it till no more marbles can be added, then add SCU pellets until no more of them can be added. This simulation would have little porosity and is analogous to a dense, compacted soil.

Such a soil would be very poor for root growth as it would have little air or water movement and much resistance to root penetration. Good turf management requires the use of cultural practices which will help to reverse this situation.

SOIL STRUCTURE

Fortunately soil particles tend to group together into larger, semi-permanent arrangements known as aggregates (clods, peds, crumbs). The result of aggregation is called soil structure and its importance is that it tends to make soils which are high in clay act like sand in terms of air and water movement.

There are a number of factors influencing the ability of a soil to have a stable soil structure. The primary factor is soil organic matter whose breakdown products create a cementing effect, holding the mineral particles together. Calcium, iron and the type of clay also have an effect.

It is necessary, however, to move the particles close together before the cementing action can become effective. This movement is brought about through root action, soil organisms such as earthworms, freezing and thawing, and wetting and drying of the soil.

Of prime importance is the resistance of the aggregates to disintegration under the destructive forces of wind, rain, vehicle and foot traffic; the latter two being the forces of concern on sport fields. Stability is very closely related to the amount and type of organic matter present, with turf providing the most effective means of promoting stable soil structure. Nevertheless under continued traffic, particularly when the soil is excessively moist, the structure can be destroyed and the soil will compacted.

Soil structure is of great significance where the soil contains silt and clay. **Soil structure, however, is not a factor in sport fields constructed on sand as sands will not form aggregates. This is why selection of the correct size distribution of sands is critical to prevent migration of fine sand particles into the spaces between the larger sand grains, creating a dense root zone.**

SOIL DENSITY

The degree of compaction of a soil is measured by determining the apparent (bulk) density of the soil. The determination is a simple procedure, involving the insertion of a small (5-cm diam. X 2-cm deep) ring into the soil. The ring is carefully excavated, trimmed level at the top and bottom and dried for 48 hours at 100C. The density is the dry weight of the soil in each cubic centimetre of volume;this volume includes both solid particles and the spaces between the particles - the porosity. The more compacted a soil the greater the density; that is, the greater the weight of soil particles compressed into each cubic centimetre and the smaller the air spaces (Table 1).

Table 1: The relationship between compaction, apparent density and porosity.

Degree of Compaction	Apparent Density (gm/cm^3)	Total Porosity (%)	Macro Porosity (%)	Micro Porosity (%)
Low	1.31	50.5	21.5	29.0
Medium	1.49	43.7	15.8	27.9
High	1.64	38.1	10.9	27.2

Soils may vary in density from 1.0 to 1.75 gm/cm^3. Then ideal soil described in the first article of this series would have a density of 1.32. It may be calculated to show that such a value would have 50% pore space. Natural soils with densities beyond 1.55 can be considered to have compaction problems. Sports fields constructed on sand, however, can be expected to have a density as high as 1.65 while still retaining good air and water characteristics.

SOIL POROSITY

The first article in this series describe the relationship between mineral and organic material, air and water. The air and water in the soil existed in the pore space in the soil, thus an understanding of soil porosity is a further step in understanding good turf management.

The size of the pores range from submicroscopic between silt and clay particles to the very large pores visible to the eye which are formed by earthworms and decaying root channels - commonly called biopores. For this discussion they may be divided into two broad groups - *macro pores,* the larger pores, and *micro pores,* the smaller range of pores.

Analytical techniques exist which permit the assessment of the relative percentage of each group of pores in a soil sample. The total porosity may be calculated directly from the density measurements. This single value, however, says nothing about the size of the pores which is important in water movement.

Other techniques, which give an assessment of the relative size of the pores are based on the amount of water retained in the soil in a container, such as the ring described above, when it is placed in a special apparatus to which suction can be applied. When the soil is saturated with water 100% of the pores are filled with water, thus the total pore space equals the volume of water in a measured volume of soil. If the soil is allowed to drain freely until all the water that will flow out due to the pull of gravity has occurred the *macro pores* will be empty. The volume of water that is removed in this process from a measured volume of soil is the macro porosity. Since the macro porosity plus the micro porosity must equal the total porosity the micro porosity is obtained by subtraction.

Macro porosity (non-capillary porosity, aeration porosity) is important in the rapid drainage of excess water from the soil after a heavy rain or excessive irrigation. Rapid removal of this water allows the air essential for root function to return to the soil.

Micro porosity (capillary porosity) retains the water required for plant growth. It also becomes filled with air as the plant extracts the water from these fine pores. The water in these pores is not lost by the forces of gravity. However, the smaller the pores, the greater the difficulty the plant experiences in extracting the water.

Compaction results in a reduction in the number, size and continuity of the soil pores. Generally the macro pores will be destroyed first (Table 1), reducing the rate of water infiltration and the drainage ability of the soil, the aeration of the soil and the ability of roots to penetrate the soil. The lack of oxygen further reduces the grass roots ability to penetrate the soil. The more moist a soil the more easily it can be compacted because the water acts as a lubricant allowing the particles to move into closer arrangements.

Fortunately, the grass ecosystem is recognized as the optimum system for promoting soil structure, hence reducing the apparent density of the soil and increasing the porosity of the soil, particularly the macro porosity. Hence using cultural practices which favour vigorous turf growth, combined with adequate drainage, is the best preventative system against compaction.