Concepts In Moisture Management

by Jim Hermann, CSFM

As the demand for Sports turf quality and playability continues to increase, moisture management has the ability to become the limiting factor in an otherwise effective management program. Irrigation and drainage, a marriage made in heaven. The irrigation giveth and the drainage taketh away. The increased individual benefit created by their combined applications (synergism), developed through the proper understanding and implementation of each of these systems will without question add to the durability and quality of any athletic field.

In order to understand moisture management a basic understanding of soils is necessary. The soil is composed of many individual particles. These particles are classified by order of their size. Sand being the largest particles, silt in the middle and clay being the smallest particles in the soil. The spaces between these particles are known as pores. There are smaller pores created by the stacking of smaller particles known as 'micro' pores, which hold moisture and nutrients in a soil solution, and there are larger pores created by the stacking of larger particles known as 'macro' pores, which not only provide an avenue for water and good air (oxygen) to enter the soil, but also an avenue for the escape of bad air (gases) produced in the soil. Turf roots generally require larger pores in excess of .1mm to efficiently force their way through the soil. At .1mm we are talking about pores around 4/1000 of an inch in diameter.

'Soil solution' is defined as the aqueous liquid phase of the soil and its solutes. Harpstead, M.I., T. Sauer, W.F. Bennett. 2001. *Soil Science Simplified* Iowa State University Press, Ames Iowa, 4th edition

In an adequately aerated, well structured soil, excess moisture drains through the macro pores, providing of course there is a place for the water to go. Water also infiltrates the soil through these macro pores. Infiltration is defined as the downward entry of water into the soil.

In a coarse textured sandy soil, the larger particle sizes create the macro pores. In a fine textured clayey soil the macro pores are the product of soil aggregates. Aggregation is the cementing together of smaller soil particles to create larger particles by various organic compounds, clay, oxides and various salts. Many influences affect aggregation and therefore the macro or larger pore space of finer textured soils. In high traffic areas of athletic fields such as goalmouths, soil structure or aggregation of finer textured clayey soils can break down, severely compromising macro pore space and therefore compromising infiltration, percolation, aeration, root development and efficient moisture and nutrient utilization. Once soil structure is destroyed, it can take years to reestablish.

When discussing moisture management, a few terms need to be understood. Saturation, free water, field capacity and wilting point are terms used when describing moisture levels in the soil. 'Saturation' of the soil is reached when all the soil pores are filled with water. 'Free water' or gravitational water as it is also referred to, is the water contained within the larger pores when the soil is saturated. This is the water that has the ability to drain from the soil given the forces of gravity and a place to go. 'Field capacity' would be considered the point at which all 'free water' has drained from the larger pores of the soil due to gravity. At field capacity, all remaining moisture in the soil is held against the force of gravity in the 'micro' or smaller pores.

I believe it important to note; the same fine textured clayey soil that can remain completely saturated at field capacity also has the potential to attain acceptable drainage characteristics given adequate particle aggregation, aeration and a place for the water to go.

Here is an example of saturation vs. field capacity: take a sponge and submerse it in water. Once the bubbles stop, the sponge is totally saturated. All the air space has been replaced with water.

Note: there will always be some air trapped in the sponge and also the soil but we will say 'all' for the sake of argument. When you remove the sponge from the water, the water that flows freely from the sponge is known as 'free water'. When the water stops flowing, the sponge is said to be at sponge or 'field capacity'. The amount of water that remains in the sponge after all free water is removed varies with the size and number of pore spaces within the sponge just as it does within the soil. If the sponge is allowed to dry due to evaporation of remaining moisture, this lack of moisture could be compared to the 'wilting point' of soil. The 'wilting point' is the point at which plants can no longer extract moisture from the soil.

As the soil moisture level increases and this level comes closer to field capacity the soil becomes increasingly unstable. The soil has less resistance to the forces of traffic and wear. There is an increased tendency for the soil to compact under vertical pressure. Moisture surrounding the soil particles acts like a lubricant allowing the soil particles to more easily slide closer together, interpacking. Smaller particles are capable of filling the macro pores created by larger particles, minimizing macro pore space and creating compaction, poor drainage and inadequate aeration of the soil. There is also the increased tendency for turf tear out caused by the lateral pressure of stopping, twisting and turning. As the soil goes beyond field capacity and saturation is reached, the soil is even more unstable. At the point the soil is more capable of smearing and eroding. Soil structure and aggregation can be severely compromised.

As moisture levels diminish from field capacity, the soil becomes more stable. It becomes more wear tolerant. The forces of cohesion and adhesion become stronger holding the soil particles together. Cohesion or surface tension as it is sometimes referred to, is the waters attraction to itself and is the force that creates water droplets. Adhesion is the attraction between moisture and soil particles. This combined force could be considered the glue that holds the soil particles together creating increased stability at lower moisture levels.

Adhesion and cohesion hold moisture in the soil against the forces of gravity and at higher levels against the forces of suction exerted by plant roots. These forces compete with the suction of the turf plant in its effort to take up moisture and nutrients from the soil solution. The point at which the turf can no longer extract moisture from the soil solution is again known as the 'wilting point'. At this point turf can die. In addition, as the soil continues to dry, it again becomes more unstable. Dust and wind erosion are products of this instability. Maintaining stability within the soil profile becomes an important issue in moisture management. It becomes a balancing act to provide adequate moisture for turf maintenance without over watering and developing excessive instability within the root zone.

I believe it is important to understand that these same forces that affect the stability of a root zone are the very same forces that affect the stability of a baseball infield mix. Moisture management and its affects on infield mix stability, safety and playability has the potential to become a limiting factor in your infield management program.

Moisture has two means of movement in the soil. The first and most obvious is gravitational movement of free water. Water not held sufficiently by surface tension (cohesion) and adhesion to the soil particles is pulled through the macro pores of the soil by gravitational pull. Hence the term 'water runs down hill'. This term should be altered to read 'free water runs down hill'. The other means of moisture movement in the soil is capillary movement.

Capillary movement can be described in the following manner. Once all free water has drained from the soil, the soil particles remain covered with a film of moisture. As the turf roots take in moisture from the soil solution surrounding particles adjacent to the roots, cohesion and adhesion cause moisture to move from soil particles with thicker films to soil particles with thinner films that are next to the roots.

Gravitational pull has little affect on capillary movement. Example: Create a small puddle of water on a level, flat surface such as a tabletop. The water clings to itself and remains in a puddle due to cohesion. It clings to the tabletop surface due to adhesion. Adhesion is defined as the physical attraction of two dissimilar materials and as such can vary considerably between different materials. Most tabletops have poor adhesive qualities by design, otherwise everything would stick to them. In the soil profile, on the other hand, adhesion is generally the dominant force in capillary moisture movement. Place the corner of a paper towel in contact with the puddle. The water is adsorbed 'up' into the paper towel against the force of gravity due to capillary movement within the paper towel. Moisture moves toward the turf roots, soil particle by soil particle in much the same way it moves within the fibers of the paper towel. It should be noted that lateral or horizontal movement of moisture in the soil is very slow. For this reason among others it is most beneficial for turf to have a deep dense root system in order to efficiently seek out and utilize available moisture and nutrients.

Once all free water has drained from the soil and field capacity is reached, there are two main avenues through which moisture can be eliminated from the soil solution. One avenue of elimination is evaporation directly into the air at the soil surface. The other is transpiration into the air through the turf blades as moisture is taken in through the roots and utilized by the turf. The cumulative total of these two forces is evapotranspiration or ET.

The purpose of an irrigation system is to aid natural rainfall in efficiently maintaining moisture at a level somewhere between field capacity and the turf stress point (the point where the turf is showing visible stress) by replacing moisture lost through evapotranspiration. This 'soil moisture deficit' will vary based on the soil characteristics. It is the responsibility of the sports field manager to understand the soil he is dealing with in order that he might effectively and properly manage his or her system.

Due to the reduced 'available water capacity' or amount of water held between field capacity and permanent wilting point of a sandy soil as compared to that of a clayey soil, light irrigation at more frequent intervals is necessary to recharge a sandy soil and maintain 'easily available moisture' within the root zone. Over watering will cause water and nutrients to travel or percolate beyond the root zone. Percolation is the downward movement of water through the soil.

Fine textured clayey soils should be watered more heavily and less frequently than sandy soils due to increased available water capacity. Soil must be wet to 'field capacity' during the process of irrigation to insure uniform wetting. Light frequent watering of fine textured clayey soils will encourage shallow rooting.

An interesting note: Although more moisture is held in a clayey soil between the permanent wilting point and field capacity, than is held in a sandy soil, some of this moisture is not 'easily available water' to the plant. Easily available water is that water available to the plant in excess of that which would be considered limiting in the growth of the plant. This limitation is due to the increased forces of cohesion and adhesion caused by lower moisture levels in combination with smaller particle size. Moisture is held by the soil with much more persistence than can be exerted by the plant in the form of suction. There is moisture in the soil but it is not available to the turf. In contrast almost all the water held in a sandy soil between permanent wilting point and field capacity is 'easily available water'

The purpose of a drainage system is to effectively and efficiently allow for the removal of free water from the soil profile and return the soil to field capacity. It is a misconception to believe that a drainage system can effectively remove moisture below the level of field capacity. I once heard it stated that the outlet of a drainage system was plugged because it was assumed that the drainage system caused the soil to dry out too much. This is a false assumption. Increased soil moisture deficit caused by internal man made drainage is at best localized within the area of the drains due to the inefficiency of lateral moisture movement within the soil profile.

Note: lateral or sideways water movement in a soil is relative to available soil pore space just as is downward water movement. Its benefits on drainage are proportionately less than downward water movement due to the decreased force of gravity. This factor is of major concern when determining drain spacing and can only be calculated accurately through the use of mathematical formulas, which are far beyond the abilities of this sports field manager.

The moisture deficit developed within close proximity to underground drainage, made evident by browning of turf is typically only noticeable under prolonged drought conditions and should not be considered a limiting factor in the efficiency of an internal drainage system. I would be more inclined to identify inefficient irrigation as the limiting factor in that situation. I hope some of the principles discussed in this article sheds light on this misconception.

When developing a drainage strategy the first consideration is to determine whether or not the water problem you are facing is derived from ground water such as an underground spring or high water table, or if your water problem is caused by surface water such as rain or run off. At the most basic level it is important to accept that ground water needs to be intercepted underground before it reaches the surface by the use of underground piping. Surface water needs to be intercepted at the surface before it soaks and saturates the soil whenever possible. This can be done with the effective use of proper field grading, swales and diversions.

Further control of surface water can be accomplished through slit drainage. Slit drainage is a series of narrow vertical trenches dug into the field and backfilled with sand to the surface. Some have pipes in the bottom of the trench. Others do not. Usually these trenches connect with larger collector trenches, which have pipes in the bottom to carry the water away to an appropriate storm water outlet. By extending the drainage material to the surface, free water is allowed to not only enter the sides of the trench from within the soil profile but also from the surface of the trench. If installed properly this ability makes slit drainage very efficient.

It should be understood that the principles and concepts provided in this article are very basic. Most all of us are sports field managers and not soil scientists. Our understanding of the different aspects of turf management is generated on a need to know basis. As the demand for quality, safety and playability of our sports fields increases, this demand will continue to push us to the limits of our abilities and understanding. I don't claim to know all there is to know about moisture management and its relationship to soil physics but I will continue to read and increase my understanding. As I do I will continue to provide our readers with what I consider to be accurate useable information. ◆

The following books were used as reference material and are highly recommended reading material for anyone wishing to gain more knowledge in this area.

Mcintyre, K. and Jacobsen, B. 2000. *Practical Drainage for Golf, Sportsturf and Horticulture* Sleeping Bear Press

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Ask The *CSFM*

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Question: Due to wet weather and the hectic schedule I had this year, I did not get early fall fertilizer on my athletic fields until late September. I normally prefer to make this application around Labor Day. I then apply a second application around mid October, six weeks after my first application. I'm afraid it's too soon for a second application but if I wait much longer I'll miss the window. What should I do?

Answer: Fertilizer applied toward the end of the growing season is known as late season fertilization. As temperatures cool and top growth slows, the turf turns its energy to lateral growth and root development. A slow release nitrogen source at this time is beneficial to the turf in providing the nutrients necessary for continued development. Over stimulation caused by excessive amounts of water-soluble nitrogen at this time of year can cause over wintering problems such as snow mold.

The main question is this; what is the current condition of the turf? If the turf is still retaining good color and looking healthy, I would delay the late season fertilization. If fertilizer were applied after top growth ceased and the turf is totally dormant, this application would be considered a dormant application. The purpose and benefit of a dormant application differs from that of late season fertilization in that the benefits are reaped in the spring. Some of the nutrients are absorbed into the root system and some are held in the soil. In either case the majority of nutrients are utilized as the turf awakens from dormancy in the early spring. Its benefits are realized by the stimulation of root development, early green up, lateral growth and finally top growth. When dormant fertilizer is applied in the late fall, any spring fertilization should be delayed and only applied when visual evaluation of the turf reveals a deficiency. This typically becomes evident in the late spring when a light application of nitrogen along with phosphorous and potassium shown to be necessary by a soil test is all that is typically required. ◆