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Drainage – A Crucial Component for Athletic Field Performance

Part Two: Internal Drainage

Water is applied to maintained turfgrass areas by irrigation or precipitation. Once water hits the soil surface, it may enter the soil, runoff the surface, or be evaporated into the atmosphere. Excessive rainfall, and/or winters with heavy snowfall, often produces excess soil water conditions. Thunderstorms will frequently result in runoff because the rainfall rate is greater than the rate at which water can infiltrate the soil. Irrigation can also cause puddles and runoff if the water application rate exceeds the infiltration rate.

Drainage is the removal of excess water from the soil surface and/or soil profile by either gravity or artificial means. Drainage is one of the most important issues when managing a sports field. Your field will not perform well if you do not have surface, internal, and/or installed drainage systems in place. Turfgrass areas need to be able to withstand foot and vehicular traffic in various weather conditions. Standing water and/or saturated fields can cause cancellation or postponement of events, increase likelihood for compaction and ruts, and lead to poor overall field health. Efficient soil drainage ensures that water does not collect on the athletic surface. A well drained athletic surface improves safety and playability, allows turfgrass plants to access necessary nutrients, allows better air exchange, and improves turfgrass recovery potential. It is important to understand drainage principles and what types of drainage will work best for your field to enhance user safety, reduce field closures, and keep your field healthy.

There are three key components to successful drainage – surface drainage, internal drainage, and sub-surface installed drainage systems. Surface drainage is when water runs off the surface of the field. Internal drainage refers to water entering and moving through the soil profile. Sub-surface installed drainage systems refer to pipe systems installed beneath the field to direct excess water from the rootzone to a drainage outlet. Depending on your facility, you may not have a sub-surface installed drainage system, or may not have the means to install a system. Therefore, it is important to maximize surface and internal drainage to ensure the health and safety of the field.

This bulletin is part of a three part series. The focus of this bulletin is internal drainage. To access the other bulletins, please visit the STMA website.

Internal Drainage

Internal drainage refers to water entering the soil and moving through the soil profile. Even where there is good surface drainage, water may remain trapped in the soil profile for days. Therefore, it is important to understand what is needed within the soil profile to ensure excess water is being removed from the playing surface. Soil texture, soil structure, porosity, permeability, geologic formation, and compaction all affect internal drainage.

Soil Texture

The sand, silt, and clay composition of the solid mineral particles in a soil is called soil texture. Soil texture affects how well the soil holds water and how easily water can move into and through the soil. Fine-textured soils have a large percentage of clay and silt particles. These soils generally hold water well, but drain poorly. Coarse-textured soils have a large percentage of sand or gravel particles. These soils drain well, but have poor water-holding ability and can create an unstable playing surface. Adding fine soil particles to a predominantly coarse-textured rootzone can increase stability, but decrease permeability. The challenge is to find the percentage of fines that can be added before infiltration and percolation are slowed to the point where the soil no longer drains well.

Soil Structure

The physical arrangement of the solid mineral particles of a soil is the soil structure. A granular structure helps promote the movement of water through a soil, but a structure that lacks any distinct arrangement of soil particles usually decreases the movement of water. Water moves downward more quickly in a soil with granular structure versus a soil with platy structure, which is more prone to move laterally. Other soil structures include prismatic and sub-angular blocky. A well-structured soil has an abundance of large, aeration-type pores from which water can quickly drain in response to gravitational force.

Soil Porosity

Pore size influences the speed at which water moves through the soil. Macropores, often found in soils with a high percentage of sand, allow water to move through the soil profile quickly. Water moves more slowly through micropores, which are often found in soils with a high percentage of clay. Loamy soils are intermediate in porosity and pore-size distribution.

Water is always moving in soil and at all directions. Gravity moves water downward. In a saturated soil, the primary mover of water is gravity. Water can move laterally due to restricted soil layers or obstructions such as bedrock. Capillary action can move water in any direction. In an unsaturated soil, the primary mover of water is capillary action. Capillary action is greater in smaller pored soils where water moves more slowly.

Permeability

The ease with which water can move through soil is permeability. Infiltration, water entering the soil, and percolation, water moving through the soil, are components of permeability. Infiltration and percolation are measured in inches per hour. Movement of water into and through the soil profile is affected by soil texture, soil structure, and compaction. A field surface is kept free of water most effectively when some water can pass downward though the soil to assist removal by positive surface drainage. If infiltration and percolation are inhibited, water will remain on the surface and rely primarily on surface drainage.

Standing water on an athletic surface - Photo courtesy of Brad Fresenburg, Ph.D.

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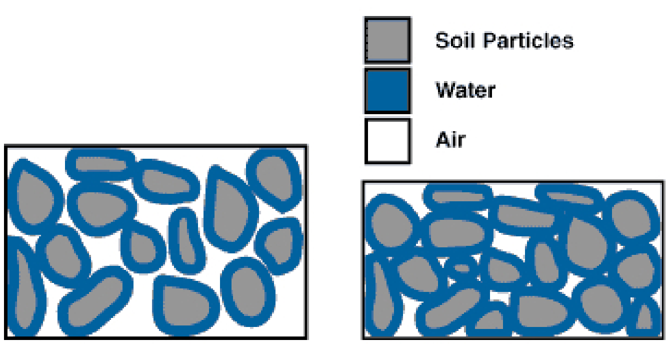
Geologic Formation
The geological formation underlying a soil can impact the drainage of water from that soil. For instance, a soil could have textural and structural properties that are beneficial to the movement of water. However, if the geologic formation underlying the soil consists of dense clay or solid rock, it could restrict the downward movement of water, causing the soil above the formation to remain saturated during certain times of the year.

Compaction
Compaction is the compression of topsoil primarily due to foot or vehicular traffic. Compaction occurs when soil aggregates are broken down and soil particles are pressed together into impermeable layers where most pore spaces have been eliminated. For example, operating equipment on wet soil can cause compaction and thereby destroy its structure. Soil water will tend to accumulate above a compacted layer because movement of water through the compacted layer is severely restricted. Not only does compaction restrict water movement, but it also impedes plant growth. Plant roots cannot access water and nutrients deep within the soil profile in compacted soils and may not be able to grow deep roots because of a compacted layer. Most compaction layers occur at the soil surface, which allows very little water to infiltrate the soil. This results in water collecting on the surface and running off the surface.



Common Problems with Internal Drainage

One of the most common problems associated with poor internal drainage is layering within the rootzone. Layering often results from a series of successive cultural practices in which soils of different textures are incorporated into the field. This includes topdressing and/or reincorporating soil cores following hollow tine aeration. As coarse-textured soils are placed over fine-textured soils, or vice versa, a water table can develop. Water tables impede internal drainage by restricting water movement. Fine soil particles over coarse soil particles can cause a perched water table and create a saturated, unstable soil surface. Coarse soil particles over fine soil particles can cause a temporary water table. Depending on weather conditions, a temporary water table can cause the soil surface to dry out quickly. Another problem seen with temporary water tables is the formation of black layer. If the movement of water into the underlying fine layer is prolonged over a long period of time, anaerobic soil conditions can develop and lead to black layer.

Black Layer - Photo from LSU Ag Centerr

Note: In some cases, addition of soil of a different particle size is desirable. See below for information on amending rootzones.

Improving Internal Drainage

Aeration

Aeration and deep tine core aeration can be an effective way to improve internal drainage. Aeration allows air into the soil profile which assists the drying process. Aeration is especially beneficial in soils with layers. Aeration breaks through layers allowing a channel for turfgrass roots to grow and for water to infiltrate. Keep in mind deep tine aeration will only work if there is an underlying layer that can be accessed for better drainage. If the existing rootzone is made up completely of fine textured soil with no underlying drainage system or coarser textured soil, deep tine aeration will not improve drainage.

Inorganic Soil Amendments

Addition of inorganic soil amendments, such as sand, calcined clay, zeolites, and diatomaceous earth, can improve internal drainage. Inorganic amendments may be more desirable because they are less prone to biological degradation (versus organic amendments) and may maintain the original rootzone physical properties longer than organics. Sand may increase water infiltration and percolation, improve aeration, and help resist compaction. Use of calcined clay, zeolites, or diatomaceous earth may improve air, water, and nutrient holding capacity of soil and help resist compaction.

Coarse sand added to athletic surfaces may improve drainage. The effectiveness depends on properties of the host soil, amount of sand added, and uniformity of soil/amendment mixing operation. The sand being applied to the rootzone must match the existing particle size. Otherwise, layers and water tables could develop and inhibit internal drainage. If transitioning from a native soil to sand rootzone, the rootzone must consist of at least 70% sand before there is any improvement in drainage. There must be enough sand particles in contact to increase macroporosity. In a rootzone with less than 70% sand, finer particles will fill in the pore spaces and create a hard surface with low permeability. Keep in mind, when sand and native soil are combined, they should be mixed offsite. If the sand is tilled into the native soil, it will create a marbling effect that is not ideal.

One drawback to using sand is its relatively poor water and nutrient holding capacity. Calcined clay, zeolites, and diatomaceous earth are also popular as inorganic soil amendments. Benefits of adding these products to a sand based rootzone include improved nutrient and water holding capacity as the result of small internal pores. They improve internal drainage by absorbing water and improving porosity. As with any amendment, the particle size of the inorganic amendment should match the particle size of the existing rootzone. During the production process, products are usually screened to uniform particle sizes to be used in various rootzones. Calcined clay, zeolites, and diatomaceous earth are most commonly added as topdressing after aeration to fill core aeration holes.

When selecting an inorganic soil amendment such as calcined clay, zeolites, or diatomaceous earth, always research the product before making a selection. Particle size, water retention and release, and nutrient holding capacity should all be taken into consideration to make the correct selection. It may be beneficial to create a test blend and monitor performance before making a final selection.

Organic Soil Amendments

Organic amendments, such as peat, sawdust, waste or by-products (sewage sludge, manure, compost) can be used to amend coarse-textured soil. Adding fine organic amendments to coarse sand allows better nutrient and water retention, but can decrease permeability. Coarse-textured amendments are best for fine-textured soil. Organic amendments in clay soils increase permeability and enhance internal drainage. The amount of organic amendments added to the rootzone is crucial for optimal drainage. Adding too much to a coarse rootzone may impede drainage. It may be beneficial to create a test blend and monitor the performance before making a final selection.

A disadvantage to using organic amendments occurs with compaction. Wet, compacted soils that have been amended with organic products will dry slowly. Organic amendments are not recommended for amending native soil sports fields.

The physical properties of a particular soil can vary throughout the soil profile, and from place to place in the same field. Soils have different physical characteristics, and the geological formations underlying soils vary as well. Therefore, each soil will have particular drainage characteristics. Soil scientists and engineers have classified soils based on their drainage characteristics. For general information about the nature of soils and their properties, refer to a soil science textbook. For specific information regarding the drainage ability of a particular soil in your area, contact the USDA Natural Resources Conservation Service (NRCS) office in your county.

Conclusion

Successful drainage starts with proper planning. The best time to solve drainage problems is before they happen due to construction or reconstruction mistakes. On fields with existing drainage systems, identifying the most serious problem and correcting it is the most effective solution. Unless a plan is developed to correct the major problems, "band-aid" solutions will cause headaches over and over again.

References:
Contributions made by STMA Information Outreach Committee
USDA NRCS – Water Movement Video - ftp://ftp-fc.sc.egov.usda.gov/NSSC/Educational_Resources/Water_Movement_V2.wmv
University of Minnesota - Agricultural Drainage: Soil Water Concepts
Ohio State University - Understanding Agricultural Drainage
Penn State University - Beneath the Surface
Penn State University - Understanding Field Drainage
2012 STMA Conference Presentation – Sports Field Drainage – What Are Your Options?
Ian LacySports Fields: A Manual for Design, Construction and Maintenance – Jim Pulhalla, Jeff Krans, and Mike Goatley
Practical Drainage for Golf, Sportsturf and Horticulture – Keith McIntyre and Bent Jakobsen