



A Technical Look At Water Movement Issues In Turf

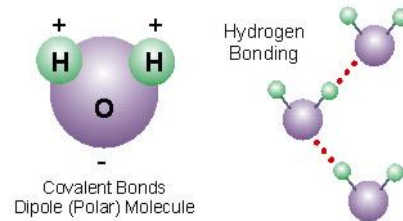
Water movement problems such as poor infiltration, hydration, and distribution of water and applied chemicals into the soil profile can create problems for professional turf managers in their efforts to establish and maintain uniform, vigorous, and healthy turf.

Physical Properties of Water

Chemical Properties

A discussion of the physical properties of water is an appropriate preface to understanding soil water movement. Many of the unique properties of water can be attributed to its molecular construction. The two hydrogen atoms and single oxygen atom of water are held together by a strong covalent bond.

Although the water molecule is electronically neutral (i.e. non-ionic), the geometric configuration of the covalent bond of water creates a molecular structure for the entire water molecule, with oxygen having a partial negative charge and each hydrogen having a partial positive charge. *This uneven distribution of charge within a bond is known as a dipole, the bond and the molecule are said to be **polar**.*



Since opposite charges attract each other, the hydrogen region (positive charge) of the water molecule is attracted to the oxygen region (negative charge) of other water molecules or negative sites on other molecules. *This attraction of the hydrogen region of water molecules to negatively charged regions of other molecules is called **hydrogen bonding**.*

Understanding the polar nature of water and the attraction of its hydrogen region to negative regions of other molecules (including negative sites on soil surfaces) will help to explain what happens to water when it is applied to, and moves through a soil profile. The natural state of water is in the form of a liquid. This fluid state of water is the consequence of water molecules existing in strong association with each other due to intermolecular polar attraction and hydrogen bonding

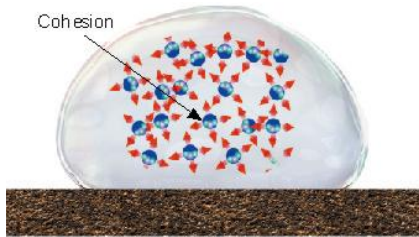
Cohesion

Within a water droplet, water molecules are in a constant state of movement toward other water molecules. Each water molecule is subject to attractive and repulsive forces from nearby molecules that, on the average, are distributed in all directions. *This strong attraction between water molecules is defined as **cohesion**.* Cohesive tension

plays a major role in determining the amount of water that is attached to surfaces, collects in pore spaces, or moves through the soil profile.

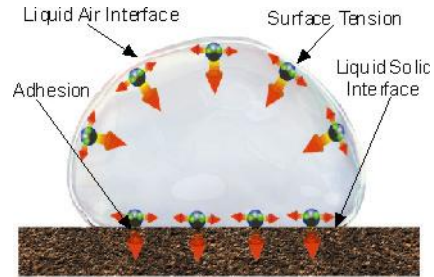
Interfacial Tensions

Any time water molecules located on the boundary of the fluid come in contact with a dissimilar solid, liquid, or vapor, their properties can be different. *Forces that alter or influence intermolecular attractions on the boundary of the fluid state of water are called **interfacial tensions**.*



When water comes in contact with the air (liquid-air interface), only half of the surrounding space is occupied by other water molecules. This causes a new arrangement of the intermolecular forces in order to hold the surface molecules in place. Since air contains no polar entity to move toward, water molecules at the surface tend to move inward toward the bulk of water molecules. *This inward movement of water molecules at the liquid-air interface is known as **surface tension**.* Surface tension is what causes water to “bead” on a surface rather than spread out. Surface tension also has a great deal to do with the ability of water to infiltrate pore spaces, whether they occur at the soil surface or within the soil profile. If the size of the water droplet exceeds pore space size, penetration and infiltration of water into and through the soil profile may be restricted.

When water comes in contact with a solid surface (liquid-solid interface), *the polar attractive forces between the water molecules and the solid surface (**adhesion**) will dictate the affinity of the water for the solid.* Water molecules at the liquid-solid interface will attach to surfaces containing polar sites through hydrogen bonding (hydration).



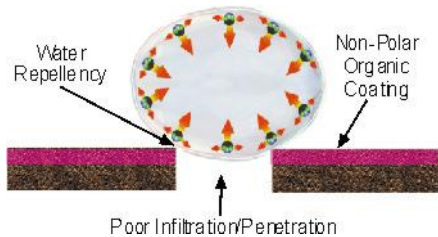
Adhesive tension is associated with hydration or “wetting” of a soil. When adhesion exceeds the attraction between individual water molecules (cohesion), water will spread out on the solid surface.

Water Repellency

Researchers generally agree that water repellency (hydrophobicity) in soils is caused by a range of hydrophobic organic materials that form non-polar “coatings” on soil particles. Decomposing plant materials, microbial deposits, organic acids, and fungal hyphae have been identified as possible sources of hydrophobic organic materials.

When a soil particle coated with these hydrophobic organic materials becomes dry, the normal polar characteristic of the soil is changed to a non-polar surface. Water molecules, because of their polar nature, tend to prefer and aggregate towards other polar molecules rather than the non-polar sites of water repellent surfaces.

Therefore, since there is no polar entity to move toward, water molecules at the water boundary tend to move inward toward the bulk of other water molecules. This is the molecular basis of water repellency. *The scientific definition of **water repellency** is described as a condition where the adhesive polar forces at the water solid interface are less than the cohesive force of water.*



Water repellency in soils can result in a number of problems caused by poor water movement patterns. The most obvious effect of water repellency is a reduction of infiltration rates. Additionally, hydration (wetting) and distribution of applied water and input chemicals can be quite irregular and incomplete. Turf decline, localized dry spots, poor drainage and non-uniform turf quality have also been linked to water repellency in soil profiles.

Water repellency is often viewed inaccurately as a condition that: 1) occurs only in a limited number of soil profiles, 2) impacts small areas only (i.e. *localized* dry spots), and 3) occurs at the surface of the soil profile.

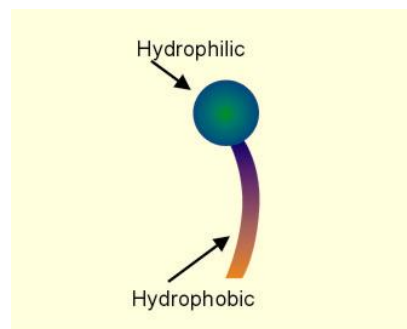
After years of investigation, soil scientists now describe water repellency in much broader terms. Current research data generated from scientists around the world characterize water repellency as a condition that: 1) occurs to some degree in the majority of soil profiles, 2) can impact water movement

to large areas of the soil profile, while visible detection is often limited to small areas, and 3) occurs from the surface to depths that would include the rootzone of most turfgrass varieties.

(For more information on water repellency, visit www.aquatrols.com - research information.)

The Role of Surfactants

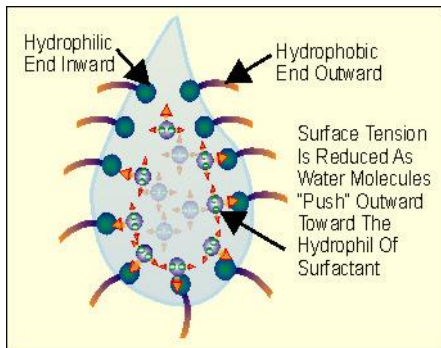
Research has confirmed that certain surfactants (“wetting agents”) are very effective in overcoming water movement problems associated with water repellency. Surfactants are chemical compounds whose molecular structure is well suited to overcome both the water repellent (non-polar) characteristics of hydrophobic soil profiles and poor infiltration of water due to surface tension.



A simplified model of a surfactant molecule is shown above to facilitate discussion regarding their structure and mode of action. It should be noted that the construction of surfactants is very complex. Although there is similarity in the function of most surfactants, surfactant chemistries and/or their formulations may differ widely in their performance characteristics. The surfactant molecule is made up of a hydrophilic (“water loving”) polar component and a hydrophobic (“water repellent”) non-polar component.

Surfactants in Water

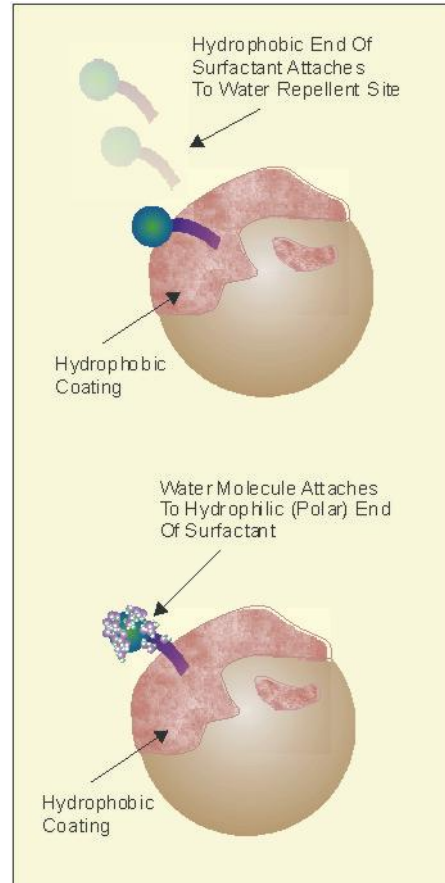
When surfactant molecules are applied to soils with water as the carrier (such as through irrigation systems), the hydrophilic ends of the surfactant molecules are strongly attracted to the water molecules. As a result, the



surfactant molecules align themselves at the surface so that their hydrophilic ends are toward the water and their hydrophobic ends are “squeezed” away from the water. These “outward” forces at the air-water interface reduce surface tension and facilitate infiltration of water from the surface into the soil profile.

Surfactants in a Soil Profile

When a surfactant is applied to the soil profile, the hydrophobic (non-polar) end of the surfactant attaches to the non-polar water repellent site on the soil particle. This serves a very important function. As water moves into and through the soil profile, individual water molecules are attracted to the polar end of the surfactant. Therefore, the polar end of the surfactant serves as an attachment site for water molecules, allowing a water repellent soil particle to hydrate (“wet”).



Surfactant Selection

Not all surfactants are the same. The molecular construction of a surfactant can significantly influence the pattern of water distribution once applied to the soil profile. Surfactants differ widely in their size, shape, structure and molecular weight. Each of these characteristics can influence how effectively water attaches to a water repellent soil particle, the uniform distribution of water and solutes, and the drainage characteristics of a treated soil profile. Professional turf managers should select surfactants based on the type of hydration and distribution pattern that will best address their identified turf management issue(s).

Sidebar: Water Movement

Non-Uniformity

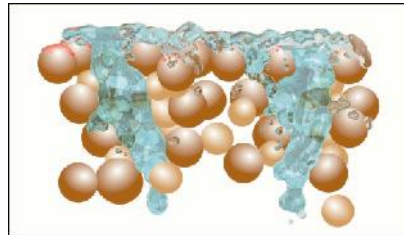
Macropore flow and flow over sloping layers are inherently associated with physical variability in soil profiles. The cause of fingered flow, however, is more closely associated with the influence of water repellent soils on the wetting front of water as it moves through a soil profile.

Since the water cannot adhere to water repellent soil particles, the tendency for water masses to attract to each other becomes greater (cohesion). Large “clusters” of water masses can form and under the influence of gravity, will preferentially move through narrow macropore channels.

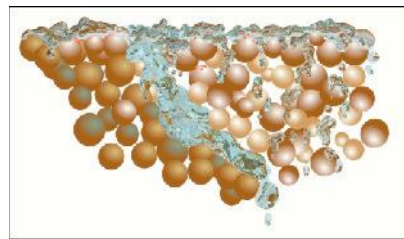
The establishment of fingered flow patterns accelerates the transport of water and surface-applied solutes that contribute to non-uniformity and/or poor turfgrass quality. This can increase the risk of groundwater reservoir contamination and contribute to reduced performance of applied chemicals and/or fertilizers.

In those areas between fingered flow patterns of water movement, dry and water repellent soil pockets or zones will persist. These areas further contribute to the non-uniformity of turfgrass quality as well as potentially manifesting themselves as localized dry spots or areas where chemical and/or fertilizer treatments display less than a desirable performance.

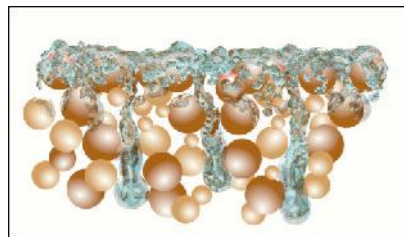
Researchers have found that water movement patterns in water repellent soils can be unstable, irregular and lead to the development of preferential flow pathways. Three types of preferential flow occur in soils:



Macropore Flow - Occurs when water follows large pores, narrow channels or cracks caused by worms, roots, or soil shrinking and swelling.



Flow Over Sloping Layers - Occurs when sloping layers of coarse soil within the rootzone redirect flow of water over the layers. This directs flow from unsaturated areas resulting in uneven wetting of the soil profile.



Fingered Flow - Occurs when water and solutes move in water repellent soils through preferential paths, or “fingers”. The occurrence of these fingerlike wetting patterns seriously accelerates the transport of water and surface-applied solutes down and through the rootzone.