A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

Section II • Volume 11, Issue 8 • **August 2002**

www.turfgrasstrends.com

WATER MANAGEMENT

Science of Surfactants Explains Their Usefulness In Managing Water Use

By Kathleen Conard

Turf managers must employ proper watering techniques so that plant roots receive adequate water and nutrients, and so that turf management chemicals are distributed uniformly to derive maximum benefit. The challenge is to ensure this is done in an environmentally responsible way and without wasting water or over-applying chemicals. Unfortunately, the complex characteristics of water and soils make it difficult to meet these challenges.

Water repellency in soils is caused by a range of hydrophobic organic materials that form non-polar "coatings" on soil particles.

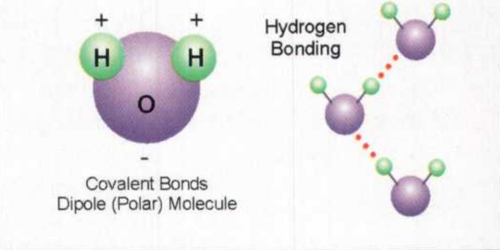
A discussion of the physical properties of water is an appropriate preface to understanding water movement through soil. Many of the properties of water can be attributed to its molecular construction. The two hydrogen atoms and single oxygen atom of water are held together by a strong covalent bond.

Although the water molecule is electrically 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, and the bond and the molecule are said to be polar.

Since opposite charges attract, 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 soil molecules. This attraction is called hydrogen bonding.

FIGURE 1



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) helps explain what happens to water when it is applied to and moves through the soil.

AN ADVANSTAR ★ PUBLICATION

IN THIS ISSUE

OUR SPONSORS

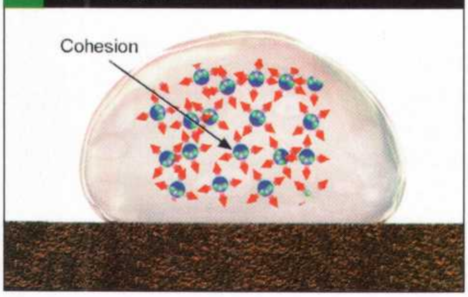
Water normally occurs in nature as a liquid. This fluid state of water exists because individual molecules bond to each other through intermolecular polar attraction and hydrogen bonding

Cohesion

Within a water droplet, water molecules move toward each other constantly. Each water molecule is subject to attractive and repellent 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 determines the amount of water that is attached to surfaces, collects in pore spaces, or moves through the soil.

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 water's boundary are called interfacial tensions.

FIGURE 2



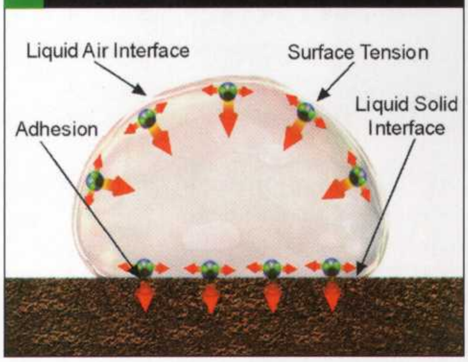
When water comes in contact with the air, only half of the surrounding space is occupied by other water molecules. This requires a new arrangement of the intermolecular forces to hold the surface molecules in place.

Since air contains no polar entity to move toward, water molecules at the surface tend to bond to each other. This inward movement of water molecules at the liquid-air interface is known as surface tension. Surface tension 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, either at the soil surface or within the soil.

If the size of the water droplet exceeds pore space size, penetration and infiltration of water into and through the soil 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 attraction of the water for the solid. Water molecules at the liquid-solid interface will attach to surfaces containing polar sites through hydrogen bonding (hydration).

FIGURE 3



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

When a surfactant is applied to the soil, the hydrophobic (non-polar) end of the surfactant attaches to the non-polar water repellent site on the soil particle.

Water repellency

Researchers generally agree that water repellency in soils is caused by a range of hydrophobic organic materials that form nonpolar "coatings" on soil particles. Decomposing plant materials, microbial deposits, organic acids and fungal hyphae have been identified as possible sources of hydrophobic organic materials.

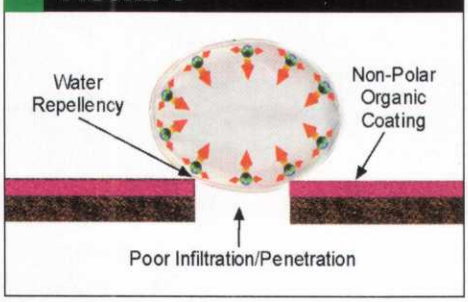
When a soil particle coated with these

hydrophobic organic materials becomes dry, the normal polar characteristic of the soil is changed to a nonpolar surface.

Water molecules, because of their polar nature, aggregate towards other polar molecules rather than the nonpolar 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.

FIGURE 4



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 and distribution of applied water and input chemicals can be irregular and incomplete. Turf decline, localized dry spots, poor drainage and nonuniform turf quality have also been linked to water repellency in soils.

Water repellency is often viewed inaccurately as a condition that:

- occurs only in a limited number of soils;
- impacts small areas only (i.e. localized dry spots); and
- occurs at the surface of the soil.

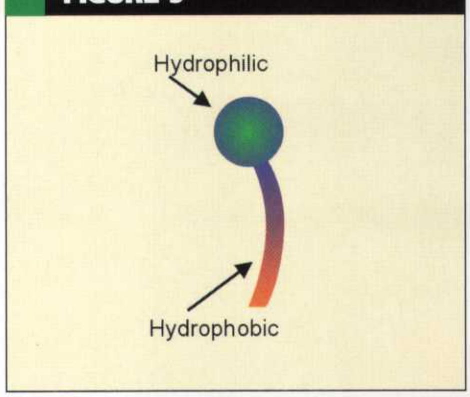
After years of investigation, soil scientists now describe water repellency in much broader terms. Water repellency is characterized as a condition that:

- occurs to some degree in the majority of soils;
- can have an impact on water movement to large areas of the soil, while visible detection is often limited to small areas; and
- occurs from the surface to depths that would include the root zone of most turfgrass varieties.

Role of surfactants

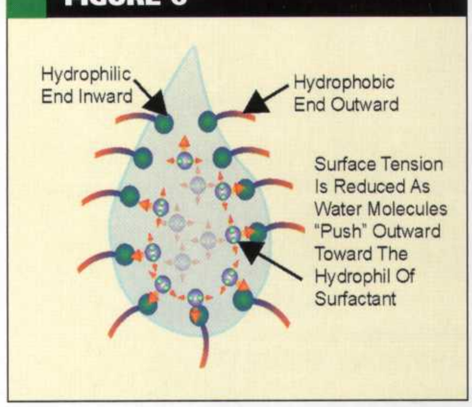
Research confirms that certain surfactants are effective in overcoming water movement problems associated with water repellency. Surfactants are chemical compounds whose molecular structure is well-suited to overcome both the water repellent characteristics of hydrophobic soils and poor infiltration of water due to surface tension.

FIGURE 5



A simplified model of a surfactant molecule is shown above to help explain a surfactant structure and mode of action. It should be noted the construction of a surfactant is quite complex. Although there is

FIGURE 6



similarity in the function of most surfactants, surfactant chemistries and/or their formulations may differ widely in their performance. The surfactant molecule is made up of a hydrophilic (water-loving) polar component and a hydrophobic nonpolar component.

Surfactants

When surfactant molecules are applied to soils with water as the carrier (i.e, through irrigation systems), the hydrophilic ends of the surfactant molecules are strongly attracted inward toward the water molecules. As a result, the surfactant molecules align themselves at the surface so their hydrophilic ends are toward the water and their hydrophobic ends are turned away from the water.

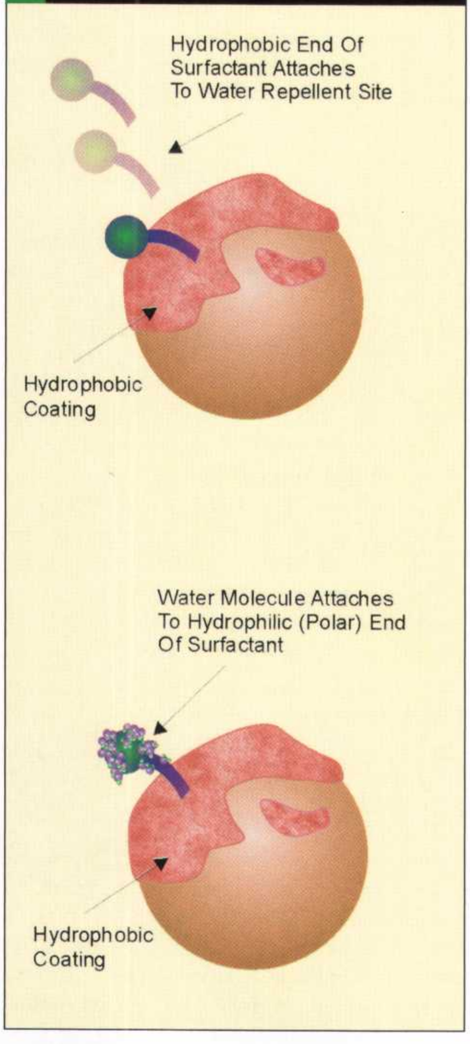
These outward forces at the air-water interface reduce surface tension and ease the infiltration of water from the surface into the soil.

When a surfactant is applied to the soil, the hydrophobic (nonpolar) end of the surfactant attaches to the nonpolar water repellent site on the soil particle. As water moves into and through the soil, individual water molecules are attracted to the polar end of the surfactant.

Water management is vital to turf health and growth.

Therefore, the polar end of the surfactant serves as an attachment site for water molecules, allowing a water-repellent soil particle to hydrate ("wet").

FIGURE 6



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. 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 chemicals, and the drainage characteristics of a treated soil.

A good surfactant promotes healthy turfgrass since water and water-soluble chemicals penetrate deeper and more uniformly into the rootzone even when water-repellent conditions are present.

Uniform distribution of water and chemicals encourages a deeper root structure, which means healthier, denser and more uniform turf surfaces.

Some surfactants allow superintendents to use less water and chemicals because little is lost to run-off, channeling or surface evaporation. Water and soil-targeted chemicals are available where they are needed — the root zone.

Kathleen Conard is marketing manager with Aquatrols in Cherry Hill, N.J. She has 15 years of experience in the turf and ornamental markets and has authored a number of articles for turf and horticulture trade journals. Contact her at kathy.conard@aquatrols.com.