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Improving Turfgrass Health with a Low-Salt Diet

TABLE 1. Saturated Soil Extract

TDS-4	Extract EC	TDS-4	Extract EC	TDS-4	Extract EC
0.1	1.1	1.1	3.8	2.1	6.5
0.2	1.3	1.2	4.0	2.2	6.7
0.3	1.6	1.3	4.3	2.3	7.0
0.4	1.9	1.4	4.6	2.4	7.3
0.5	2.2	1.5	4.9	2.5	7.6
0.6	2.4	1.6	5.1	2.6	7.8
0.7	2.7	1.7	5.4	2.7	8.1
0.8	3.0	1.8	5.7	2.8	8.4
0.9	3.2	1.9	5.9	2.9	8.6
1.0	3.5	2.0	6.2	3.0	8.9

Use this conversion table for determining the saturated soil extract EC (Extract EC) from the direct TDS-4 saturated soil reading. All values are in dS/m = mS/cm = mmhos/cm.

By Dr. Larry J. Stowell

In many areas, irrigation management becomes a challenge especially during the low rainfall, heavy irrigation months from April through October — when soil salts accumulate, turf requires more water to grow and there is peak demand for high quality turf that can tolerate stress from athletes, insects and diseases. For turf managers, three critical components in effective irrigation are water quality, evapotranspiration (ET) rate and soil electrical conductivity (EC).

This article focuses on the interaction among these factors and provides suggestions for utilizing EC and ET data to help you make better informed irrigation management decisions.

Electrical Conductivity (EC)

Soil electrical conductivity (measured in decisiemens/meter or millimhos/cm) readings are related to the concentration of salts that are dissolved in a solution and can be an extremely valuable tool in irrigation management. A relatively simple method has been developed (see pg. 17) to help you monitor the EC and, therefore, the salt levels in your soils. But why, you may ask, is it so important to monitor salinity?

The answer lies in the constant struggle for water between two opposing forces — the turfgrass (which must obtain water via its roots to survive) and the soil. Both the *physical* nature of the soil (soil particles have a sponge-like ability to suck water away from plant roots) and the *chemical* suction caused by dissolved salts in the soil/water solution act to suck water away from turfgrass roots. When there are high concentrations of solutes such as calcium, magnesium, sodium, potassium, chloride or sulfates in the soil, the plant will not be able to draw water from the soil into the roots, and the plant will wilt and die if the salts are not diluted.

In some cases, a high salinity situation can produce dying turfgrass, even when the soil appears wet. In these cases, even though it seems counter-intuitive, leaching to remove salts will drop the chemical suction and will aid the survival of the plants.

Role of Water Quality and EC

The salts that cause turfgrass so many problems come primarily from irrigation water and not from fertilizers, as many people believe. Although the United States has a wide range of irrigation-water qualities, electrical conductivity is likely a critical factor wherever you live. California serves as an example.

A casual survey of nine southern California golf courses showed that irrigation water usage averaged 3.2 acre-feet per year per acre. Combined with the fact that southern California irrigation water has an average EC of about 1.0 dS/m (equivalent to 640 ppm or 640 mg/l), it means that an area the size of a 5,000-square-foot golf course green will receive 600 pounds of salts during the year! Moreover, most of the salts will be delivered between April and October. During that time, about 85 pounds of salts per month will be delivered to a 5,000-square-foot area. Without effective irrigation management, salts will rapidly accumulate to

TABLE 2. Tolerance of Turfgrasses to Soil Salinity

Sensitive <3 dS/m	Moderately Sensitive 3-6 dS/m	Moderately Tolerant 6-10 dS/m	Tolerant > 10 dS/m
Annual bluegrass	Annual ryegrass	Bent. cv. Seaside	Alkaligrass
Colonial bentgrass	Chewings fescue	Perennial ryegrass	Bermudagrass
Kentucky bluegrass	Creeping bentgrass	Tall fescue	Seashore paspalum
Rough bluegrass	Hard fescue	Buffalograss	St. Augustinegrass
Centipedegrass	Bahiagrass	Zoysiagrass	

Relative tolerance of turfgrasses to soil salinity. (From Harivandi, M.A., Butler, J.D. and Wu, L. 1992. Salinity and turfgrass culture. Pages 207-229 in Turfgrass — Waddington, D.V., Carrow, R.N. and Shearman, R.C. eds. — Series No. 32. American Society of Agronomy, Madison, Wis.)

levels that are damaging to most turfgrass varieties.

Unlike southern California, irrigation water in northern California has a fairly low salt content, with ECs frequently below 0.5 dS/m. Even so, with salts at 0.5 dS/m, 43 pounds of salts will be delivered per month to a 5,000-square-foot area. Salinity will accumulate more slowly, but by August, about 172 pounds of salt will have been deposited to such an area. In any region of the state or in areas of the country with similar water qualities, irrigation to prevent accumulation of soil salts is a critical component of a turfgrass management system.

Leaching to Lower ECs

A leaching event is an irrigation cycle or a period of rainfall that results in an application of more than one inch of water in a single eight-hour period. The water can be applied by standard irrigation systems, or to prevent runoff, low-volume irrigation heads may be used to match water application with infiltration.

Regardless of the irrigation method, leaching events are needed to prevent accumulation of salts to levels that will damage the turfgrass variety. (See Table 2 for the sensitivity of turfgrass varieties to soil salts.)

ET — A Good Tool Badly Used

ET, or evapotranspiration (measured in inches of water), refers to the water lost by evaporation from the soil, plus the water lost from plants through transpiration. ETs are usually highest on warm, dry, sunny days when there is a good breeze. Water lost during the day or days between irrigations can be estimated by analysis of prevailing weather conditions.

In order to conserve water, tremendous emphasis has been placed upon evapotranspiration. Many new irrigation systems provide on-site weather stations and estimates of ET. Computer controls will apply the exact amount of water that was lost during the day on a daily basis.

But beware! In many cases, irrigation strategies based solely upon daily ET losses will result in accumulation of salts to levels that are damaging to turfgrass. The reason is that this approach leaves no room for leaching when salts reach damaging levels. In addition, light and frequent irrigations often lead to anaerobic conditions, black layer and death of many of the deeper turfgrass roots. The overall result is declining turf, increased disease and insect susceptibility, resulting in increased pesticide use and both wet and dry areas where no turf is growing.

To illustrate some of the problems associated with sole reliance on ETs for irrigation management, let's look at a case study in San Diego. Based upon California Irrigation Management Information System (CIMIS) reference evapotranspiration (ETo), almost 2 acre-feet of water per acre are needed between April and October to grow turfgrass in San Diego at 80 percent of the reference ETo. (Note that this value is about 30 percent below the average of 3.2 acre-feet for southern California, mentioned above, and probably reflects the milder San Diego environment.)

Based on these conservative ET values, if 1.0-dS/m irrigation water is applied nightly beginning on April 1 to a soil with an initial EC of 1.0 dS/m, the salts deposited into the top three inches will raise soil salinity to about 3 dS/m by the middle of June. That exceeds the tolerable level for such

Figure 1 (below) based on a case study in San Diego, shows the theoretical accumulation of soil salts in the top three-inch layer of a soil irrigated nightly with a water containing 640 ppm dissolved salts (1.0 dS/m) when the initial soil EC was 1.0 dS/m. If no leaching events are included, the full season of irrigation accumulates sufficient salts to severely stress or kill many cool season varieties and some warm season varieties

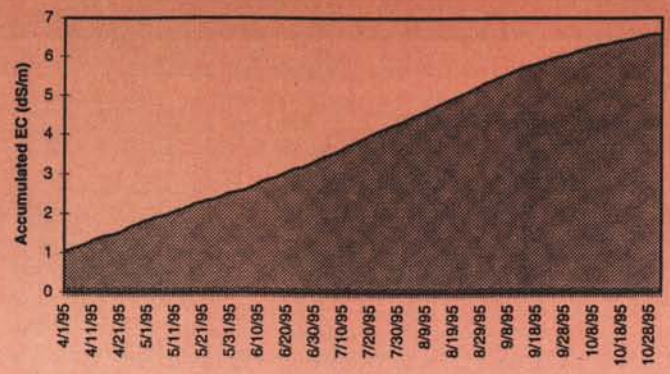
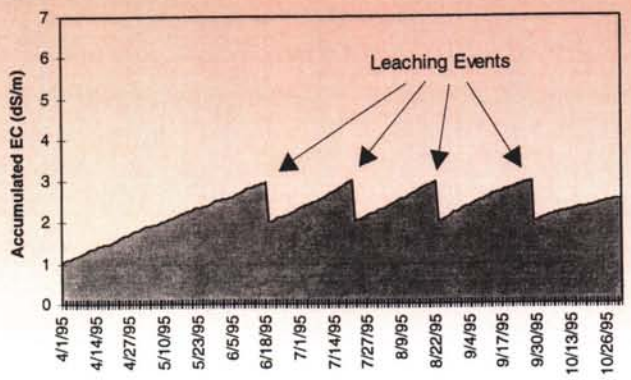


Figure 2 (below) shows accumulated soil salts based upon San Diego CIMIS ET data (80 percent of reference ET). Note the leaching events based upon soil EC values. This strategy prevents accumulation of salts to levels that result in turf losses. Leaching is only needed if the accumulation of salts exceeds the tolerance of the turfgrass variety.



species as *Poa annua* and Kentucky bluegrass. If the soil salts are not reduced with a leaching irrigation (at least one inch of water and frequently more), accumulation of salts would continue to rise and exceed 6 dS/m by the end of October.

As a rule of thumb, 6 inches of water need to be applied to drop the soil EC by 50 percent. Allowing accumulation of salts to higher levels will only make leaching events more difficult to conduct and will also result in very wet areas.

Leaching is only needed when the accumulation of salts is expected to exceed the tolerance of the turfgrass variety. For example, based upon the data presented in Table 2, bermudagrass would not require leaching in the scenario presented above for San Diego, where soil salts usually do not exceed 7.0 dS/m during a "normal" year. In a normal year in California and other parts of the country, fall and winter rains have the effect of re-setting soil ECs to about 1.0 dS/m, so soils are in good shape going into the heavy irrigation period of April through October. Leaching strategies will therefore change for some areas after fall and winter rainfall.

The bottom line is that soil salts should be regularly monitored and irrigation should always be based upon plant needs, not computer models. Computer models should be used as guides for decision making, but it is you, not the computer, who should be making the irrigation management decisions.

In addition to ETs, ECs and water quality measurements, your decisions should be influenced by plant rooting depth, soil type, turfgrass variety and always field inspection. Areas that have lighter (sandier) soils will require more frequent irrigation than heavier soils. Deeper-rooting varieties will be able to mine water from the lower soil profiles to tap soil reserves more effectively. High salinity waters will have to be applied in higher volumes than low salinity waters.

Complicated? Yes! Challenging? Absolutely! But with the right information in hand (some of which was hopefully provided here), good irrigation management is also feasible.

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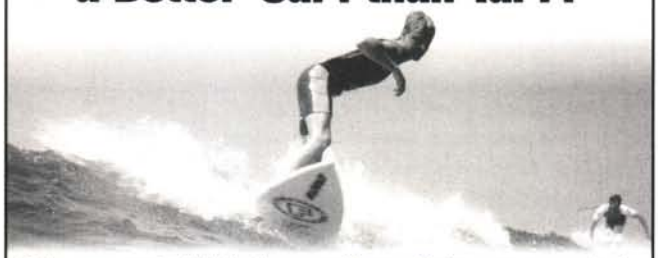

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Conducting Low-Cost, In-Field EC Measurements

Evaluation of soil solution salinity via electrical conductivity (EC) measurements normally requires a complex laboratory procedure involving preparation of a saturated soil paste and vacuum filtering the solution out of the soil before an EC measurement can be taken. Fortunately, Cole-Parmer makes a relatively low-cost EC meter, the TDS-4 ($55.50), that allows direct measurement of soil ECs under field conditions. The company does not manufacture the TDS-4 for this purpose, and therefore does not supply instructions; but following the protocol described below, you can use the meter to monitor soil ECs on-site:

1. Run the irrigation system or use a watering bucket to saturate the area to be evaluated. The soil must be saturated to obtain an accurate reading.

2. Shove the probe into the thatch/soil so the electrodes are completely immersed in the thatch/soil.

3. Read the meter and convert the meter reading using the conversion table provided here (Table 1). Record the converted value for future reference.

4. To measure soil ECs from deeper in the profile, pull a core sample, saturate the area to be tested and stick the probe into the soil. Note: do not be gentle with the electrodes. Firm contact between the electrodes and the soil is critical for accurate measurements.

Measurements taken directly from soils in the field are somewhat variable because they are dependent upon soil-moisture conditions and effective contact between the electrodes and the soil. However, the direct field readings will provide an estimate of soil solution EC that will allow you to determine when salts are building up and leaching is needed.

For example, when the TDS-4 meter reading exceeds 0.7 mS/cm (dS/m), the extract EC is approaching 3.0 dS/m, the upper limit for healthy Kentucky bluegrass growth and development. In this example, leaching will be needed to prevent further increase in EC and resultant plant stress. All turfgrass varieties will grow more vigorously at low soil ECs.

Reference: Stowell, L.J., and Davis, S. 1993. Direct measurement of electrical conductivity (EC) in golf course high-sand-content soils. Phytopathology 83:693.

How to order the TDS-4: Call Cole-Parmer at (800) 323-4340 and request the TDSTestr 4™, Cat. No. 19800-30. Calibration solution (1.4 mS/cm = 1,400 µS/cm) is also available in 500 cc quantities, Cat. No. 01482-70, for $15.50. ❑