SALINITY MANAGEMENT

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IT SEEMS to be a universal truth that an ounce of prevention is worth a pound of cure. It is true in medicine, in criminal justice, and it's also true in turfgrass management. In the arid and semi-arid regions of the United States, the successful management of soil salinity conditions requires preventive action. If preventative measures aren't taken and conditions reach a critical point, it could mean starting over from barren soil.

Fundamentally, salinity is the total concentration of soluble salts in either the irrigation water or the soil solution. Salinity is measured as electrical conductivity (EC) in either decisiemens per meter (dS/m) or millimhos per centimeter (mmhos/cm). To approximate EC from total dissolved salts (TDS), the value reported in ppm is divided by 640. Likewise, to roughly convert EC to TDS, the value reported in dS/m or mmhos/cm is multiplied by 640.

Salinity affects turfgrasses by lowering the osmotic pressure in the soil solution, thus limiting water availability to the root system, or by physically destroying the soil's structure. When these two destructive forces are combined, the turf wilts prematurely and gradually declines over a long period of time.

Frequently, salinity buildup in the soil is misdiagnosed as a disease problem. This is especially prevalent on courses with annual bluegrass-bentgrass putting greens, and often prompts the needless application(s) of fungicide(s). However, in defense of turfgrass managers, it is true that turfgrasses are weakened by salinity buildup and therefore are more susceptible to disease infection. The proper cure in this situation is to manage both the salinity and the disease, not just the disease alone.

Salinity buildup is an inevitable process in many parts of the country and occurs as salts in the irrigation source accumulate in the soil. Through evapotranspiration (ET), salinity increases in the soil because only pure water evaporates from the soil and transpires from the leaf surfaces, leaving salts behind. At best, the resulting buildup can be leached below the root zone or into an artificial drainage system by scheduling extra irrigation in proportion to the salinity increase.

The amount of water required to reduce soil salinity to an acceptable level is primarily a function of the salinity of the irrigation source. As a rule, the higher the salt content of the irrigation source, the higher the requirement for extra irrigation to prevent excessive salinity buildup. Other factors that must be considered to leach salts from the soil include infiltration rate, surface compaction, irrigation scheduling, and the use of the facility.

When salinity is a problem, infiltration must be monitored and steps taken to improve the water infiltration rate. If this problem is not corrected, adequate irrigation cannot be scheduled to move salts below the root zone. Compacted turf areas may need to be aerified before attempting to leach salts to help reduce runoff and allow more water to enter the soil.

Irrigation scheduling should always be planned to minimize excess runoff. Typically, multiple 30-minute cycles are more effective than a single irrigation cycle of one to two hours. Low emission, portable sprinklers also can be very effective for small areas or putting greens with surrounding bunkers or steep grades.

The use of the facility immediately after leaching is often ignored as a potential problem, but is nonetheless an important consideration. Depending on how the greens are built, putting greens can require several hours to adequately dry before they are suitable for play. If the course is closed on Mondays, then Sunday nights would be best for scheduling leaching irrigation cycles.

When high temperatures coincide with salinity buildup, managing the situation is even more difficult. On one hand, the irrigation system may not be able to apply the needed volume of water within a given time period to maintain healthy turf and leach the soil. On the other hand, the soil may be so impervious that it will not accept the needed volume of water without becoming soft and unplayable. Extra care needs to be taken in these situations.

Table 1
Relative 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	

Harivandi, M. A., Butler, J. D., and Wu, L. 1992. Salinity and turfgrass culture. Turfgrass Series No. 32. American Society of Agronomy, Madison, WI.

Sometimes salinity buildup is misdiagnosed as a disease infection, setting in motion the needless application(s) of fungicide(s). To help tell these two common problems apart, look for healthy turf growing in recent aerifier holes. This sign indicates salinity may be the culprit because salts are being leached where water penetrates through the green. Note, too, that some golfers never forget to repair their ball marks, no matter how bad the circumstances may be!

Developing a Salinity Management Program

Obtaining accurate soil and water analyses are the first steps in developing a salinity management program. All water supplies should be tested annually. Water analysis should include measurements of EC and sodium, calcium, magnesium, and bicarbonate concentrations.

Soil analysis for salinity should be done a minimum of twice per year. The first analysis should be made at the end of a rainy season to establish a baseline measurement and to detect the effect of annual rainfall on salinity buildup. A second analysis should be made at the end of a dry growing season to detect the total salinity buildup, and to find out how effectively salinity was controlled by the management program. Soil analysis should include measurements for EC, pH, and the concentrations of sodium, calcium, magnesium, potassium, and hydrogen. The sodium adsorption ratio (SAR) also should be calculated by using the sodium, calcium, and magnesium concentrations.

Besides routine water and soil analysis, crude field measurements of electrical conductivity can be used during the dry growing season to judge the immediate results of a weekly or biweekly leaching program. These measurements can be easily made by making a saturated soil paste and measuring with a digital electrical conductivity probe, such as the TDStestr 4 (Cole Parmer, P.O. Box 48898, Chicago, IL 60648-0898, Cat. No. 19088-30).

Data from water and soil analyses also are important for calculating the application rate of needed soil amendments. Typically, amendments used to help correct salinity buildup supply calcium to the soil. The most often used form of calcium is gypsum (calcium sulfate). According to on-site circumstances, gypsum can be applied directly to the turf or injected through the irrigation system.

Agricultural gypsum, or the more expensive pelletized form, is surface applied to the turf. These products are most effective when tilled into the soil. Therefore, soil aerification prior to the gypsum application should always be considered, if possible. To inject gypsum through the irrigation system, finely ground or solution-grade gypsum that dissolves quickly in water usually can be purchased locally.

If the soil has a high free-lime content (calcium carbonate) and a high pH reading, elemental sulfur or sulfuric acid can be used to increase the calcium concentration. This increase in calcium occurs by the reaction between the free lime in the soil and the added elemental sulfur or sulfuric acid which produces gypsum in the soil. The slowest reaction occurs when elemental sulfur is used because it first must be converted by soil microorganisms into sulfuric acid before it can react with the free lime.

It also is important to appreciate that different turfgrass species have a varying tolerance to salinity buildup. Generally, cool-season turfgrasses have a lower tolerance to excessive soil salinity than warm-season turfgrasses. If salinity levels cannot be maintained below the critical point for a

Table 2
Electrical Conductivity and Sodium Adsorption Ratio Measurements for a Green Built with a Well-Drained, Sand-Modified Root Zone

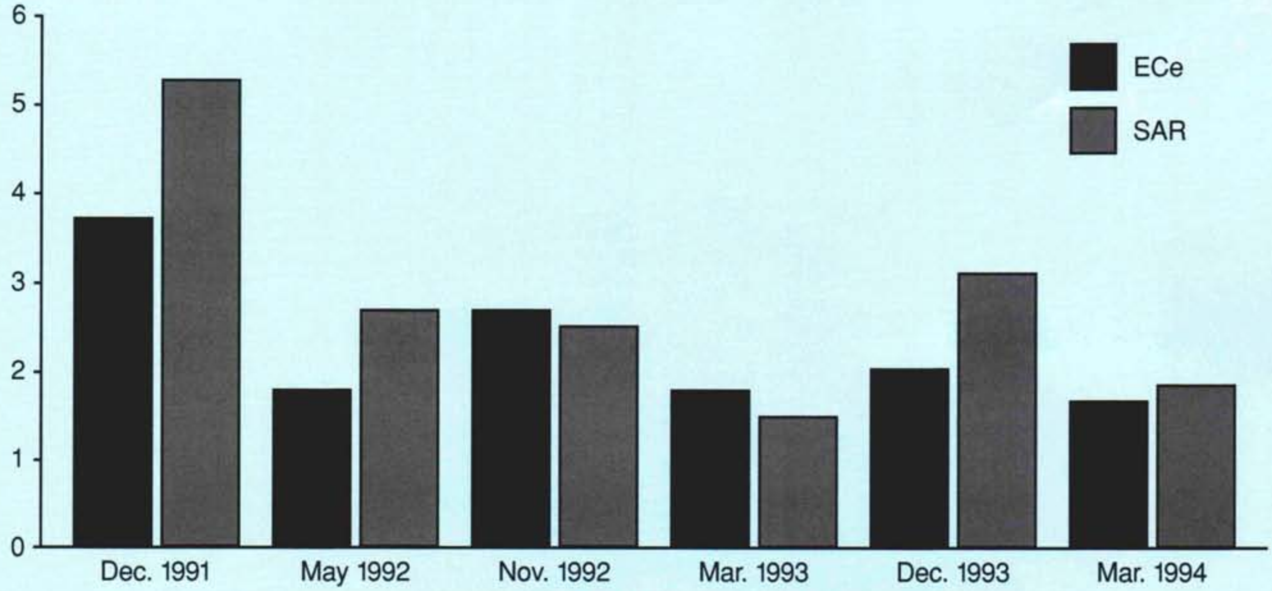
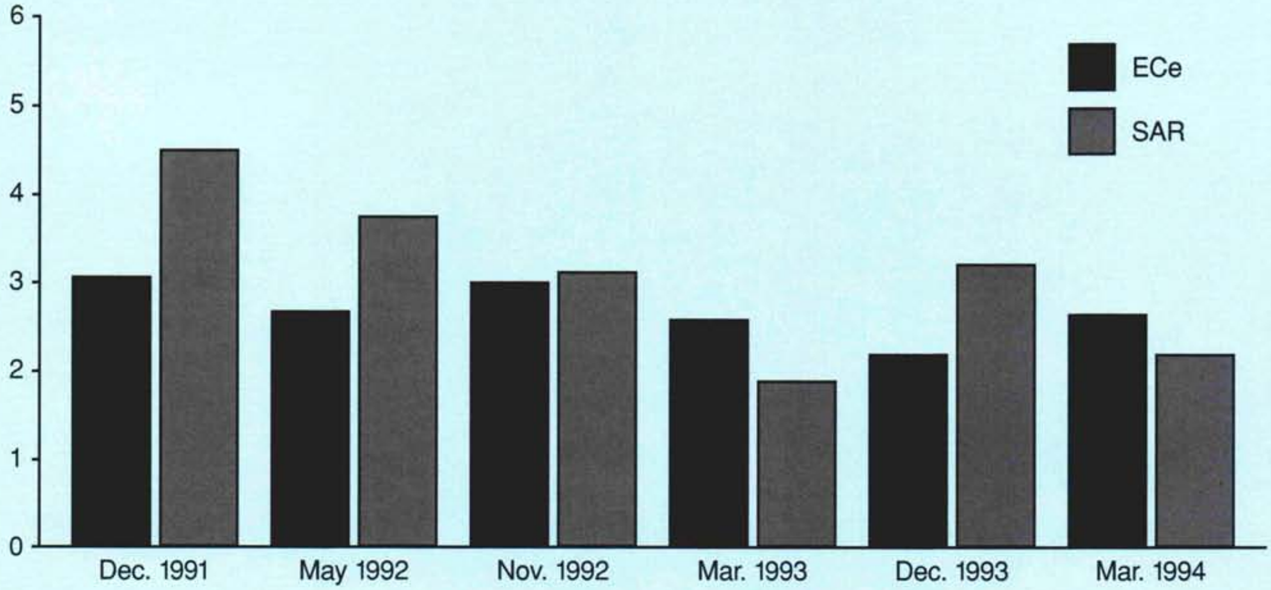


Table 3
Electrical Conductivity and Sodium Adsorption Ratio Measurements for a Green Built with a Poorly Drained Native Soil



particular turfgrass species, then replanting to a more tolerant species should be considered.

Mesa Verde Country Club — A Case Study

Mesa Verde Country Club is a private facility built in the late 1950s. The putting greens had developed a history of occasional turf loss during the late summer because of poor drainage and salinity buildup. The recent drought in California was especially troublesome and caused serious turf loss in the fall of 1990.

An average annual rainfall of less than 7.5 inches for the previous five years produced salinity readings on some greens that exceeded 8 dS/m. For the most part, leaching attempts were ineffective due to the poor drainage that would not allow salts to move past the root zone. Soil and water monitoring were undertaken to develop a strategy for reducing salinity measurements below the upper tolerance range for putting greens dominated by annual bluegrass.

Irrigation source analysis revealed that the well water used on the golf course had

To successfully manage greens with a salty irrigation source, periodic leaching is necessary to prevent salinity buildup. If leaching isn't practiced, the cure for turf loss will inevitably involve starting over from barren soil.

an EC of 0.56 dS/m and an adjusted SAR of 3.39. Normally this is considered good quality water for irrigation; however, research by Dr. James Oster, University of California at Riverside, had shown that low-EC waters are likely to have poor infiltration rates as the SAR increases. As odd as it may seem, both the water infiltration and the efficiency of the leaching program were improved by adding gypsum to the irrigation supply.

Salinity monitoring was initiated in December 1991 after a few light seasonal rains. At this time, the top four inches of the root zone had an EC of 4.7 dS/m and an SAR of 6.8. To maintain annual bluegrass/bentgrass putting greens, salinity needed to be reduced to below 4 dS/m throughout the year and calcium levels needed to be increased to improve soil structure.

A double strategy was developed. First, to improve the infiltration rate of the irrigation source, 700 pounds of gypsum (salt) was dissolved in each acre foot of water (326,000 gallons) used for irrigation. Gypsum was dissolved in the water by a machine that injects a mixture of gypsum and water into the discharge side of the well that feeds the irrigation reservoir. The treated water resting in the reservoir was then pumped through the irrigation system.

The quantity of gypsum applied was based on the amount of calcium needed and the salinity increase required of the irrigation water to improve infiltration. As a point of reference, 235 pounds of 100% gypsum will raise the calcium concentration of the water by 1 meq/liter and the EC by 0.12 dS/m. The use of a digital electrical conductivity meter before and after water treatment verified that the proper amount of gypsum was added.

Second, to improve the quality of the irrigation source, a twice-per-month leaching program was initiated by applying two hours of irrigation in four 30-minute sets. The leaching program was started in the spring of 1991, approximately one month after the last significant rainfall. By starting early in the season, salinity was maintained below the target measurement of 4 dS/m.

Two noteworthy conclusions were made as a result of the salinity management strategy. First of all, salinity buildup in the putting greens built with native soil can be held at a tolerable level. If the leaching program is not started until midsummer, when ET demands are at their highest, it is very difficult to apply enough irrigation water to move the salts below the root zone and still have a firm, playable surface. Secondly, we found that salinity buildup in the putting greens rebuilt with a sand root zone can be reduced faster and with less water compared to those built with native soil.

While most prevalent in the arid and semi-arid regions of the United States, salinity problems can occur anywhere a poor-quality irrigation source is used during drought conditions. To prevent such a set of circumstances from causing the deterioration of top-quality putting greens, the key to success is getting an early start at correcting the problem. Symptoms of salinity damage are not revealed until after turf damage occurs, so electrical conductivity monitoring with regular water and soil analyses is critical. As the old adage says — an ounce of prevention is worth a pound of cure.