Another Look — Turf and Salinity

by DR. GARALD HORST
University of Nebraska

ONE OF THE most difficult challenges in the field of turfgrass management deals with soils and water that are high in salts. Previously arid and semi-arid regions were the primary areas where salinity and water quality problems were encountered. Salinity problems also appeared in humid, high-rainfall climates, particularly among coastal areas where saline groundwater intrusion occurred. Now, however, due to degradation of ground and surface water supplies, salinity problems appear where these difficulties have not been encountered before.

Salinity problems can be caused by a number of factors. Sometimes the soil itself is high in salts as a result of environmental conditions. Occasionally, problems arise from cultural practices, such as improper irrigation or the use of water high in salts. Although good-quality effluent water is a resource that should be used more often for irrigation, effluent supplies that are high in salts are not uncommon.

There are complex interactions between the turfgrass plant and salts in the water and/or the soil. While "quick fixes" are often promised, they cannot alter the basic laws of chemistry. It's a little like losing weight. Fad diets come and go, but unless you take in fewer calories than you burn off, your jeans won't fit any better. Let's take a brief look at some basic facts about salts so you can be better prepared to meet this challenge.

Salinity Effects on Turfgrasses

Soluble salts in saline soils injure plants because of the increased salt concentration in the soil solution. Turfgrass responses vary depending on the turfgrass species, soil texture, salt distribution in the soil profile, and types of salt ions present.

Salts affect plants by making water and nutrients less available for growth. High salt concentrations in the soil solution create osmotic pressures that decrease the amount of water available

Salt accumulations around an irrigation pond are caused by poor water quality and high evaporation rates. Note the absence of turf near the water's edge; when used for irrigation, turfgrass quality suffered.

for plant growth. Turfgrass plants growing under these conditions are particularly susceptible to wilt and drought, and the problem is especially apparent during turfgrass establishment. Frequent, light irrigations with poor-quality water and/or the presence of saline soils often results in reduced rooting, impaired topgrowth, and poor turfgrass density.

Turfgrass injury as a result of high osmotic conditions is called physiological drought. This phenomenon occurs when plants cannot take in enough water to meet growth requirements through cell expansion and normal processes such as respiration. Injury from physiological drought also occurs when soluble salt concentrations build up on the external surfaces of leaves as a result of desiccating weather conditions, improper irrigation practices, or exudation.

Certain soluble salts in the soil solution can restrict the uptake of essential nutrients for plant growth by occupying nutrient absorption sites on turfgrass roots. Such secondary induced salt injuries most commonly result in potassium and/or phosphorus deficiencies.

Visual symptoms of salinity effects on turfgrasses include wilting and a blue-green appearance of the leaves, followed by irregular shoot growth. Higher salinity levels cause leaf tip burn and eventually thinning of the turf. Root growth is shallow and stunted, with individual roots sometimes enlarged.

Bentgrass establishment can be reduced by salt accumulations caused by poor-quality water containing bicarbonates and other salts.

Reading the Test Results

Three of the most useful and informative measurements for evaluating salt effects are Electrical Conductivity (EC), Sodium Absorption Ratio (SAR), and Exchangeable Sodium Percentage (ESP).

Electrical Conductivity (EC)

Salinity is measured as electrical conductivity (EC), and is reported in the scientifically preferred term of decisiemens per meter (dS/m). Salinity is also reported in other units as millimhos per centimeter (mmhos/cm), parts per million total dissolved solids (ppm and/or TDS ppm), and total dissolved solids as milligrams per liter (TDS mg/l). Keep in mind, salinity units are all interchangeable by the following conversions:

$$\text{dS/m} = \text{mmhos/cm} = \mu\text{mhos/cm} \times 1000$$

$$\text{dS/m} \times 640 = \text{TDS ppm} = \text{TDS mg/1}$$

$$\text{TDS (ppm)} / 640 = \text{EC (mmhos/cm)}$$

A good guideline for evaluating reported EC results is listed below.

	Degree of Problem		
Salinity	None	Increasing	Severe
EC (mmhos/cm)	<0.75	0.75 - 3.0	>3.0
TDS (ppm)	<480	480 - 1920	>1920

Sodium Absorption Ratio (SAR)

SAR is the ratio of sodium to calcium and magnesium ion concentrations. The following formula calculates SAR when sodium (Na), calcium (Ca), and magnesium (Mg) are expressed as meq/l (milliequivalents per liter).

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

SAR is a good relative indicator of the sodium hazard or danger to soil permeability. Irrigation water used with SAR values greater than 4 may result in sodium accumulations in the soil profile. This factor can enhance the salinity problem by causing deflocculation of clay and clay-loam soils, resulting in reduced permeability. Coarse-textured soils, such as those on golf greens constructed of a high percentage of sand, may be able to withstand irrigation water with SAR values in excess of 9, without experiencing severe permeability problems.

Exchangeable Sodium Percentage (ESP)

The degree of saturation of the soil exchange complex with sodium is referred to as Exchangeable Sodium Percentage. It is calculated as follows:

$$ESP = \frac{\text{Exchangeable sodium (meq/100 gm soil)}}{\text{Cation exchange capacity (meq/100 gm soil)}} \times 100$$

On most soil tests, this figure is reported as a percentage of the base saturation. When sodium begins to occupy more than 3% of the total base saturation, degradation of soil structure can begin.

Saline Soils

Saline soils usually have a pH of 8.4 or less. The electrical conductivity (EC) of a saturation extract from saline soils will be greater than 4 mmhos, and the exchangeable sodium percentage (ESP)

Calcium and magnesium salts accumulated along a seepage zone next to the cart path. Seepage occurred from excess irrigation applied to the adjacent landscaping.

will be less than 15. Major ions present in these soils are calcium, magnesium, sulfate, chloride, and sometimes nitrate. White crusts, as a result of ion accumulations, are usually visible around irrigation lakes where saline conditions are prevalent. Sufficient concentrations of these soluble salts can cause turfgrass injury.

Arid and semi-arid regions exhibit characteristic saline soils by the white salt accumulation on the surface. This process of salt accumulation is called salinization. Factors that affect salt salinization include: a) natural weathering of existing soils; b) evaporation rate; c) rate of water movement to the soil surface; d) salt content of ground and irrigation waters; e) amount of applied irrigation water; f) soil permeability; and g) quantity and quality of surface drainage water.

Soil salinity problems may also develop from improper irrigation practices and/or poor-quality irrigation water. Groundwater resources in some areas have tested as high as 22 tons of salt per acre-foot of water. This groundwater source could not be used for irrigation without major modification. Many irrigation water sources range from 0.1 to 5.0 tons of salt per acre-foot of water.

Sodic Soils

Another soil condition is sodic or alkali soils, where the principal soil cation is sodium. These soils have an ESP greater than 15, and pH is usually 8.5 or higher. In sodic soils, more than half the soluble cations in the soil solution are sodium. Sodium influences soils by inhibiting clay flocculation and promoting soil structure deterioration. The major consequence is very low water permeability in the soil. In addition to the indirect soil effects, the sodium concentration in the soil solution is usually high enough to influence adversely turfgrass growth and quality.

Reducing Salinity Problems

The first step in reducing salinity problems is to confirm that a salinity problem exists or that the factors present will eventually cause problems. Obtaining soil and/or water chemistry tests from a reputable laboratory will help accomplish this goal. Be sure to collect representative samples for testing and use the same lab for subsequent testing for the sake of continuity.

Drainage, proper irrigation, and irrigation water quality are key factors in managing salinity problems. Excess salts may be leached out of turfgrass root zones with proper application of irrigation water or by natural rainfall. However, if irrigation water has excess or undesirable dissolved salts, the water should be carefully evaluated before it is used for irrigation purposes. It is a good idea to monitor water quality throughout the year, since changes can occur. Good-quality water should have an SAR no greater than 4. Irrigation waters with high EC values can be used if the soil has a high infiltration rate, an adequate internal drainage system, and the irrigation delivery system can supply excess water during all seasons. This situation means the safest place to use poor-quality irrigation water is on properly constructed USGA greens. Greens that suffer from poor internal drainage and/or a lack of good surface drainage should be rebuilt as soon as possible. In the meantime, deep mechanical cultivation, flushing the soil profile with deep irrigations, and the use of soil amendments remain the best hope.

Sodic and Saline Conditions

When a soil has an EC greater than 4 mmhos/cm and an ESP greater than 15, it is classified as saline-sodic or saline-alkali. In areas of poor-quality irrigation water or low rainfall, soils may accumulate high quantities of dissolved minerals. Saline soils usually contain large quantities of soluble minerals or salts that influence turfgrass and ornamental plant growth and development. Both saline and sodic conditions require special cultural practices to maintain turfgrass growth and quality. Predictably, saline-sodic soils are among the most difficult to manage.

Conclusion

Confused? Well, don't feel too bad. The chemistry involved in dealing with salts in soil and water will challenge even the best soil scientist. If you're looking for a little late night reading, you might pick up Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soil," from the United States Department of Agriculture. In the meantime, always remember, there are no quick and easy "fixes" to poor water quality or soils. Correction, or at least management of these problems, takes time and work.