Diagnosing and Rectifying Salt Toxicity

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Soil and water salinity are covert killers. Although there may be no symptoms at first, as salts build up to a toxic level, a tree receives fewer and fewer nutrients and less and less water until it gradually exhibits symptoms. Without remediation, this condition can lead to decline and death.

Salinity kills in two ways. High concentrations of soil salt ions leads to osmotic stress in roots that limits water uptake and other root functions such as specific mineral uptake. Specific ions can also accumulate in tree foliage and become toxic to chlorophyll, killing the machinery necessary to gather energy for a tree.

If you irrigate, you are leading to salinization of your soils. In the United States, the USDA estimates a 30 percent yield reduction in irrigated agriculture sites due to salinity.

THE SALTY SOUTHWEST

Sodium, calcium, magnesium, potassium, sulfate chloride, and boron all form salts that can be present in irrigation water. Water has been called the "universal solvent". When water flows over or through land, these salts dissolve from rocks, ravines and other geologic features it passes by. In the arid West, soils are often high in these elements.


Salt burn on a bay tree scorches the tips of the leaves. Photo courtesy: Russ Thompson

According to research scientists in Nevada, Las Vegas water carries about one ton of salt per acre foot or 326,000 gallons. ***This adds nearly 400 pounds of salt for every 1,000 square feet of fescue turf per year.*** While most trees do not require that much supplemental irrigation, these figures illustrate how salts can build up in soils.

In some areas of the Southwest, soils can exhibit a white crust of surface salts. This usually occurs during dry spells after irrigation has stopped. As the water rises through the soil to evaporate at the surface, salts are also drawn up. Since the salts don't evaporate, they accumulate and leave a crust.

Plants have different degrees of salt tolerance or salt resistance, which is the ability to withstand high salt levels in their leaves or in the root zone. Research on salt tolerance has primarily been on agricultural crops and use of deicing salts, usually sodium chloride. Salts containing sodium and chlorides are the most damaging to plants (boron is also an issue in some parts of the Southwest).

RECYCLED WATER AND SALT ACCUMULATION

As drought tightens water supplies in the West, more and more large properties are using recycled water for irrigation. Also known as reclaimed or effluent water, it is simply former waste water (yes, that means sewage) that is filtered and treated so that it is safe for irrigation. (Technically, wastewater can be treated to a potable level, but public perception has not embraced the "toilet to tap" process.)

Although safe, most recycled water is high in salts, especially in the Southwest. The level of salinity is dependent on the amount of soluble salts in the source water and the method of water treatment. Recycled Colorado River water will usually have higher salt levels than Northern California waters, for example.

Irrigation water containing large concentrations of sodium can actually destroy the physical structure of the soil. This effect is called a sodium hazard, and is noted on soil and water tests as SAR (sodium adsorption ratio). SAR is determined by the ratio of sodium to calcium and magnesium. The higher the SAR, the greater the risk of soil structural damage. For example, the SAR of water from Hetch Hetchy reservoir in California is .78, while water recycled from South Bay Water Recycling read 4.1. ***For this reason, it is important to test recycled water to understand its potential effects on landscape trees.***

Soil salinity is also measured by determining the electrical conductivity (EC) of a soil sample at or near the root zone of a plant. Filtered water is mixed with and extracted from soil, then measured as deciSemiens per meter (dS/m). For example, the EC of water from Hetch Hetchy reservoir in California is .2, while the South Bay Water Recycling sample read 1.21. For comparison, the EC of distilled water is approximately 0.002 dS/m, while seawater is approximately 58 dS/m.

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Total Dissolved Solids (TDS) measures suspended solids, most of which are salts. It is noted as milligrams per liter (mg/L). Again, the higher the level, the greater potential for salt damage. Rainwater usually has a TDS of 20 mg/L or less; the EPA suggested maximum for drinking water is 500 mg/L. Most landscape plants can tolerate 200 to 800 mg/L TDS.

SALTS AND SOILS

Sodium attaches to soil particles. The soil then becomes harder and more compacted when dry, and eventually becomes impervious to water. This is a slow process that can take years.

Soil types can also affect plant response to salt levels. ***Since clays can hold and exchange more salt than sands plants will tolerate more salt in a clay soil than in a sand soil.***


Salts accumulated on this pine tree due to overhead irrigation. Photo courtesy: Russ Thompson

Salts accumulate in the leaf tissue of trees until symptoms become visible. Roots absorb salts with water, which moves up the trunk to the branches and leaves and eventually transpires into the air. Salts are left behind and increase gradually. ***Sometimes plants can go for years before exhibiting symptoms.***

Salt toxicity symptoms often starts with interveinal chlorosis (yellowing of the leaves between the veins with the veins remaining green). Burning on leaf surface or margins is also a symptom. As salts accumulate, the damage increases. Leaf burn becomes more severe until defoliation and twig dieback occurs.

Examine the oldest leaves on a tree for salinity damage since they have had the most transpirational time to accumulate salt. Damage observed on younger leaves may be from other causes such as pathogens, injurious sprays or other forms of injury.

Trees have varying levels of salt resistance or salt tolerance. Tamarix (salt cedar) can actually sequester salt in salt glands. Eucalyptus polyanthemos (silver dollar gum), Morus alba (fruiting mulberry) and Platanus x acerifolia (London planetree) can all tolerate higher levels of salts. On the other hand, Magnolia spp., most Prunus spp. and Sequoia sempervirens (Coast redwood), will suffer in salty situations. (See the links below for lists of salt-tolerant trees.)

A leaf that is burned by accumulated salts will never recover. However, saline water and/or soils can sometimes be compensated for with thoughtful management practices.

Keep in mind that salts are drawn up and deposited when soils dry out. If there is a large amount of salts accumulated, thoroughly irrigating so that they are flushed below the root zone of the plant can offer some relief. Leaching with pure water such as rainfall is the best cure of salt affected soils. This is why drought can be so damaging—there are few or no leaching rainfall events during droughts.

Practically out in the field, this means that trees should occasionally be irrigated deeply, beyond the root zone. Since most absorptive roots are in the top 12 inches of the soil, this can be determined using a soil probe after irrigation. In addition, soils in the root zone should not be allowed to dry out completely, as this will increase the accumulation of salts in the root zone. Applying mulch can help keep the soil's surface from drying out and prevent salt accumulation.

Although a complex issue, salinity will become a greater concern as water supplies tighten. Arborists need to have a working knowledge of the basic concepts, symptoms and irrigation techniques necessary to tree survival.

Further Reading/Links

Boron and Salt Tolerant Trees and Shrubs for Northern Nevada
http://www.unce.unr.edu/publications/files/ho/2012/sp1204.pdf

Salt Tolerance Of Various Temperate Zone Ornamental Plants
http://www.coopext.colostate.edu/TRA/PLANTS/stable.shtml#contree

Salinity Management Guide
http://www.salinitymanagement.org/Salinity%20Management%20Guide/index.html

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