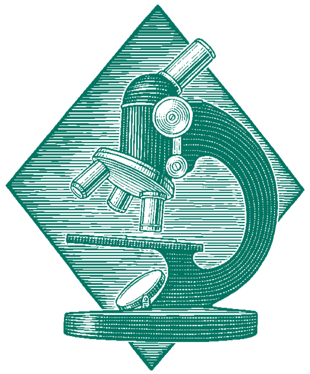
# INTERPRETING SOIL SALINITY ANALYSES



**OSU Soil, Water and Forage Analytical Laboratory** offers two packages (Salinity Management and Comprehensive Salinity) of salinity tests to help farmers and environmental remediation specialists manage soil salinity problems. Remediation of salt contaminated sites and managing high salt content soil for crop production is more effective if the specific nature of the salt in the soil is considered. All the analyses in the *Salinity Management* package are measured from a 1:1 soil to water extract. Analyses, however, in the *Comprehensive Salinity* package are measured from the saturated paste extraction, which is closer to field conditions than the1:1 extract. The *Comprehensive Salinity* package also includes determinations of important anions (Table 1), which are not provided in the *Salinity Management* package. Therefore, the *Comprehensive Salinity* test package is more suitable for consulting or litigation purposes related to salt remediation than the *Salinity Management* test.

## What Results do I Get from Soil Salinity Testing ?

Table 1. The Analyses Included in the Two Soil Salinity Test Packages Offered by This Lab

| I. Salinity Management (1:1 extraction) | II. Comprehensive Salinity (saturated paste extraction) | |
|---|---|---|
| Sodium (Na) | Sodium (Na) | Carbonate ($CO_3^{2-}$) |
| Calcium (Ca) | Calcium (Ca) | Bicarbonate ($HCO_3^-$) |
| Magnesium (Mg) | Magnesium (Mg) | Chloride ($Cl^-$) |
| Potassium (K) | Potassium (K) | Nitrate-nitrogen ($NO_3^-N$) |
| Boron (B) | Boron (B) | Sulfate ($SO_4^{2-}$) |
| pH | pH | |
| Electrical conductivity (EC) | Electrical conductivity (EC) | |
| Total soluble salts (TSS) | Total soluble salts (TSS) | |
| Sodium adsorption ratio (SAR) | Sodium adsorption ratio (SAR) | |
| Exchangeable sodium percentage (ESP) | Exchangeable sodium percentage (ESP) | |

## How to Collect a Good Soil Sample for Salinity Testing

The purpose of salinity analyses is to evaluate the size and extent of salt contamination; therefore, the samples should represent the salt affected areas only, instead of the entire field. The top 3" or plough depth should be sampled if the salt accumulation is induced by irrigation or other farming practices. On the other hand, samples from 0-6" and 1-foot increment below the surface need to be collected to evaluate the extent of brine contamination. A similar sample from nearby normal soil is often useful as a benchmark for comparison. Multiple sub-samples (15-20 cores with a soil probe) are needed to make a representative composite.

## What Do Those Test Results Mean?

**Total soluble salts** refer to the total amount of salt dissolved in the soil extract expressed in parts per million (ppm). The salts include substances that form common table salt **(sodium and chloride)** as well as **calcium, magnesium, potassium, nitrate, sulfate and carbonates.**

**Electrical conductivity** measures the ability of a water sample to conduct electricity. This relates to the amount of total soluble salts, or TSS, in the water sample. Pure water has very low conductivity. As TSS increases, water becomes more conductive. Although different dissolved substances affect conductivity differently, the average TSS = 0.66 x EC. The unit for EC used in our lab is $\mu$mhos/cm. Different units, such as mmhos/cm or dS/cm (1 mmhos/cm = 1 dS/cm = 1000 $\mu$mhos/cm), may be used in other labs.

**Exchangeable sodium percentage (ESP)** is the sodium fraction adsorbed on soil particles expressed as a percentage of cation exchange capacity. ESP is normally calculated from SAR.

**Sodium adsorption ratio (SAR)** is a relation between soluble sodium and soluble divalent cations (normally Ca and Mg) in a soil-water solution which can be used to predict the exchangeable sodium fraction of soil equilibrated with a given soil-water solution.

## What Effects Do Salts Have on Soils and Plants?

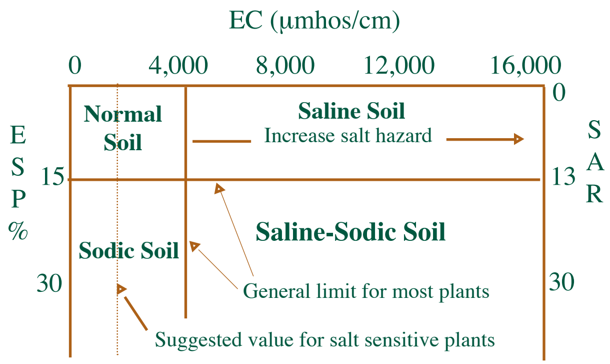
**EC and Osmotic Potential:**

High EC indicates high salinity in soils. Salinity is correlated to osmotic potential, which is the primary cause of plant damage and death. Osmotic potential causes dissolved constituents in soil to try to retain water, so plants have to compete with salt for water. The presence of excessive salts in soils causes plants to prematurely suffer drought stress even though substantial water may be present in the soil. Osmotic potential is a direct result of the combined concentrations of dissolved Na, Ca, K, and Mg cations, and Cl, $SO_4$, $HCO_3$, and $CO_3$ anions which are common constituents in salty water. The soil is considered saline if EC is greater than 4000 $\mu$mhos/cm (4 mmhos/cm used by some other labs).

**ESP and Soil Dispersion:**

The second major problem caused by excessive salts, is due to the dispersive effect sodium has on soil clays. Dispersion in soil is the reverse process to aggregation (Ca, Mg and other di- or trivalent cations promote aggregation). Unless the soil salinity is also high, dispersion will occur in soils having excess sodium and relatively low Ca and Mg. As a result of clay dispersion, soils will have poor physical properties. This results in a massive or puddled soil with low water infiltration, poor tilth, and surface soil crust formation. As a general rule in soils, dispersion can be expected to occur when ESP is greater than 15% and EC less than 4000 μmhos/cm. The pH is also usually 8.5 to 10. Those soils are called sodic, alkali, or natric soils.

**Figure 1.**
**Plant growth response to EC and ESP.**




## How to Manage Saline and Sodic Soils

The total salts and sodium must be reduced before plants can grow normally. The only effective way to reduce salts in soil is to remove them. This can be done either by leaching the salts out of the root zone or by plant uptake and removal. Adding organic matter and installing drain tiles can improve internal soil drainage. However, gypsum is needed to reclaim sodic soils by replacing Na with Ca on soil particles. See Extension Fact Sheet PSS-2226 for more information on saline and sodic soil management.

## Related Extension Publications

PSS-2207 How to Get a Good Soil Sample
PSS-2226 Reclaiming Slick-Spots and Salty Soils

## How to Categorize Soils Based on their Salinity and Sodicity

Soils can be classified into four categories based on EC and ESP (Table 2). Soil properties in each category are unique and the tolerance of various plants to various combinations of salinity and sodium levels is also unique. Different management options for crop production or reclamation should be used according to the makeup and content of salts. Figure 1 illustrates the relationship of plant growth to salinity and sodicity.

Table 2. Categories of Salt Affected Soils and Associated Problems

| EC (μmhos/cm) | ESP (%) | Soil Classification | Soil and Plant Response |
|---|---|---|---|
| <4000 | <15 | Normal | No osmotic stress; well aggregated |
| <4000 | >15 | Sodic | No osmotic stress; dispersed |
| >4000 | <15 | Saline | Osmotic stress; well aggregated |
| >4000 | >15 | Saline-Sodic | Osmotic stress; potentially dispersive |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