

Another Helping of Alphabet Soup

Editor's Note: This is the third of a series of articles discussing water quality. Parts one and two appeared in the September and October 2004 issues of On Course.

The highly negative effects of sodium displacement of calcium and magnesium at the cation-exchange sites has lead to a number of indices designed to help predict and determine the potential effects water quality has on your soil and turf. The following review should be helpful in understanding these indices and how to work through them.

Here in the Midwest, we rarely encounter natural waters with high sodium levels, but we can suffer from induced sodium problems when high pH and high bicarbonates "tie up" calcium and magnesium, making them unavailable for exchange.

Sodium Adsorption Ratio (SAR)

One index we see with regularity is the SAR. This has been used to rate the permeability hazard, but really gives a limited view of our Midwestern waters because it neglects to incorporate considerations for pH and bicarbonate alkalinity. However, we should review it for background.

We know that high sodium levels are problematic because the sodium adsorbs onto the soil cation-exchange sites. This causes sealing of the soil and a corresponding reduction in the permeability of water and air flow. The potential for sodium to replace other cations (Ca & Mg) on the cation-exchange sites is calculated with the SAR, which looks at the ratio of sodium levels to calcium-plus-magnesium levels in the water. This is called the Sodium Adsorption Ratio.

The SAR is determined by the following formula:

$$\text{SAR} = \frac{\text{Na}}{\sqrt{(\text{Ca} + \text{Mg}) \div 2}}$$

These values are expressed in meq/l. (Refer to the second piece in this series, October 2004, for important equivalent weights and conversion calculation.)

The SAR does not account for well-documented chemical reactions between alkalinity and water hardness (Ca & Mg). Water hardness is the natural result of rock weathering. Calcium usually is higher than magnesium. These elements are the main ones causing the scale-forming properties of waters.

In general terms, as water hardness increases, the tendency for sodium to become toxic decreases. However, where pH and alkalinity are high (< 7.0 and < 120 ppm), the hardness is tied up with bicarbonates and therefore, the sodium can displace them at the exchange sites.

Adjusted Sodium Adsorption Ratio (adj.SAR)

The Adjusted Sodium Adsorption Ratio (adj.SAR) is more complex than the SAR but should be used when the carbonates or bicarbonates are high. If bicarbonates are less than 2.0 meq/l (120 ppm) and carbonates are less than 0.5 meq/l (15 ppm), use SAR.

In many of your waters, the bicarbonates are higher than the levels shown above. These waters should be evaluated by the adj.SAR.

Adjusted Sodium Adsorption Ratio = SAR [9.4-pHc]

Determining pHc is necessary to calculate adjusted SAR. Make sure that the SAR and adjusted SAR are included on your water-analysis reports.

The pHc

- Theoretical calculated pH of water when it is in contact with lime.
- Indicator of dissolution (> 8.4) or precipitation (< 8.4) of lime in soil.
- Saturation Index = pHa-pHc
- If positive—precipitation likely—referred to as a “depositor.”
- If negative—dissolution likely—referred to as a “stripper.”

The pHc adds consideration for pH and alkalinity to the mix.

$$\text{pHc} = (\text{pK}'2 - \text{pK}'\text{C}) + \text{p}(\text{Ca} + \text{Mg}) + \text{p}(\text{Alk})$$

(continued on page 20)

- (pK⁺ - pK⁻) obtained from the sum total of Ca/Mg/Na from a table.
- p (Ca + Mg) obtained from sum of Ca and Mg in table as well.
- P(Alk) is sum of HCO₃ and CO₃ from table.

Recommended Guidelines

- SAR (Sodium Adsorption Ratio).....< 3*
 - Adjusted SAR.....< 6*
 - pHc (Calculated).....> 8.4
- *meq/l

Residual Sodium Carbonate (RSC)

In addition to the pHc and Adj. SAR, the use of the Residual Sodium Carbonate (RSC) is very useful for evaluating sodium hazard in water applied directly to the soil. In these calculations, the potential for precipitation of calcium, magnesium bicarbonates and carbonates is considered. If these constituents precipitate out of the water, relative amounts of sodium will increase in the soil solution. This fits Midwestern waters nicely.

The RSC:

- Forecasts the accumulation of sodium in the soil based on the potential pre-

cipitation of calcium and magnesium with bicarbonates and carbonates.

- Should be ZERO or less. Anything above that should be considered for treatment. Above 2.5 is not suitable for irrigation.

If HCO₃ and Ca are high (10 meq/l), the RSC will be low but will still precipitate CaCO₃ and cause a problem. This requires further analysis.

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

The RSC equals the sum of the bicarbonate and carbonate ion concentrations minus the sum of the calcium and magnesium ion concentrations, where the ions are expressed in meq/l. Where excess or "residual" carbonates are in the water, calcium

will be stripped from the soil exchange sites. These unoccupied exchange sites then become available for sodium to dominate. A reduction of carbonates and bicarbonates will leave the calcium and magnesium in solution.

A negative RSC indicates that sodium build-up is unlikely since sufficient calcium and magnesium are in excess of what can be precipitated as carbonates. A positive RSC indicates that sodium build-up in the soil is possible. The degree of sodium hazard is as shown in the table below.


Next time, we'll review various techniques to reduce the negative impacts of poor water quality. Happy New Year!



RSC	HAZARD
< 0	None.
0-1.25	Low, with some removal of calcium and magnesium from irrigation water.
1.25-2.50	Medium, with appreciable removal of calcium and magnesium from irrigation water.
> 2.50	High, with most calcium and magnesium removed leaving sodium to accumulate. Unacceptable.

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