Know your soils

Understanding Soil Sodicity

Soils are considered sodic when they have levels of sodium above a defined threshold. In general, the threshold used is an Exchangeable Sodium Percentage (ESP, measured by a laboratory) of greater than 6%. The ESP is the proportion of sodium relative to other cations (like calcium, magnesium and potassium) attached to clay particles in the soil. Soils are considered to be strongly sodic if their ESP is greater than 15%.

A common (but not universal) feature of sodic soils is that they may disperse. Dispersion results in the suspension of clay particles in water and leads to problems such as tunnel erosion, gully erosion and poor water movement through soils.

The distinction between sodicity and dispersion is important. Sodicity is a classification based on soil chemistry. Dispersion is a process that occurs when a soil gets wet. *Not all sodic soils disperse and not all dispersive soils are sodic*. The fact that a soil might be classified as sodic or strongly sodic may tell you very little about the risk of dispersion and associated soil degradation. How a sodic soil behaves is influenced by many factors, not just it's sodium content—factors such as soil salinity, clay content, clay type, organic matter content, magnesium content, iron content, pH, history of working the soil and speed of wetting all make a difference.

Sodic soils occur naturally—around 45% of Queensland has sodic soils. Sodicity is more common in subsoils, but may also occur in the topsoil. Many clay subsoils in the semi-arid zone of Queensland have an ESP of between 20 and 30%. The highest ESP observed in soil in Queensland (>90%) is associated with Great Artesian Basin springs that release water high in sodium bicarbonate. Irrigation with effluent or other waters high in sodium can also raise the sodicity of soils.

Sodicity can be a constraint to productivity in cropping lands as it influences the permeability, drainage and water availability of soils. Surface sodicity can also lead to surface crusts that reduce seedling emergence.

The behaviour of a soil when wet is more important than whether or not it is classed as sodic. A simple field test can be done to see if a soil will disperse when wet (see fact sheet *Understanding Dispersive Soils* for a description on how to do the test). The exact ESP of the soil is not critical, as no specific recommendations should be made on the basis of ESP alone. For example, soils with an ESP less than 6% can disperse. It is important to understand whether or not the dispersion of the soil is caused by excess sodium and consequently what management options might be adopted. This is when ESP is useful.

Image 1: Failure of a rock check dam in a sodic clay soil.

How can I identify sodic soils?

Sodic subsoils are common in texture contrast soils, especially those with columnar soil structure (see fact sheets *Understanding Soil Texture* and *Understanding Soil Structure* for information to help identify these soils). Sodic soils come in many colours e.g. brown, black, grey, yellow, reddish. There are many characteristic vegetation types associated with sodic soils in certain landscapes—for example bulloak, gum-topped box, tea tree, Brigalow and belah. Sodic soils are usually alkaline (i.e. they have a high pH around 8 to 9.5) (though they may be acidic or neutral). Sodic soils in gullies often have distinctive 'fluting' shapes.

For more information, contact
Soil.Enquiry@resources.qld.gov.au

Image 2: 'Fluting' shapes are commonly seen in gullies containing sodic soils that have dispersed.

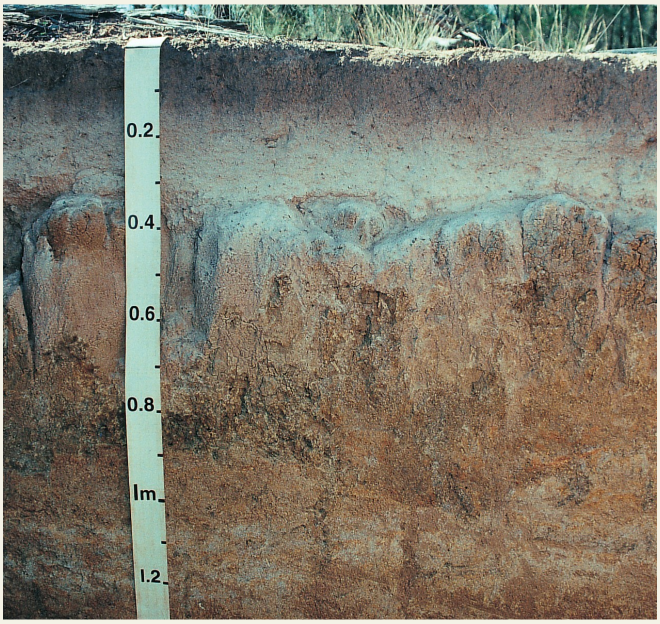

Image 3: Columnar soil structure is seen at the top of the subsoil (around 0.4 m) in this soil profile. This type of structure is often associated with soils that are high in salt and/or sodium.

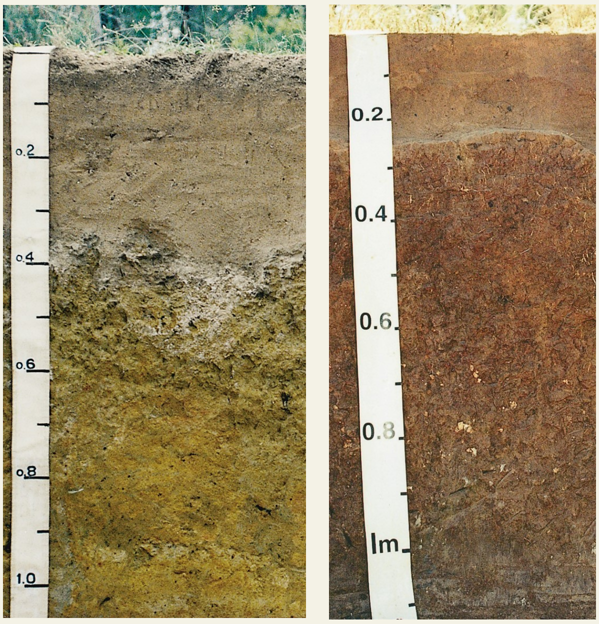

Image 4: Texture contrast soils have a sandier/light textured topsoil which overlies a clay/heavy textured subsoil (which is usually sodic and/or saline).

Managing sodic soils

Irrespective of the ESP, if sodicity is causing a problem in a soil there are a number of universal management strategies. The first is organic matter. Increasing the soil organic matter will counter the effects of sodium. This may not always be possible though, particularly in the drier parts of Queensland.

Addition of gypsum is a common strategy for ameliorating sodic soils. Before applying gypsum, do a field dispersion test. There is little point applying gypsum unless your soil disperses. While there are laboratory methods to calculate gypsum application rates to achieve a target ESP in your soil, they do not always successfully allow for all variables in the field.

From a practical perspective, gypsum application rates usually range from about 2.5 t/ha to more than 10 t/ha and are usually influenced by cost as much as anything. Gypsum applied to the soil surface will improve the structural stability of dispersive topsoils quite quickly; however it may take several years to reach the subsoil. Surface applications of gypsum may be of less benefit in texture contrast soils or in soils where the dispersive clay subsoil is deeper than 40 cm. After applying gypsum, it is useful to monitor the soil for the next couple of years to see if reapplication of gypsum is necessary.

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Sodic soils explained

At the microscopic level in soils, clay particles and organic matter have a negative charge on their surface. This is how soils ‘hold’ onto nutrients—positively charged cations (like calcium and potassium) are attracted to the negative charge, just like how negative and positive ends of a magnet hold together. If you’ve looked at soil test results from a laboratory, you may have seen something called Cation Exchange Capacity (or CEC). This is a measure of how much negative charge is in a soil i.e. it’s a measure of how well a soil can hold onto cations—in general, the higher the CEC, the higher the clay content. CEC ranges from about 1 cmol(+)/kg of soil in sands to about 40 cmol(+)/kg of soil in heavy clays.

In sodic soils, the CEC is dominated by sodium cations (rather than by ‘good’ cations like calcium or potassium). Sodium is a dispersing or deflocculating agent. For this reason, it is used in many detergents, as it pushes things apart. Other cations, especially calcium, are flocculating cations and pull particles together to form aggregates. When sodium cations dominate the soil cation exchange sites, the sodium cations essentially push the particles apart, especially clays.

In the past, a lot of reliance has been placed on the ESP of a soil and whether or not it is above certain thresholds to determine how the soil will behave. Over the years, it has been discovered that the complexities of soil sodicity are such that relying on the ESP value alone is not particularly useful. For example, the relationship between sodicity and dispersion means that ESP is not meaningful if the soil has a low clay content (less than 10%). Similarly, because ESP is the proportion of sodium relative to other cations, the value is not meaningful if the total of all cations is very low (e.g. if the CEC is less than ~3 to 5 cmol(+)/kg).

Why does gypsum work?

Gypsum (calcium sulfate, $CaSO_4.H_2O$) supplies extra calcium to the soil. The calcium cations switch places with sodium cations on cation exchange sites, pushing sodium into the soil solution, where it is leached deeper into the soil or out of the soil. Calcium causes the soil particles to flocculate (bond together). Due to the low solubility of gypsum, effects are not instantaneous and it may be necessary to apply several applications over a period of years.

Sodic and saline soils

Salinity affects plant productivity (due to toxic effects and by making it difficult for plants to extract water from the soil). Sodicity degrades soil structure, creating poor conditions for plant growth, and making the soil susceptible to surface crusting and erosion. There are different types of salts found in soil—sodium chloride, NaCl, is common. Gypsum (calcium sulfate) is another type of salt found naturally in soils. Sodicity can be confused with salinity because both saline soils and sodic soils are associated with sodium. In sodic soils, the sodium is bound to the clay particles. In saline soils, the sodium is in the soil solution.

Many clay soils of inland Queensland are both sodic and saline at the same time—this can make management tricky as the salinity masks the impacts of sodicity. In sodic soils with medium to extreme salinity levels, the salt in the soil solution prevents the clay particles from dispersing. However, if the salts are leached (washed out) from the soil, sodicity impacts will start to appear.

Image 5: Tunnel erosion in a sodic soil.

Other fact sheets in this series:

- Understanding Soil Colour
- Understanding Soil Texture
- Understanding Soil Structure
- Understanding Soil pH
- Understanding Dispersive Soils
- Understanding Soils from an Erosion Rehabilitation Perspective

For further information on soils, refer to the Queensland Government website at https://www.qld.gov.au/environment/land/soil/

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