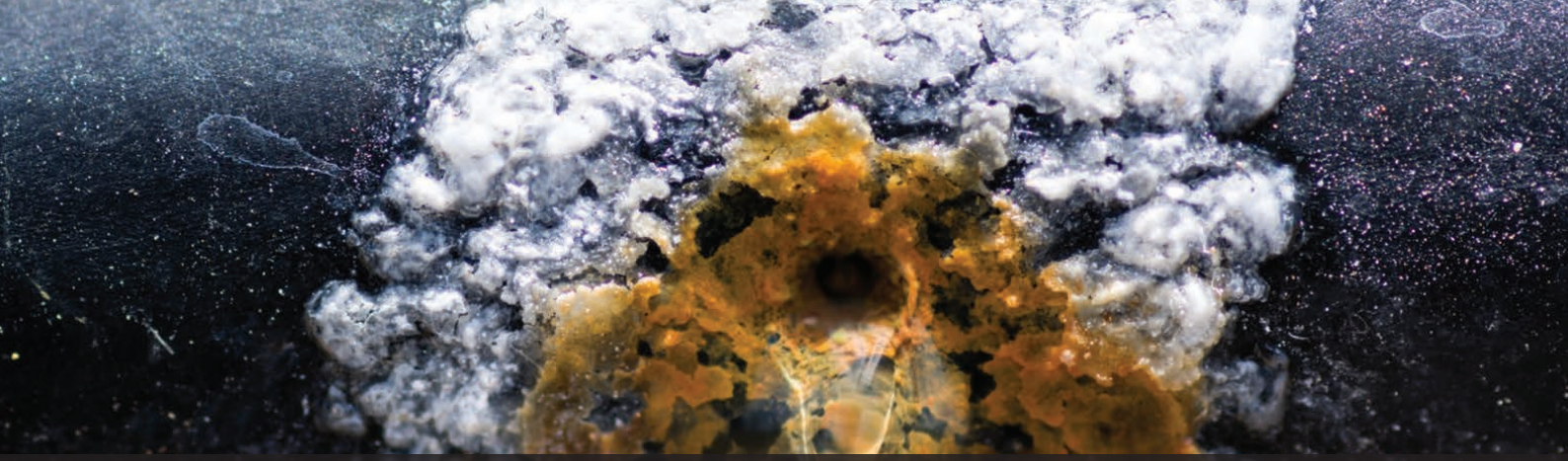

Best Management Practices for Clogging of Irrigation Infrastructure by Calcium Carbonate Scale

Irrigation Water Quality in the Limestone Coast Region

In the Limestone Coast region, irrigation water is obtained from underground aquifers, with the most heavily used being the unconfined Tertiary Limestone Aquifer (TLA). Irrigation water sourced from this aquifer is generally of good quality (salinity less than about 1,200 mg/L as Total Dissolved Solids). However, many irrigators face issues with irrigation water quality that affect productivity or increase the costs of infrastructure and/or labour.

These include:

- High calcium (Ca) and bicarbonate (HCO_3) concentrations that lead to formation of calcium carbonate scale ($CaCO_3$) and blockage of irrigation infrastructure components (e.g. drippers).
- Iron and sulphate bacteria that cause clogging and reduced performance of irrigation infrastructure (e.g. pumps and pipes).
- Elevated salinities in some areas that affect crops and increase soil salinities.

The Limestone Coast Irrigation Water Quality project has been funded by the Limestone Coast Grape and Wine Council (LCGWC), the South East Natural Resources Management Board (SENRMB) and Wine Australia. The first step in the project was an online survey designed to capture information about the extents of irrigation water quality issues in the Limestone Coast region and the approaches that are being used to mitigate these.

The results of this survey are available as a report from the Limestone Coast Grape and Wine Council website (http://limestonecoastwine.com.au). Local information obtained from the survey has been used with a review of national and international literature to develop Best Management Practices (BMPs) for managing irrigation water quality issues in the Limestone Coast region.

The full report on the development of the BMPs is also available from the Limestone Coast Grape and Wine Council website. This brochure provides a user-friendly summary of the background information and the BMPs developed for calcium and magnesium scale issues.

Wine Australia for Australian Wine

The Limestone Coast Grape & Wine Council Inc.

Government of South Australia
South East Natural Resources Management Board

Some Useful Definitions

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Bicarbonate in groundwater. An ion that is very commonly found dissolved in natural waters. Its chemical formula is HCO_3-. It is added to water by the dissolution of carbon dioxide (CO_2) from the atmosphere and by the dissolution of carbonate rocks, e.g. limestone.

Calcium and magnesium in groundwater. Calcium (Ca) and magnesium (Mg) are ions that are commonly found dissolved in natural waters. They are added to groundwater by the dissolution of minerals.

Calcium carbonate. A solid mineral with the formula $CaCO_3$. It is a major component of limestone rocks, often along with magnesium carbonate (dolomite). It is also the main component of pearls and the shells of marine organisms, snails, and eggs. Calcium carbonate is the active ingredient in agricultural lime and is created (precipitated) when calcium ions dissolved in water react with carbonate and bicarbonate ions. The unconfined aquifer in the Limestone Coast contains a lot of calcium carbonate.

Calcium (or magnesium) carbonate scale. Also known as 'chemical scale', 'limescale' or 'mineral scale'. A build-up of minerals (especially calcium or magnesium carbonates) inside or around irrigation pipes, tubes etc.

Groundwater. Water occurring below ground level.

Groundwater salinity. The concentration of dissolved salts in groundwater, usually expressed in parts per million by weight or as milligrams of salts per litre of water (mg/L).

pH. A figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid and higher values more alkaline.

Precipitate. Cause (a substance) to be deposited in solid form from a solution or the substance that is precipitated from a solution.

Unconfined aquifer. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Unconfined aquifer Management Area. For the purpose of management and allocation of the groundwater resource, the unconfined aquifer (and the confined aquifer) in the Limestone Coast region has been divided into 'Management Areas'. For the unconfined aquifer, these Management Areas are generally based on hundred subdivisions. Groundwater resource status and condition are often reported by Management Area as it is a useful way to report spatially variable data.

Well (or bore). An opening in the ground that gives access to underground water.

What Causes Calcium and Magnesium Scale?

The name of the Limestone Coast region gives an indication of the high potential for problems with calcium carbonate ($CaCO_3$) scale to occur here. Forty-three of the 54 respondents to the recent irrigation water quality survey (80%) reported having problems with calcium or magnesium carbonate build-ups blocking infrastructure and the problem was identified across all of the 15 unconfined aquifer Management Areas represented in the survey. Anecdotal evidence suggested that the problem is most severe in the Padthaway region.

Calcium carbonate scale build-up in a drip line.

Calcium (and magnesium) carbonate scale is a common cause of clogging in irrigation systems using groundwater. The build-up of this 'mineral scale', is normally gradual and difficult to locate. The problem occurs when calcium (and/or magnesium) and bicarbonate that were dissolved in water come out of solution or 'precipitate' as solid minerals. Irrigation water is susceptible to calcium carbonate precipitation if it has a pH of 7.5 or higher and a bicarbonate concentration of at least 120 mg/L with similar levels of calcium. In the Limestone Coast, most irrigation water is pumped from a limestone (mainly $CaCO_3$) aquifer so it generally has pH above 7 and often above 7.5 and contains high concentrations of calcium (Ca > 100 mg/L) and bicarbonate (HCO_3 > 300 mg/L). Whilst under natural conditions in the aquifer, these ions remain dissolved in the groundwater. However, for groundwater with such high calcium and bicarbonate concentrations, any of the following changes can cause them to precipitate out as solid minerals:

- Pumping the water out of the aquifer, which reduces in the pressure of the water as it flows into the well.
- Mixing with water of a different composition, which changes the water temperature, pressure, chemistry, or overall salinity. This can occur in wells screened across multiple geological formations with different chemical characteristics, or when corrosion of well casing creates a connection between two groundwater types that were not previously connected.
- An increase in temperature, for example, as the water travels through or sits in irrigation lines during the day.
- Evaporation from drippers, which increases the concentration of dissolved salts in the water.
- Application of fertilizers through the irrigation system.

Mitigation Strategies

Most irrigators in the Limestone Coast manage carbonate mineral build-up in irrigation systems by passing acid through drip / spray system components, usually on an annual basis, but up to three times per year in more severely affected areas (e.g. Padthaway). Most people use local contractors to carry this out.

Several irrigators reported in the recent survey that they have tried magnetic water conditioners to reduce the hardness of their water and the occurrence of mineral scale. These magnets are clamped around a pipe through which the water discharged from the pump is flowing (see picture next page). There is very little

information available about how the application of magnets improves the quality of water, but some reviews suggest that they may reduce the occurrence of mineral scale in some scenarios. In general, those who have tried magnetic water conditioners for this problem in the Limestone Coast region are unsure whether they make a real difference, but some report that the water seems better.

The magnets that have been tried in the Limestone Coast region have predominantly been supplied by Delta Water Solutions (www.deltawater.com.au).

A magnetic water conditioner applied just downstream of a pump.

Recommended Best Management Practices

Groundwater used for irrigation in the Limestone Coast region is drawn from a limestone aquifer and contains high concentrations of dissolved calcium and bicarbonate. This groundwater therefore always has a high potential to cause clogging with calcium carbonate. However, the following practices may help to manage calcium and magnesium carbonate scale problems:

1. Target lower salinity groundwater where possible when drilling new wells – this is likely to have lower calcium and bicarbonate concentrations in general, but a lower overall salinity also means that calcium carbonate may have less tendency to precipitate in irrigation systems.
2. Avoid screening wells across hydrogeological units containing different water quality.
3. Flush irrigation lines with acid at least annually and more often as necessary to remove scale build-up in drippers and dripper lines. A local contractor can be employed to do this to reduce the hazards associated with storing and handling acid.
4. Until the results are available from any independent studies into the effectiveness of magnetic water conditioners in the Limestone Coast region, irrigators could try this method.

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