

Salinity impacts of low Murray River flows in the South Australian Riverland

Introduction

Under normal flow conditions, South Australian irrigators on the River Murray receive full allocations which are more than adequate for crop water requirements and salt leaching. These same normal flows also dilute the natural inflows of saline groundwater into the river, giving irrigators access to good quality water.

Inflows into the River Murray in 2007 have been at record lows. As a result, irrigators face severely restricted water allocations. At the same time, the reduced river flows provide insufficient dilution flows for the natural saline inflows, resulting in a significant rise in river salinity. What does this mean for irrigation management, leaching and crop growth and production?

Irrigation Induced Salinity

Even under normal conditions, irrigators add some salt to the soil every time they irrigate. Figure 1 indicates the amount of salt added for each megalitre of water at a range of salinities. For example, if irrigation water salinity is 500 $\mu\text{S/cm}$, a little less than 0.3 tonnes of salt is added with each megalitre of water. If salinity is doubled to 1000 $\mu\text{S/cm}$, slightly less than 0.6 tonnes of salt is added with each megalitre.

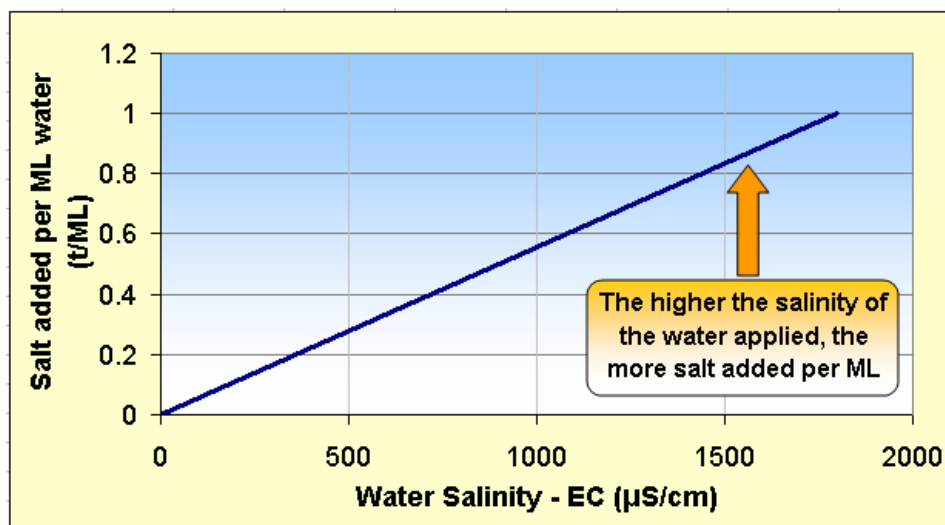


Figure 1: Salt added per megalitre of water at various salinities

If there is no movement of water beyond the bottom of the rootzone (known as leaching), the salt accumulates, increasing the concentration within the rootzone. Figure 2 shows the rate of accumulation of salt in the soil for various irrigation water salinities and total depths of water applied, assuming no leaching takes place (and other assumptions as listed). It indicates that, without regular leaching, rootzone salinity can climb very rapidly if the salinity of the irrigation water is raised.

For example, at water salinity of 250 $\mu\text{S/cm}$ (the blue line in Figure 2), application of 5 ML/ha of water without any leaching raises the salinity of a 0.5 m deep rootzone from 1.0 to 1.5 dS/m. The same application (5 ML/ha) of water at 1000 $\mu\text{S/cm}$ (red line in Figure 2) will raise rootzone salinity from 1.0 to more than 3.0 dS/m.

To put the numbers in context, at rootzone ECe above 2.0 dS/m, almost all permanent horticultural crops will experience some level of growth and yield impact (see Table 4).

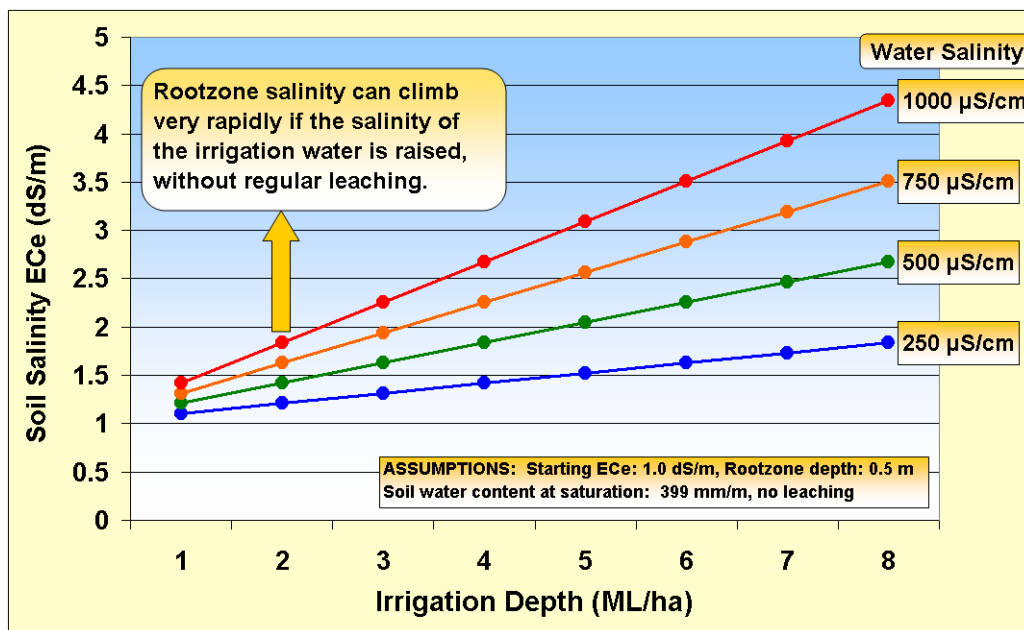


Figure 2: Salt accumulation effect of irrigation depth and water salinity

Under drip or other partial cover irrigation systems, irrigation water is applied to a smaller volume of soil than under full cover irrigation. The same amount of salt is applied over the course of the season, but is concentrated in this smaller volume of soil, and salinity rises even faster, as shown in Figure 3.

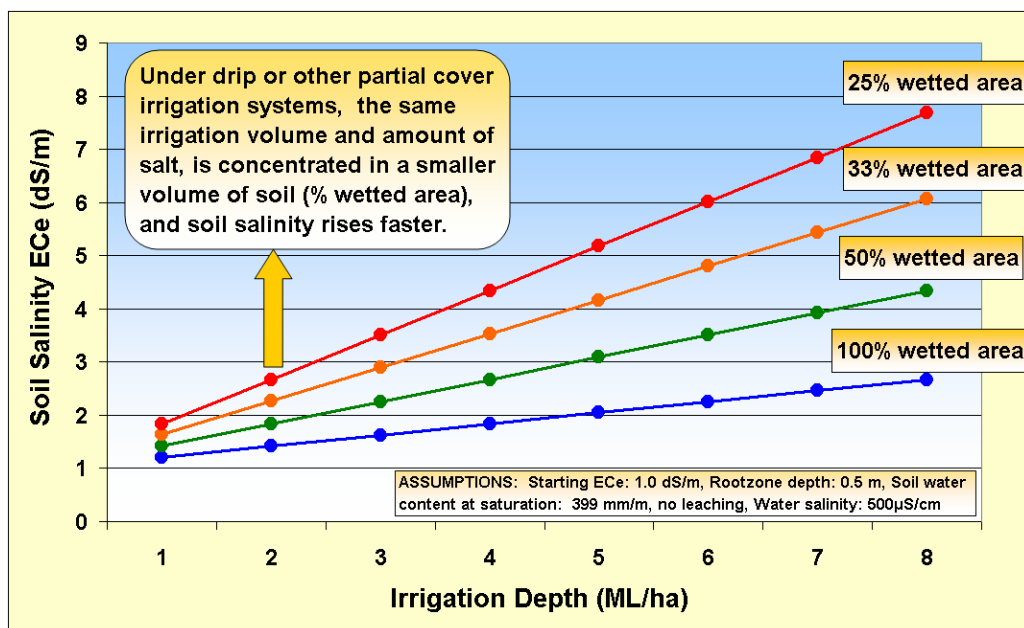


Figure 3: Salt accumulation effect of irrigation depth and % wetted area

The lines in Figure 3 represent different wetted areas as a percentage of full cover, with all other things remaining the same. For example, with water of 500 µS/cm and a rootzone 0.5 m deep, if the water is applied using a full cover irrigation system (blue line in Figure 3), 5.0 ML/ha with no leaching will raise the soil salinity from 1.0 to 2.0 dS/m.

However, if the same 500 µS/cm water is applied using a drip irrigation system that utilises only 25% of the available soil volume (red line in Figure 3), the application of 5 ML/ha without leaching will raise the salinity within that small volume of soil from 1.0 to more than 5.0 dS/m.

Impacts of Salinity

Salt in the soil impacts crops in two ways. One is referred to as the osmotic effect. This effect occurs because the high concentration of salt in the soil water makes it harder for roots to absorb water from the soil, reducing the rate of water uptake by plants even when there is sufficient water available. This effect is progressive, increasing in proportion to salinity.

The other impact of soil salinity on crops is through toxicity of specific ions (predominantly sodium (Na^+) and chloride (Cl^-)).

Under normal conditions, the roots of most plants exclude these salts when taking up water, which is why their concentration increases in the soil.

The plants do this to protect themselves from the negative effects of these salts. However, above a certain threshold, which varies for different crops, the roots are unable to exclude the salts, and they enter the plant, causing damage to tissues.

The level of tissue damage increases as soil salinity increases, as this increases the concentration of salts entering the plants.

The toxic impact of salinity is increased if salty water contacts the leaves of the crop. Many plants will take up salt much more readily through their leaves than through their roots, so tissue damage can occur even when soil salinity is low, if salt enters directly through the leaves.

These processes are described in more detail in: *Water Salinity and Plant Irrigation* and in: *Using Saline Water for Irrigation* (refer *Further Reading* section at the end of this Fact Sheet).

Box 1: Salinity and Winegrape Contracts

The Australian Food Standards Code (P4) (www.foodstandards.gov.au) specifies an upper limit of 1,000 mg/L soluble chlorides expressed as sodium chloride. Put another way, wine must not contain more than 606 mg/L of Cl^- .

There is no standard for sodium (Na^+) in Australia, but some potential export destinations including Canada, Switzerland and Poland specify maximums for sodium which range from 60 to 500 mg/L of Na^+ .

An extensive survey of juice from wine grapes in the middle 1990's found that 18 out of 1200 samples exceeded chloride levels.

These excesses were all from a region where saline water was applied with overhead sprinklers. Salinity in wine is generally higher than in juice made from the same grapes.

Sodium chloride concentrations below the upper limit (1,000 mg/L) may be detectable in wine tastings.

The descriptor "saltiness" has been reported in wines with sodium chloride concentrations higher than 400 to 600 mg/L.

If you consider yourself at risk of producing grapes with excess concentrations of chloride and/or sodium, then you should speak with your purchasing winery.

Box 2: Rootstock Effects on Salinity Tolerance

The use of particular rootstocks can impart some level of salinity tolerance to crops, by their ability to exclude toxic ions (such as sodium and/or chloride), when extracting water from the soil. Rootstocks cannot provide any protection from foliar uptake of salt.

Although rootstocks cannot be changed once plantings are in the ground, knowing what rootstocks are planted will assist in determining which plantings may be more or less at risk from salinity.

Table 1: Grapevine - salt tolerance of varieties and rootstocks

Salt-tolerance Classification (& Threshold ECe)	Grapevine Variety or Rootstock
Sensitive (1.8 dS/m)	Own Roots: Sultana, Shiraz, Chardonnay, Pinot Noir, Riesling, Semillon, Merlot, Cabernet Franc, Cabernet Sauvignon, Grenache Rootstocks: 3309, 1202C, K51-40
Moderately sensitive (2.5 dS/m)	Own Roots: Colombard Rootstocks: 5BB, 5C Teleki, Richter 110, Richter 99, K51-32
Moderately tolerant (3.3 dS/m)	Rootstocks: Rupestris St. George, Ruggeri 140, Schwarzmann, 101-14, Ramsey
Tolerant (5.6 dS/m)	Rootstocks: 1103 Paulsen

Reproduced from Tee et al. (2003), with permission from the Cooperative Research Centre for Viticulture and the Murray Darling Basin Commission; values are drawn from the work of Zhang et al. 2002, but include some unpublished data from Rob Walker, 2003. Threshold tolerance salinity levels are approximate threshold soil saturation paste salinity. Threshold levels reflect when salinity damage may start, but not the rate of decline, which may vary.

Table 2: Citrus - salt tolerance of rootstocks

Salt-tolerance Groupings	Citrus Rootstock
1 - Most tolerant	Cleopatra Mandarin
2	Swingle Citrumelo
3	Sweet Orange, Troyer Citrange, Carrizo Citrange
4	Rough Lemon
5 - Least tolerant	Poncirus trifoliata

From Gallasch & Staniford (2003); also reproduced in "Comparing Citrus Rootstocks" on the SARDI website (refer Reference section at the end of this Fact Sheet)

The relative salt tolerance of **Almond** rootstocks requires further research. Some almond rootstocks used in South Australia include: almond seedlings, Nemaguard and hybrids (eg Bright and GF677).

Appearance of Salt Damage

Photographs of salt damage on a variety of crops are displayed below (Figures 4 to 9), to illustrate the damage caused by salt, and to assist in identifying potential salt damage. The photographs are generally of toxicity effects, rather than osmotic effects, and as such growth and yield potential has already been severely affected, and cannot be easily reversed. It is important to be aware that the symptoms of water stress can be very similar to the symptoms of salinity, so the only way to be sure that salinity is the issue is to sample soil and/or plant tissue, and have it analysed.

Figure 4: Salt burn on grapevine leaves



Figure 5: Symptoms of chloride toxicity in grapevine



Figure 6: Symptoms of sodium toxicity in grapevine



Figure 7: Citrus leaf tip burn due to salinity



Figure 8: Citrus leaf bronzing due to salinity



Figure 9: Citrus canopy thinning due to salinity



Box 3: Salinity Impact of Fertilisers

All fertiliser is made up mostly of salts; however the salts in fertilisers are essential elements for crop growth, and at normal application rates they cause no toxic effects. They add to the osmotic effect of salinity, and if soil salinity is already high this may cause a short term spike. However, the salts in fertilisers are required by the plants, and they actively take them up, so accumulation over time is generally not a problem.

The following example seeks to quantify the relative contribution of fertilisers to salinity. If the total amount of fertiliser applied to an orchard or vineyard per season is around 500kg/ha, and we assume that all of this is some form of salt, the total annual salinity input from fertiliser is less than that contained in 2 ML of irrigation water at 500 dS/m. This should not cause significant problems unless it is added all at once.

With drip irrigation, the fertiliser, like the water, is concentrated in a smaller volume of soil, so care needs to be taken not to apply too much fertiliser at a time, but to spread fertiliser application out over the season. With fertigation, this is normal practice.

Measuring Salinity

Salinity can be measured in both water and soil. Water salinity is the easiest to measure, using a simple salinity meter and a sample of water taken from the source (in a clean container, rinsed a couple of times with the water to be tested). The units for water salinity will usually be $\mu\text{S/cm}$, with River Murray water usually measuring between 200 and 500 $\mu\text{S/cm}$ in the Riverland under normal river flow. Other units and their relationship to $\mu\text{S/cm}$ are shown in Table 3.

Table 3: Relationship of Salinity Measures

Measurement	Unit		Conversion from $\mu\text{S/cm}$
Conductivity	$\mu\text{S/cm}$	(micro Siemens per centimetre)	x 1
	dS/m	(deci Siemens per metre)	x 0.001
	mS/cm	(milli Siemens per centimetre)	x 0.001
Concentration	ppm	(parts per million)	x 0.55
	mg/L	(milligrams per litre)	x 0.55

Soil salinity is best assessed by a laboratory (such as the *Analytical Crop Management Laboratory* - refer *Further Reading* section at the end of this Fact Sheet).

Guidelines for collecting soil samples are outlined in: *Monitoring Soil Salinity for Irrigated Horticulture* (refer *Further Reading* section at the end of this Fact Sheet).

Specify the saturation paste extract method to the laboratory; this will result in true EC_e figures for comparison with the figures in Table 4.

Box 4: Critical Values of ECe

Critical values of ECe indicate the impact of soil salinity on crop growth and production. Table 4 indicates these levels for commonly grown permanent horticultural crops in the Riverland. Leaching fraction can be determined according to these figures and irrigation water salinity, to ensure that the level of leaching applied is sufficient to keep rootzone ECe below these critical values.

Table 4: Critical soil salinity ECe for various potential yield levels in horticultural crops

Crop	Yield Potential			
	100%	90%	75%	50%
Date Palm	4.0	6.8	11.0	18.0
Grapefruit	1.8	2.4	3.4	4.9
Orange	1.7	2.3	3.3	4.8
Peach	1.7	2.2	2.9	4.1
Apricot	1.6	2.0	2.6	3.7
Grape	1.5	2.5	4.1	6.7
Almond	1.5	2.0	2.8	4.1
Plum, Prune	1.5	2.1	2.9	4.3

From Ayers and Westcot (1989)

The data in Table 4, indicate the critical values which cause reductions in growth and yield potential. It should be noted that rootzone salinity varies over time, and at different depths within the rootzone. Plants will compensate for variation in salinity at different depths of the rootzone, by drawing water preferentially from less salty zones.

Similarly, a short term spike in rootzone salinity may have minimal impact if it is short lived, unless it is sufficiently high to cause immediate damage to tissues, for example if it causes leaf drop.

Managing Salinity

Information about managing salinity is contained in *Managing Salinity with Restricted Allocations in the South Australian Riverland* (refer *Further Reading* section at the end of this Fact Sheet).

References

Ayers, RS & Westcot DW 1989, *Water Quality for Agriculture*, FAO Irrigation and Drainage Paper, 29 (Rev. 1), Food and Agriculture Organization of the United Nations, Rome.

<http://www.fao.org/DOCREP/003/T0234E/T0234E00.HTM>

Gallasch, PT & Staniford, M 2003, *Citrus Varieties and Rootstocks for the Riverland*, South Australian Research and Development Institute, Loxton, pp. 13. Also reproduced in *Comparing Citrus Rootstocks*, http://www.sardi.sa.gov.au:82/pages/horticulture/citrus/hort_citp_comparingpub.htm:sectID=301&templID=100

Tee, E, Burrows, D, Boland, AM & Putland, S 2003, *Best Irrigation Management Practices for Viticulture in the Murray Darling Basin*, Cooperative Research Centre for Viticulture, Adelaide.

Zhang, X, Walker, RR, Stevens, RM & Prior, LD, 2002, 'Yield salinity relationships of grapevine (*Vitis vinifera* L.) on own roots and a range of rootstocks', *Aust. J. Grape Wine Res.*, 8:150-156.

Further Reading

Monitoring soil salinity for irrigated horticulture (PIRSA Fact Sheet No. 31/02/06)

http://www.pir.sa.gov.au/pirsa/drought/irrigation_and_water_management/salinity_management

Managing Salinity with Restricted Allocations in the South Australian Riverland (PIRSA Fact Sheet No. 05/07)

http://www.pir.sa.gov.au/pirsa/drought/irrigation_and_water_management/salinity_management

Using saline water for irrigation (NSW Department of Primary Industries - webpage)

<http://www.agric.nsw.gov.au/reader/wm-plants-waterquality/dpi389.htm>

Water salinity and plant irrigation (WA Department of Agriculture and Food, Farmnote No. 234)

http://www.agric.wa.gov.au/content/LWE/WATER/IRR/FN2007_H2OSALINITY_JBURT.PDF

Irrigated Crop Management Service (ICMS) & Analytical Crop Management Laboratory (ACML), Rural Solutions SA, Primary Industries & Resources SA (PIRSA), Loxton Research Centre, PO Box 411, Loxton South Australia 5333, phone: 08 8595 9100, web: www.ruralsolutions.sa.gov.au



South Australian Government Drought Response Initiative

Drought Link website: www.service.sa.gov.au/drought.asp

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