

Irrigation water quality—salinity and soil structure stability

A major concern with water used for irrigation is decreased crop yields and land degradation as a result of excess salts being present in water and in soils. Salinity means the presence of soluble salts in or on soils, or in water.

Assessing irrigation salinity

For salinity management purposes, to assess the suitability of water and soil for irrigation, the following must be considered:

- quality of the irrigation water
- characteristics of the soil to be irrigated
- salt tolerance of the crop to be grown.

Climate, soil management and water management practices can also impact on salinity.

Measuring water quality

Irrigation water must be analysed for:

- electrical conductivity (EC_i), which is a measure of the total soluble salts in the water. EC_i may be measured and reported in deciSiemens per metre (dS/m) or microSiemens per centimetre ($\mu\text{S/cm}$). A value in $\mu\text{S/cm}$ can be converted to dS/m by dividing by 1000
- the level of sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions present.

General salinity ratings for water are shown in Table 1.

Table 1—Salinity ratings for water

EC_i dS/m	Water salinity rating (levels of soluble salts)
< 0.65	low
0.65–1.3	moderate
1.3–2.9	high
2.9–5.2	very high
> 5.2	extremely high

These EC_i values can then be used to determine the suitability of water and soil for a particular irrigation situation as outlined below.

Soil structure stability

The EC_i value can be used to predict soil structure stability in relation to irrigation water quality and the sodium adsorption ratio (SAR). The SAR value is a

measure of the relative concentration of sodium to calcium and magnesium. SAR can be calculated from the following equation:

$$SAR = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}}$$

where Na, Ca and Mg are expressed in milliequivalents per litre (meq/L). A SAR value is provided in the water analysis report provided by the laboratory analysing the water sample.

High concentrations of sodium in irrigation water can result in the degradation of soil structure. This will reduce water infiltration into the soil surface and down the profile, and limit aeration, leading to reduced crop growth.

The potential impact of irrigation water quality on soil structure can be evaluated using EC_i and SAR values, as shown in Figure 1.

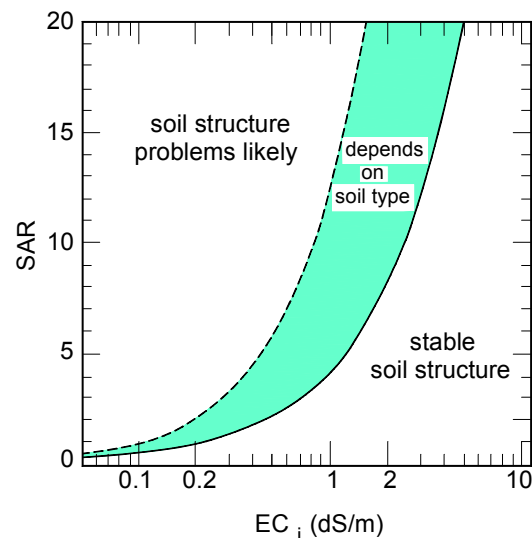


Figure 1—Relationship between SAR and EC_i of irrigation water for prediction of soil structure stability

In Figure 1 above, water quality that falls to the right of the coloured area is considered satisfactory for use, while values to the left are considered unsatisfactory and special irrigation management will be required. Values that fall between the lines (indicating marginal water quality) should be treated with caution.

Crop salt tolerance

Crop salt tolerance also needs to be taken into account when assessing the suitability of water and soil for irrigation.

The salt content of the soil water in the crop's root zone—referred to as the average root zone salinity (EC_{se})—is important in assessing which crops are suitable for growing in particular soils.

The average EC_{se} can be calculated using the measured EC_i of the irrigation water. This requires estimation of the average root zone leaching fraction (LF) of the soil under irrigation, i.e. the proportion of applied water moving below the root zone. This is shown in Figure 2.

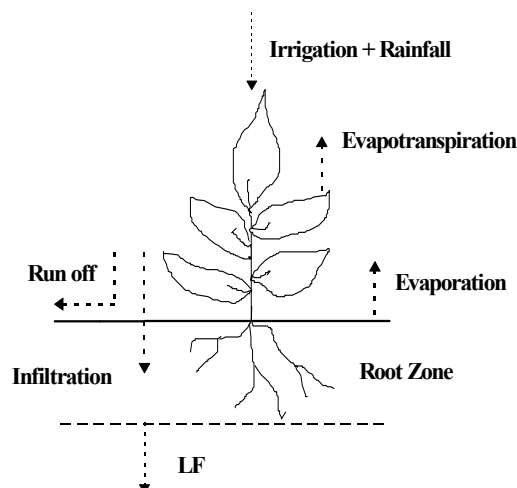


Figure 2—Diagram of the leaching fraction (LF) concept

Average root zone leaching fractions for four soil types are listed in Table 2.

Table 2—Soil type and average root zone leaching fraction

Soil type	Average root zone LF
Sand	0.6
Loam	0.33
Light clay	0.33
Heavy clay	0.2

Average root zone salinity (EC_{se}) can then be calculated using the following equation:

$$EC_{se} = \frac{EC_i}{2.2 \times LF}$$

where:

EC_{se} = average root zone salinity in dS/m

EC_i = electrical conductivity of irrigation water in dS/m

LF = average leaching fraction.

The calculated EC_{se} can then be compared against the EC_{se} values in Table 3 to assess the general level of salinity tolerance required of the preferred crop in the particular irrigation situation.

Table 3—Soil and water salinity criteria based on plant salt tolerance groupings

Plant salt tolerance grouping	Water or soil salinity rating	Average root zone salinity EC_{se} (dS/m)
sensitive crops	very low	< 0.95
moderately sensitive crops	low	0.95–1.9
moderately tolerant crops	medium	1.9–4.5
tolerant crops	high	4.5–7.7
very tolerant crops	very high	7.7–12.2
generally too saline	extreme	> 12.2

Common crop and pasture species are listed in Table 4 in order of salt tolerance determined by average root zone salinity at the threshold level causing yield reduction. Electrical conductivity of irrigation water at the threshold level for a range of soil types is also shown and can be used as a general guide for selecting suitable crops for the particular irrigation situation.

When to seek expert management advice

Where there is uncertainty regarding the effect of irrigation water quality on soil structure stability or crop salt tolerance, it is recommended that soil samples from the surface and subsoil of representative profiles of the soil under irrigation be submitted for laboratory analysis. Expert management advice should be sought.

Further information

Chapter 4 of the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) has information about water quality for irrigation and stock watering. You can download the guidelines from the Commonwealth Department of the Environment, Water, Heritage and the Arts website <www.environment.gov.au>. Go to 'Water', then 'Publications and resources'. The guidelines are under the 'Water quality publications' subheading.

Fact sheets on water and other topics are available from the Department of Environment and Resource Management (DERM) website <www.derm.qld.gov.au>.

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Table 4—Tolerance of plants to salinity in irrigation

Common name	Scientific name	EC _{se} average root zone salinity threshold for yield reduction (dS/m)	EC _i (dS/m) threshold for yield reduction for crops growing in		
			sand	loam	clay
Field Crops					
Sorghum, crooble	<i>Sorghum alnum</i>	8.3	11.6	6.6	3.9
Barley, grain	<i>Hordeum vulgare</i>	8.0	12.6	7.2	4.2
Cotton	<i>Gossypium hirsutum</i>	7.7	12.1	6.9	4.0
Beet, sugar	<i>Beta vulgaris</i>	7.0	11.0	6.3	3.7
Sorghum	<i>Sorghum bicolor</i>	6.8	9.4	5.3	3.1
Safflower	<i>Carthamus tinctorius</i>	6.5	8.2	4.7	2.7
Wheat	<i>Triticum aestivum</i>	6.0	9.4	5.3	3.1
Wheat, durum	<i>Triticum turgidum</i>	5.7	9.6	5.5	3.2
Sunflower	<i>Helianthus annual app.</i>	5.5	7.5	4.3	2.5
Oats	<i>Avena sativa</i>	5.0	7.0	4.0	2.3
Soybean	<i>Glycine max</i>	5.0	7.0	4.0	2.3
Peanut	<i>Arachis hypogala</i>	3.2	4.4	2.5	1.5
Rice, paddy	<i>Oryza sativa</i>	3.0	4.8	2.7	1.6
Cowpea, Caloona	<i>Vigna unguiculata var. Caloona</i>	2.0	3.7	2.1	1.2
Corn, grain, sweet	<i>Zea mays</i>	1.7	3.2	1.8	1.1
Flax/Linseed	<i>Vinum usitatissimum</i>	1.7	3.2	1.8	1.1
Sugarcane	<i>Saccharum officinarum</i>	1.7	4.3	2.5	1.4
Cowpea (seed)	<i>Vigna unguiculata</i>	1.6	3.4	2.0	1.1
Phasey bean, Murray	<i>Macroptilium lathyroides</i>	0.8	2.7	1.5	0.9
Fruits					
Natal plum	<i>Carissa grandiflora</i>	6.0	7.6	4.3	2.5
Fig	<i>Ficus carica</i>	4.2	5.3	3.0	1.8
Date	<i>Phoenix dactylifera</i>	4.0	8.7	5.0	2.9
Olive	<i>Olea europaea</i>	4.0	5.1	2.9	1.7
Pomegranate	<i>Punica granatum</i>	4.0	5.1	2.9	1.7
Macadamia seedling		3.6	4.6	2.6	1.5
Peach	<i>Prunus persica</i>	3.2	4.7	2.7	1.6
Rockmelon	<i>Cucumis melo</i>	2.2	4.6	2.6	1.5
Grapefruit	<i>Citrus paradisi</i>	1.8	3.0	1.7	1.0
Orange	<i>Citrus sinensis</i>	1.7	2.9	1.7	1.0
Walnut		1.7	2.2	1.2	0.7
Apricot	<i>Prunus armeniaca</i>	1.6	2.5	1.4	0.8
Almond	<i>Prunus dulcis</i>	1.5	2.7	1.5	0.9
Blackberry	<i>Rubus spp.</i>	1.5	2.5	1.4	0.8
Boysenberry	<i>Rubus ursinus</i>	1.5	2.5	1.4	0.8
Grape	<i>Vitis spp.</i>	1.5	3.3	1.9	1.1
Plum (Prune)	<i>Prunus domestica</i>	1.5	2.5	1.4	0.8
Avocado	<i>Persea americana</i>	1.3	2.3	1.3	0.8
Guava, pineapple	<i>Feijoa sellowiana</i>	1.2	1.5	0.9	0.5
Apple	<i>Malus sylvestris</i>	1.0	2.0	1.2	0.7
Lemon	<i>Citrus limon</i>	1.0	1.3	0.7	0.4
Pear	<i>Pyrus spp.</i>	1.0	1.3	0.7	0.4
Raspberry	<i>Rubus ideaeus</i>	1.0	1.3	0.7	0.4
Strawberry	<i>Fragaria</i>	1.0	1.6	0.9	0.5
Lychee		0.8	1.0	0.6	0.3
Pastures					
Urochloa	<i>Urochloa mosambicensis</i>	8.5	11.8	6.7	3.9
Wheatgrass, fairway	<i>Agropyron cristatum</i>	7.5	11.3	6.4	3.7
Wheatgrass, tall	<i>Agropyron elongatum</i>	7.5	12.5	7.2	4.2
Rhodes grass, Pioneer	<i>Chloris gayana</i>	7.0	12.8	7.3	4.2
Couch grass	<i>Cynodon dactylon</i>	6.9	10.8	6.1	3.6
Barley, forage	<i>Hordeum vulgare</i>	6.0	9.4	5.3	3.1
Barley, hay	<i>Hordeum vulgare</i>	6.0	9.4	5.3	3.1
Buffel grass, Nunbank	<i>Cenchrus ciliaris var Nunbank</i>	6.0	9.5	5.4	3.2
Buffel grass, Gayndah	<i>Cenchrus ciliaris var Gayndah</i>	5.5	8.2	4.7	2.7
Trefoil, birdsfoot	<i>Lotus corniculatus tenuifolium</i>	5.0	7.6	4.3	2.5
Phalaris	<i>Phalaris tuberosa (aquatica)</i>	4.2	5.3	3.0	1.8
Fescue	<i>Festuca clatior</i>	3.9	7.3	4.2	2.4
Wheatgrass, crested	<i>Agropyron desertorum</i>	3.5	7.6	4.3	2.5
Barrel medic, Cyprus	<i>Medicago truncatula</i>	3.0	4.7	2.7	1.6
Green panic, Petri	<i>Panicum maximum</i>	3.0	5.6	3.2	1.8
Kikuya grass, Whittet	<i>Pennisetum clandestinum</i>	3.0	8.0	4.6	2.6
Leichhardt	<i>Macrotyloma uniflorum</i>	3.0	4.6	2.6	1.5
Trefoil, big	<i>Lotus uliginosus</i>	3.0	4.9	2.8	1.6
Sudan grass	<i>Sorghum sudanense</i>	2.8	6.5	3.7	2.1
Setaria, Nandi	<i>Setaria speculata var. sericea</i>	2.4	4.0	2.3	1.3
Townsville stylo	<i>Stylosanthes humilis</i>	2.4	3.7	2.1	1.2

Common name	Scientific name	EC ₅₀ average root zone salinity threshold for yield reduction (dS/m)	EC _i (dS/m) threshold for yield reduction for crops growing in		
			sand	loam	clay
Sesbania	<i>Sesbania exaltata</i>	2.3	4.7	2.7	1.6
Desmodium, green leaf	<i>Desmodium intortum</i>	2.1	3.5	2.0	1.2
Clover, berseem Clover	<i>Trifolium alexandrinum</i>	2.0	3.8	2.2	1.3
Lovegrass	<i>Eragrostis spp.</i>	2.0	4.0	2.3	1.3
Lucerne, Hunter River	<i>Medicago sativa</i>	2.0	4.7	2.7	1.6
Lucerne (USA)	<i>Medicago sativa</i>	2.0	4.3	2.5	1.4
Pangola grass	<i>Digitaria decumbens (pentzii)</i>	2.0	5.7	3.3	1.9
Siratro	<i>Macroptilium atropurpureum</i>	2.0	4.2	2.4	1.4
Corn, forage	<i>Zea mays</i>	1.8	4.0	2.3	1.3
Glycine tinaroo	<i>Glycine ughtii</i>	1.8	3.5	2.0	1.2
Paspalum	<i>Paspalum dilatatum</i>	1.8	3.7	2.1	1.2
Clover, strawberry (Palestine)	<i>Trifolium fragiferum</i>	1.6	3.3	1.9	1.1
Bambatsi	<i>Panicum coloratum</i>	1.5	5.8	3.3	1.9
Clover, alsike, ladino, red	<i>Trifolium spp.</i>	1.5	2.9	1.7	1.0
Clover, white (Safari)	<i>Trifolium semipilosum</i>	1.5	2.9	1.7	1.0
Meadow foxtail	<i>Alopecurus pratensis</i>	1.5	3.2	1.8	1.1
Orchard grass	<i>Dactylis glomerata</i>	1.5	3.9	2.2	1.3
Snail medic	<i>Medicago scutellata</i>	1.5	2.9	1.7	1.0
Strand medic	<i>Medicago littoralis</i>	1.5	3.0	1.7	1.0
Cowpea (vegetative)	<i>Vigna unguiculata</i>	1.3	2.5	1.4	0.8
Barrel medic, Jemalong	<i>Medicago truncatula</i>	1.0	2.9	1.7	1.0
Clover, rose (Kondinin)	<i>Trifolium hirtum</i>	1.0	2.7	1.5	0.9
Clover, white (New Zealand)	<i>Trifolium repens</i>	1.0	2.5	1.4	0.8
Desmodium, silverleaf	<i>Desmodium uncinatum</i>	1.0	1.8	1.0	0.6
Dolichos Rongai	<i>Lablab purpureus</i>	1.0	2.0	1.2	0.7
Lotononis, Miles	<i>Lotononis bainesii</i>	1.0	2.3	1.3	0.8
Vegetables					
Kale	<i>Brassica campestris</i>	6.5	8.2	4.7	2.7
Zucchini	<i>Cucurbita pepo melopepo</i>	4.7	7.3	4.2	2.4
Rosemary	<i>Rosmarinus lockwoodii</i>	4.5	5.7	3.3	1.9
Asparagus		4.1	5.2	3.0	1.7
Beet, garden	<i>Beta vulgaris</i>	4.0	6.5	3.7	2.1
Squash, scallop	<i>Cucurbita pepo melopepo</i>	3.2	4.8	2.7	1.6
Broccoli	<i>Brassica oleracea</i>	2.8	4.9	2.8	1.6
Cauliflower	<i>Brassica oleracea</i>	2.5	3.2	1.8	1.1
Cucumber	<i>Cucumis sativus</i>	2.5	4.2	2.4	1.4
Pea	<i>Pisum sativum L.</i>	2.5	3.2	1.8	1.1
Squash	<i>Cucurbita maxima</i>	2.5	3.2	1.8	1.1
Tomato	<i>Lycopersicon esculentum</i>	2.3	3.5	2.0	1.2
Spinach	<i>Spinacia oleracea</i>	2.0	4.2	2.4	1.4
Cabbage	<i>Brassica oleracea (var. Capitata)</i>	1.8	3.5	2.0	1.2
Potato	<i>Solanum tuberosum</i>	1.7	3.2	1.8	1.1
Celery	<i>Apium graveolens</i>	1.8	4.3	2.5	1.4
Sweet corn		1.7	2.2	1.2	0.7
Broadbean	<i>Vicia faba</i>	1.6	3.3	1.9	1.1
Sweet potato	<i>Ipomoea batatas</i>	1.5	3.0	1.7	1.0
Pepper	<i>Capsicum annum</i>	1.5	2.8	1.6	0.9
Lettuce	<i>Latuca sativa</i>	1.3	2.7	1.5	0.9
Onion	<i>Allium cepa</i>	1.2	2.3	1.3	0.8
Radish		1.2	1.5	0.9	0.5
Eggplant	<i>Solanum melongena</i>	1.1	3.2	1.8	1.1
Bean	<i>Phaseolus vulgaris</i>	1.0	1.9	1.1	0.6
Carrot	<i>Daucus carota</i>	1.0	2.2	1.2	0.7
Turnip	<i>Brassica rapu</i>	0.9	2.5	1.4	0.8
Ornamentals					
Bougainvillea	<i>Bougainvillea spectabilis</i>	8.5	10.8	6.1	3.6
Euonymus	<i>Euonymus japonica var. grandiflora</i>	7.0	8.9	5.1	2.9
Dracaena	<i>Dracaena endivisa</i>	4.0	6.5	3.7	2.1
Aborvitae	<i>Thuja orientalis</i>	2.0	2.5	1.4	0.8
Privet	<i>Ligustrum lucidum</i>	2.0	3.9	2.2	1.3
Pyracantha	<i>Pyracantha braperi</i>	2.0	3.9	2.2	1.3
Lantana	<i>Lantana camera</i>	1.8	2.3	1.3	0.8
Boxwood	<i>Buxus microphylla var. Japonica</i>	1.7	3.3	1.9	1.1
Star jasmine	<i>Trachelosperum jasminoides</i>	1.6	2.0	1.2	0.7
Bottlebrush	<i>Callistemon viminalis</i>	1.5	1.9	1.1	0.6
Juniper	<i>Juniperus chinensis</i>	1.5	3.3	1.9	1.1
Xylosma	<i>Xylosma senticososa</i>	1.5	2.9	1.7	1.0
Viburnum	<i>Viburnum spp.</i>	1.4	2.8	1.6	0.9
Algerian ivy	<i>Hedera camariensis</i>	1.0	1.3	0.7	0.4