Productive Saltland Pastures
Salinity Manual

Module 9
Measuring Salinity

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA
natural resource management program

All photos from SGSL DAFWA team

MEASURING SALINITY

INTRODUCTION

Measurement of salinity through field and laboratory testing (in both water and soil) throughout a catchment will aid in monitoring and management decisions. For the purposes of this module only field and laboratory testing will be discussed. A hand-held meter can be used in the field while more sophisticated equipment and testing procedures are used in the laboratory. With both methods it is important to ensure the sampling procedures obtain an accurate result for the soil or water at the time of sampling.

Reading the Electrical Conductivity (EC), a measure of soil salinity, using a hand-held EM38 Electrical Conductivity metre. This measurement is made with the instrument in the 'horizontal' plane, so measuring approximately the top 50cm of soil.

SALINITY UNITS

Soil and water salinity is measured to:

- benchmark and monitor the health of our natural resources
- determine whether soil and water resources are suitable for their intended use
- assist with management decisions and on-ground actions.

Salinity can be measured using a variety of methods and reported in many different units. An understanding of these methods and units is necessary for appropriate salinity management.

Water and soil salinity are measured using a salinity meter. When placed in a soil or water sample, an electric current passes between the two electrodes of the salinity meter. The electrical conductivity or EC of the sample is influenced by the concentration and composition of dissolved salts. Salts increase the ability of a solution to conduct an electrical current, so a high EC value indicates a high salinity level.

Electricity conductivity (EC) is a surrogate for quantitative measures and therefore an indirect unit of measure for salinity testing results. It is simply the electrical conductivity of the sample. The EC meter converts this into a unit of measure for example, microSiemens per centimeter (µS/cm) or milliSiemens per centimetre (mS/cm) which reflects the salt level. In WA salinity readings are expressed in mS/m therefore a simple conversion is needed from the units given by the meter. The conversion is:

µS/cm to mS/m divide by 10

mS/cm to mS/m multiply by 100

The table below lists EC measurement units.

Units of salinity measurement and EC conversion table

	microSiemens per centimetre (µS/cm)	milliSiemens per centimetre (mS/cm)	milliSiemens per metre (mS/m)	milligrams per litre (mgL*)
Equivalent units	100	0.1	10	550
Worked example	40	0.04	4	2560

*mgL is calculated by multiplying mS/m by 5.5. Converting to this unit gives an estimate of Total Soluble Salts (TSS) relative to mass/volume of the sample.

For more detail on measuring soil salinity including the units used visit DPIRD's webpages measuring soil salinity:

https://www.agric.wa.gov.au/soil-salinity/measuring-soil-salinity

ELECTRICAL CONDUCTIVITY SUBSCRIPTS

Electrical conductivity subscript (letter or numbers e.g. EC_W) indicates what the sample represents as listed below:

EC_W - THE SALINITY OF A WATER SAMPLE:

The term EC_W represents the salinity of a water sample. Additional abbreviations such as EC_{iw} or EC_{dw} may be used to indicate that the source of the water sample is irrigation water or drainage water respectively.

EC_W represents the EC of a water sample.

$EC_{1.5}$ - THE SALINITY OF A 1:5 SOIL-WATER EXTRACT:

$EC_{1.5}$ is the salinity of a soil-water suspension made by mixing 1 part soil to 5 parts water by weight. This test can be performed in the field or a laboratory.

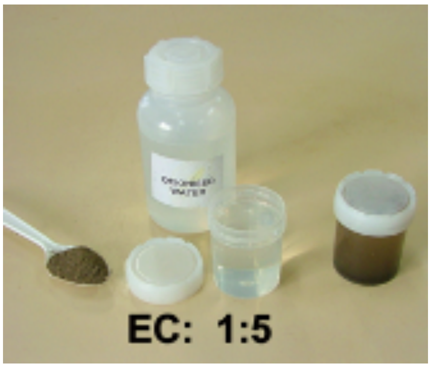
Soil samples can be measured by the '1:5' w/v method - one-part by weight (g) air dried soil to five parts by volume (ml) distilled water, which is agitated then allowed to settle, then the solution is measured for Electrical Conductivity ($EC_{1:5}$).

This measure is usually interpreted to allow for soil texture differences. Sand particles will not hold as much salt from the soil water as will clay. Therefore, sand will give apparently lower readings than from clay, even though the soil water (which is the part affecting plant roots) is the same.

This result is then multiplied by a conversion factor based on soil texture to estimate actual soil salinity (EC_e(est)). See Table 1 in the Section "Determining EC_e".

Note: Some field surveys estimate an $EC_{1:5}$ based on volume:volume (v/v). That is, one scoop of soil to five scoops of water. This can lead to large errors in reporting relative to the w/v method and between samples from the same site, especially for clay soils. It would pay to 'calibrate' any $EC_{1:5}$ estimated from the v/v technique against the w/v estimated technique. The technique is not recommended for critical measurements.

Soil salinity can be measured using either EC_e or $EC_{1.5}$ testing techniques

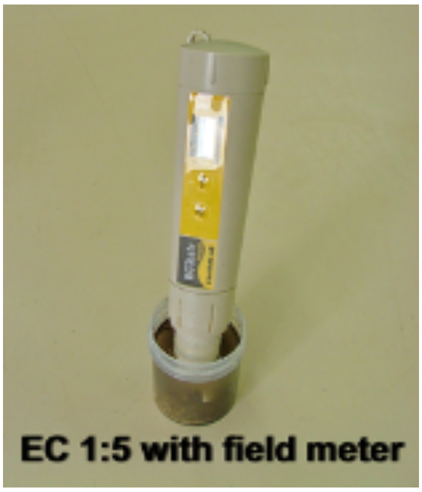


Ingredients for a field EC/pH 1:5 soil sample preparation

EC_E - THE SALINITY OF A SOIL SAMPLE

EC_e is the most useful and reliable measure of salinity for comparing between soil types however it also the most expensive as it needs to be done in the laboratory. EC_e is the salinity of a saturated soil water extract. This may have been estimated from an $EC_{1.5}$ field test (as above) or determined directly from a saturated soil paste in a laboratory.

If the soil salinity has been estimated from an $EC_{1.5}$ test it may be expressed in soil test reports as EC_e (est). See Table 1 in the Section "Determining EC_e". If the soil salinity has been determined from a saturated soil extract it may be expressed as EC_e. Laboratory reports should specify which of the two methods has been used ($EC_{1.5}$ test or a saturated soil extract) as this has implications for test accuracy as discussed above. Plant tolerance to soil salinity generally refers to EC_e.

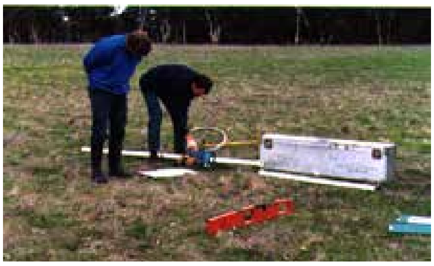


Field measurement

ECA - THE APPARENT ELECTRICAL CONDUCTIVITY OF SOIL FROM EM MEASUREMENTS:

EC_a is the apparent electrical conductivity of soil using electromagnetic (EM) induction technology. Electromagnetic induction instruments include an EM 31, EM 34 or EM 38. Consultants or researchers survey land by this method for rapid assessment of apparent soil salinity over a large area. The EM instruments require trained operators and interpretation of results by experts as factors other than salinity can influence test results. Particularly, soil texture and moisture content can affect the reading.

They measure a large volume of soil. $1m^3$, $40m^3$, $500m^3$ and are affected by other factors such as clay content (soil texture) and moisture content.



EC_a is the apparent electrical conductivity of soil which can be measured using EM instruments mounted on a 4 wheel motorbike or carrying the instruments by hand over the soil surface.

SOIL TEXTURE EFFECT ON EC1:5 (W/V) MEASURES AND SALINITY CLASS

Table 2 has been provided because ECw/v is most commonly used to estimate salinity from field samples. The measure is usually done in a laboratory.

Note that these values are estimates of salinity in the plant root zone. When salinity is measured from the surface layer, the estimate of salinity at the root zone may be incorrect. Note also, that the $EC_{1:5}$ is one-part soil by weight to five parts of water by volume. When the $EC_{1:5}$ volume:volume technique is used in the field, it is prone to large errors.

Table 2: Converting your EC1:5(w/v) mS/m values to a Salinity Rating.

Salinity Rating	Sand	Sandy loam	Loam	Clay loam	L/Med Clay	Heavy Clay
Non-saline	<13	<17	<20	<22	<25	<33
Slightly	13-26	17-33	20-40	22-44	25-50	33-67
Moderately	26-52	33-67	40-80	44-89	50-100	67-133
Very	52-106	67-133	80-160	89-178	100-200	133-267
Extremely	>106	>133	>160	>178	>200	>267

Characterising a salt affected soil, using a 2 metre soil pit. This provides the opportunity for collecting precise information and samples about the soil at specific depths. Location is Wagin, WA

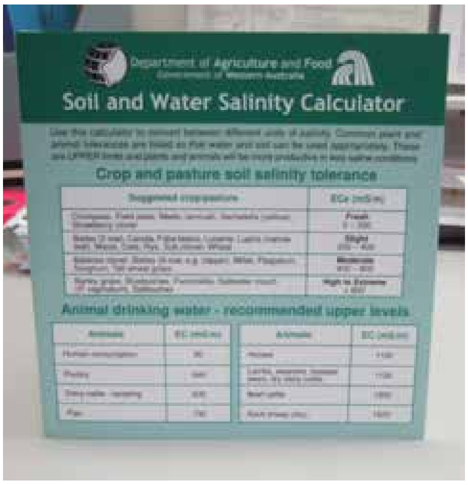
MEASURING EQUIPMENT

FIELD SAMPLING

A typical 'Salt water and soil monitoring kit' can be put together for under $200 (2009).

Things to include are:

PVC or metal 'plopper' attached to a graduated measure tape measure for testwell/ piezometer depth measurement



A 'Soil and Water Salinity Calculator' reference card

A waterproof handheld 'EC Salinity and pH' meter. Note: it is important to calibrate and check the instrument for accuracy regularly.

Two plastic bottles (1 x 1.413 dS/m calibration solution and 1 x distilled water)

Reference and information booklets such as, Saltland Scoring Solutions

Two straight sided plastic jars with graduated measures (1 x water sample jar and 1 x $EC_{1:5}$ soil testing jar).

Alternatively you could purchase a kit from NSW DPI however not all of the information is applicable for WA.

A 'Salt Bag water and soil monitoring kit' is an ideal kit for conducting field tests. The NSW 'Salt Bag' has been assembled for WA and is compact and contains the following testing equipment:

- A comprehensive 'Salt Bag Manual'
- A 'Soil and Water Salinity Calculator'
- A waterproof 'EC Scan High' salinity meter
- PVC 'plopper' on graduated measure for testwell/ piezometer depth measurement and water sample extraction
- Two plastic bottles (1 x 1.413 dS/m calibration solution and 1 x distilled water)
- Two straight sided plastic jars with graduated measures (1 x water sample jar and 1 x $EC_{1:5}$ soil testing jar).

Salt bag and contents (Elizabeth Madden, NSW DPI, Wagga Wagga, 2008).

LABORATORY TESTING

WATER

A water sample can be sent to a laboratory for a more comprehensive analysis and to check accuracy of field tests. Remember to provide details on both the water source and proposed use, as these two factors will determine the water quality parameters to be tested.

The Department of Primary Industries and Regional Development operate a farm water testing service measuring pH and salinity for landholders to determine the suitability of their water for agricultural and domestic applications.

Privately operated laboratories can offer more comprehensive testing of water if required.

SOIL

Soil chemical and physical laboratory tests can be used to check the accuracy of field observations, and are recommended when field tests indicate saline and/or sodic soil.

Private laboratories such as CSPB can undertake a range of soil analyses. From a salinity point of view it is important to obtain readings for:

- exchangeable sodium percentage (ESP)
- cation exchange capacity (CEC)
- alkalinity
- texture and structure.
- Chloride
- Sodium
- pH

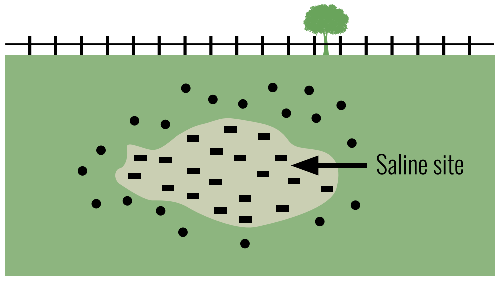
SOIL SAMPLING PROCEDURES

WHEN TO SAMPLE

Points to consider:

- Do not sample for salinity when soil is moist from a recent rainfall or irrigation event as the salt in the soil is likely to be leached from or washed-off the upper soil surface. The extent of the leaching or wash-off will depend on the permeability of the soil and water volume.
- Soil salinity levels are likely to fluctuate with weather conditions. Mid-summer to mid-autumn sampling will capture peak salinity levels and indicate site suitability for perennials and/or summer active species.
- Sampling during the growing season will be required to assess site suitability for winter-active, short-growing season species (Liddicoat and McFarlane 2007).

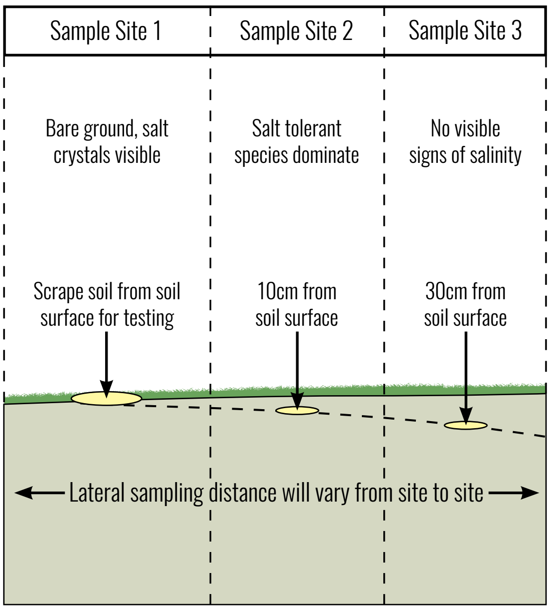
WHERE TO SAMPLE



Sampling a potential saline site (Slinger and Tenison 2005).

SAMPLING SALINE DISCHARGE SITES

When collecting samples from a saline discharge site take an auger sample from each of the depths indicated. Collect separate samples from the saline and non-saline area as shown in the diagram below.



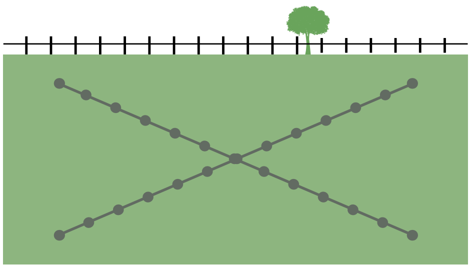
Soil sampling in saline discharge sites (Slinger and Tenison 2005).

If the site is not obviously saline the following information is useful (if available), as a guide in selecting sample sites:

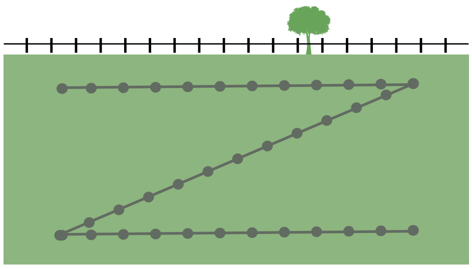
- Electromagnetic (EM) mapping – EM38 or EM31 are used to estimate and map areas of high and low electrical conductivity (but these can be difficult to interpret without further soil testing).
- Aerial photos showing waterlogged or saline areas.
- Cut and fill maps showing sodic or saline subsoil.
- Visual indicators of salinity (indicator plants and surface conditions including bare areas).
- Reading the landscape – identifying features that predispose an area to salinity e.g. position in the landscape, break-of-slope, depressions and drainage lines.

PADDOCK SAMPLING

When paddock sampling, collect samples in a defined pattern so sampling can be repeated over time. Commonly an 'x' or 'z' pattern is used as shown in the figures below.



'x' pattern for bulk sampling (Slinger and Tenison 2005).



'z' pattern for bulk sampling (Slinger and Tenison 2005).

SAMPLING DEPTH

For shallow-rooted crops and pasture collect at least 20 samples from a depth of 0–10 cm in one of the patterns shown above. Avoid collecting surface material such as leaf or organic matter.

In horticultural blocks or where there are deep-rooted perennials use an auger or shovel to dig a hole to the bottom of the root zone if practical. Dig 5–10 cm at a time and lay the soil down in a line in the same order it comes out of the hole. Note carefully any change in soil colour. This avoids mixing soils and provides greater accuracy when determining where any soil layers begin and end.

Take a sample (several handfuls) from each soil layer (or at intervals of 30 cm if layers are not clearly defined). These samples can be bulked together for an overall sample of the paddock or left separate and tested individually for a detailed site assessment.

Once the samples have been collected if they are not field tested, they should be sent as soon as possible to the laboratory for analysis. If you collect multiple samples you can submit your samples, in 500 g plastic bags to the laboratory.

SOIL SALINITY FIELD TESTING PROCEDURES

A simple field test for soil salinity can be conducted using a hand-held salinity meter. While the test is reasonably accurate for preliminary investigations of suspected salinity and ongoing monitoring on-farm, it is recommended that for management decisions involving considerable investment soil samples should be sent to a certified laboratory for more accurate analysis and confirmation.

SOIL SALINITY FIELD TEST

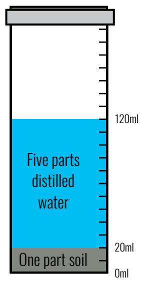
Determining EC_e from a field test is a three part process which involves:

1. Measuring the salinity of a solution made up of distilled water mixed with the soil collected. $EC_{1:5}$ (EC one-to-five).
2. Determining the texture of your soil sample.
3. Multiplying the water test result by a conversion factor (based on soil texture) to get an estimate of actual soil salinity (EC_e), which shows how soil salinity will affect plant growth.

1. Determining $EC_{1:5}$ and pH

This step involves adding one-part soil to five parts distilled water. To perform this test, you will need the following equipment:

- waterproof salinity (electrical conductivity) meter
- calibration solution (note: it is important to calibrate your meter regularly)
- deionised water (or rainwater)
- a clear, straight sided, screw top container with graduated measures (as shown in the diagram on the right).



Clear, straight sided, screwtop container for testing $EC_{1:5}$

(Slinger and Tenison 2005).

SAMPLING PROCEDURE

1. Take a soil sample from the rootzone of your crop or pasture.
2. Ensure each soil sample is air dried by leaving the soil sample in a warm dry room for 24 hours.
3. Crush the dried sample so there are no aggregates larger than 2 mm. Remove foreign bodies i.e. grass and stones.
4. Fill the container with soil to the 20 ml mark (one-part soil).
5. Pour 100 ml of deionised water or rain water into the container (five parts water) i.e. Soil 20 ml + water 100 ml = 120 ml.
6. Replace container lid and shake for at least three minutes and up to 10 minutes, to ensure salts dissolve.
7. Allow sample to settle for up to ten minutes.
8. Use a handheld salinity meter to measure the salinity of the solution.
9. Wash the salinity meter electrodes and container with deionised water or rain water and dry.

ASSESSING SOIL TEXTURE

Soil texture describes the proportion of sand, silt and clay particles in a soil. You need to estimate the texture of your soil to convert your soil salinity EC1:5 result to soil salinity as ECe.

This step estimates the relative amounts of sand, silt and clay the soil sample contains. A given amount of salt in a sandy soil will be more concentrated in its effect on plant roots than an equivalent amount in clay soils. This is because sandy soils hold less water to dilute salts than clay soils (sands have a lower available water content).

It takes a little practice to get this skill, so do not be put off if at first it seems difficult to get the soil ball to just the right moisture or feeling the difference between two different textures. Keep at it. It needs practice. Take every opportunity to texture in a group to compare results!

Follow the steps below:

Step 1- Take a sample of crushed soil

Take about a cupful of soil. Crush any clods and remove stones and plant material.

Step 2 - Roll the moist soil into a ball

Moisten the soil with water - add only a little water at a time and knead the soil into a ball about 3–5 cm in diameter ensuring any lumps are broken up and thoroughly wetted. Add more soil or water if needed to obtain the right consistency. The sample should not be too wet or dry, just uniformly moist such that the ball just sticks together. Continue kneading (and moistening if necessary) until there is no further change in the feel of the ball. About three minutes should be enough. Assess the ball for coherence and feel.

Step 3 - Squeeze a soil ribbon between thumb and forefinger

Ribbon the soil ball by pressing it between your thumb and forefinger.

Try to keep the ribbon about 2 mm thick and continue squeezing out a ribbon of soil between your thumb and forefinger until the ribbon breaks. It takes a little practice to get this technique. Ribbon the soil several times and note an average length of an unbroken piece of ribbon.

Step 4 - Measure the length of soil ribbon to determine texture

Use this length and the table below to estimate soil texture.

Soil texturing (Slinger and Tenison 2005)

STEPS IN DETERMINING FIELD TEXTURE

Check the moist soil ball for coherence, feel and resistance to shearing as follows:

Coherence: Describes how the particles in the moist soil ball hold together.

- Strong: holds shape well, little water is needed to form ball for example, clays
- Firm: holds together but needs more water to form a ball for example, loams
- Nil to slight: soil will not hold together or stay in a moulded ball for example, sands.

Feel of the ball

- Gritty: typical of soils high in sand. Coarser sand grains may be visible. Fine sand grains make a grating sound as you rub the soil between your thumb and fingers close to your ear.
- Equally smooth, sticky and gritty: a feature of loamy soils. Beware - high organic matter content gives a spongy feel that may be confused with loam texture. However high organic matter usually colours fingers dark brown or black.
- Greasy, buttery or silky: a smooth, soapy, slippery feel is typical of silty soil.
- Plastic and sticky: the ball can be squeezed and holds its new shape strongly; typical of clays.

Resistance to shearing: Describes how firm the soil feels as you form a ribbon.

Place the ball of soil between your thumb and forefinger and squeeze, pushing your thumb into the soil. The amount of force needed to deform the moist ball of soil is a good way to distinguish between light, medium and heavy clays. A light clay is fairly easy to shear; a medium clay is stiff; a heavy clay is very stiff and takes a lot of force to squeeze into a ribbon (see table below).

Soil Texture Group	Coherence	Feel	Other Features	Approx ribbon length	Approx % Clay content
Sand	nil to slight	sandy, gritty	unable to form a stable ball; single sand grains stick to fingers	less than 15mm	up to 10
Sandy Loam	slight to just firm	sandy	sand grains can be seen and/or felt	15-25mm	10-25
Loams	firm	spongy, may be greasy	ball is soft with spongy feel; silky or sandy	approx 25mm	20-30
Clay Loams	firm to strong	smooth	ball is smooth and plastic; may be slightly silky or sandy	40-50mm	30-35
Light Clays	firm to strong	plastic	smooth like soft plasticine	50-85mm	35-45
Med + Heavy Clays	strong	plastic	smooth; handles like plasticine; resists rolling out and shearing	greater than 85mm	greater than 45

Soil texturing table (Slinger and Tenison 2005).

DETERMINING EC_E(EST)

Step 1 - Carry out EC15 of soil sample

Step 2 & 3 - Determine soil- texture of sample

4 Step 4: Select the correct multipilcation factor from the Table based on soil texture, (Soil Guide 1998).

Soil Texture Group	Multiply $EC_{1:5}$ (w/v) by factor
Sand	15
Sandy Loam	12
Loams	10
Clay Loams	9
Light Clays	8
Med + Heavy Clays	6

5 Step 5: Multiply the EC1:5 of the sample by the multiplication factor = ECe(est)

Example: 22 ($EC_{1:5}$) X 9 (clay loam) = 198 EC_e(est)

WATER SAMPLING PROCEDURES

WHEN TO MONITOR WATER SALINITY

- Before using new irrigation water sources (dams, groundwater bores and drainage water) to establish suitability and a baseline measurement.
- When saline water may need to be 'shandied' with good quality water to dilute salts to bring it down to stock quality.
- If you have any concerns about the quality of the water supply.
- During drought periods when low water volume and high evaporation of water sources may concentrate salts.
- When the water source has not been used for an extended period of time.
- Following 'fresh' in-river flows (a flushing event following rainfall, particularly during storms) especially when flows have been low for some time.
- If dam water appears clear, as high salinity levels will cause suspended sediment to settle out.
- If stock refuse to drink the water, are scouring or die for no apparent reason, or a decline in production is noticed.
- If water tables are high in the area as saline groundwater may seep into dams, channels and rivers.

It is important to know why you want to test the water as this will help determine how often you need to measure.

SAMPLING & TESTING TIPS

- If the hand-held salinity meter readings (in field) are borderline for the required use, you may wish to have the sample analysed at a laboratory to improve accuracy and hence make a better decision. Sampling and testing at **depth** in dams may be necessary as saline water and fresh water can remain in layers within water bodies.
- Mix the water source thoroughly before taking a sample to test.
- Rinse the sample container with the sample water before collection.
- Sampling from a dam: collect and test a sample from any channel entry point, and at several other locations (about 4 samples/ha) around the dam. Avoid collecting muddy sediment.
- Sampling from a channel, creek or river: for initial field sampling try to collect samples from the middle of the streamflow at different depths (eg. 4 samples). Sampling numbers will vary according to the size of the watercourse.
- Sampling from a bore: collect a sample near the outlet pipe after pumping for at least 30 minutes.
- Sampling from a monitoring bore: bail out the monitoring bore to ensure all stagnant water is removed. Allow the monitoring bore to refill overnight before taking the sample.
- If the sample's salinity level is out of the meter's range (i.e. > 20 mS/cm) add an equal volume of distilled water to the sample and this will halve the total salinity. Then double the reading to find the correct salinity of the sample.
- Regularly calibrate your salinity meter to ensure its accuracy.

WATER SALINITY TESTING PROCEDURES


Sampling water salinity (Slinger and Tenison 2005).

COLLECT WATER SAMPLE

1. Thoroughly mix the water to be tested before taking a sample.
2. Dip the sample container into the water being tested and rinse thoroughly.
3. Then allow the sample container to half fill with water.

TEST WATER WITH SALINITY METER

1. Calibrate the meter before any testing. Check the information on calibration which came with the meter. Standard calibration solutions are 141.3mS/cm and 1288mS/cm.
2. Remove the meter cap and switch on the meter.
3. Immerse the salinity meter about 25 mm into the sample, so that the meter electrodes are covered. (If testing free water in the paddock do not rest the end of the meter in the sediment on the bottom).
4. Swirl the meter slowly and allow the reading to stabilise (it takes up to 20 seconds to adjust for the temperature), then read the number on the meter.
5. Record this result and the Unit ie mS/cm before converting to your desired Units.
6. Wash electrodes of the meter with deionised or rain water, dry, switch off and replace cap.
7. Compare the result using the Salinity tables in Module 10 to determine water suitability for intended purpose.

Sampling the salinity concentration of water in a farm dam using a hand held Electrical Conductivity Meter.

REFERENCES

Liddicoat, C and McFarlane, J 2007, Saltland pastures for South Australia. Department of Water, Land and Biodiversity Conservation, Adelaide.

Slinger, D and Tenison, K 2005, Salinity Glove Box Guide: NSW Murray & Murrumbidgee catchments. NSW Department of Primary Industries, Wagga Wagga, NSW.

Moore, G. 1998, Soil Guide – a handbook for understanding and managing agricultural soils. Bulletin 4343, Dept of Agriculture and Food.

https://researchlibrary.agric.wa.gov.au/bulletins/2/

QUESTIONS

When measuring soil or water salinity a Electrical Conductivity (EC) meter is used.
How does it work?

- ❑ It measures the speed of the water and converts this to a unit of measure ie uS/cm
- ❑ A electric current passes between 2 electrodes which is converted to a unit of measure ie uS/cm.
- ❑ I don't know and it doesn't matter, the meter works.

2) When sampling soil for salinity or pH, what are the main points to consider?

- ❑ Sample from mid-summer to mid-autumn for highest concentration of salt and in the growing season for the lowest.
- ❑ Don't sample too deep and make sure the soil is moist.
- ❑ Take one sample from the site.

3) What does a $EC_{1:5}$ refer to?

- ❑ The electrical current going through a salinity meter.
- ❑ The salinity of 1.5 times seawater.
- ❑ The electrical conductivity of a soil after it has been mixed in 1 part soil and 5 part water mixture.

4) Why is EC_e a more accurate measure of soil salinity than $EC_{1:5}$?

- ❑ EC_e takes into account the soil type and is a closer approximation of what the plants roots are dealing with.
- ❑ It is more complicated and therefore must give a better reading.
- ❑ You need to measure it in the lab.

5) What are the standard water salinity units used in WA?

- ❑ uS/cm
- ❑ mS/m
- ❑ mS/cm

NOTES

PRODUCTIVE SALTLAND PASTURES

www.gillamii.org.au

Design by: Synergy Graphics 0439 936 514