Salinity Bridge for *In-situ* Salinity Measurement

The salinity bridge is a special purpose, alternating current bridge designed specifically for use with soil salinity sensors. A bridge makes it possible to read the soil solution conductivity in millimhos cm^{-1} at 25°C directly from the sensors.

Real Time Dynamic Automated Salinity Logging System

In this system salinity sensors are buried at the desired root-zone depths where salinity monitoring is required. Each salinity sensor is fitted with an external smart interface that consists of an integrated microprocessor containing all the required information to allow autonomous operation of the sensor, including power requirements and logging interval. The smart interface resolution is 16 Bit offering a highly precise and accurate recording of the salinity sensor. The smart interface is connected to the DataBus which leads to the Smart Datalogger.

The Smart Datalogger searches the DataBus and automatically identifies the number of salinity sensors connected and begin logging them at predetermined intervals. Instantaneous readings from sensors can be viewed on the logger's display directly in the field without the need for a laptop. Data can also be accessed in the field by memory stick or remotely by using a mobile phone modem. This data is then available for graphing and interpretation in Excel.


Viewing instant EC


Buried sensor and interface

Soil Salinity in Irrigated Fields and Relative Yield Prediction

Salinity mapping and monitoring in irrigated agriculture fields provide general guidance about yields from the salinized area relative to yields without salinity. Crops can tolerate salinity up to certain levels without a measurable loss in yield (i.e. threshold level). At salinity levels greater than the threshold, the crop yield reduces linearly as salinity increases. Using the salinity values in a salinity/yield model developed by Maas and Hoffman in 1977, predictions of expected yield loss can be made. Maas and Hoffman expressed salt tolerance of crops by the following relationship:

$$Yr = 100 - s(ECe - t)$$

where Yr = percentage of the yield of crop grown in saline conditions relative to that obtained on non-saline conditions; t = threshold salinity level where yield decrease begin; and s = percent yield loss per increase of 1 ECe (dS m^{-1}) in excess of t.

In the Maas and Hoffman model, it is assumed that crops respond primarily to the osmotic potential of soil solution, and specific ion effects is of secondary importance.

In the above context, salinity monitoring helps understand the root zone salinity levels, whether below or above the threshold level of crops in the field. The latter requires the application of extra water to maintain the root zone salinity below the crop threshold salinity.

General threshold (t) and slope (s) values to calculate crop yield as a function of soil salinity for various crops

Crops	Threshold (t) ECe dS m^{-1}	Slope (s) % yield loss per 1 ECe (dS m^{-1}) above (t)
Alfalfa (*Medicago sativa*)	2.0	7.3
Barley for grain (*Hordeum vulgare*)	8.0	5.0
Bean (*Phaseolus vulgaris*)	1.0	18.9
Bean, dry edible (*Phaseolus vulgaris*)	1.0	19.0
Cabbage (*Brassica oleracea*)	1.8	9.7
Carrot (*Daucus carota*)	1.0	14.1
Clover (*Trifolium spp.*)	1.5	12.0
Corn for grain (*Zea mays*)	1.7	12.0
Corn for silage (*Zea mays*)	1.8	7.4
Cucumber (*Cucumis sativus*)	2.5	13.0
Date (*Phoenix dactylifera*)	4.0	3.6
Lettuce (*Latuca sativa*)	1.3	13.0
Onion (*Allium cepa*)	1.2	16.1
Pepper (*Capsicum annum*)	1.5	14.1
Potato (*Salanum tuberosum*)	1.7	12.0
Radish (*Raphanus sativus*)	1.2	13.0
Sorghum for grain (*Sorghum bicolor*)	6.8	16.0
Soybean (*Glycine max*)	5.0	20.0
Spinach (*Spinacia oleracea*)	2.0	7.6
Sugar beet (*Beta vulgaris*)	7.0	5.9
Tomato (*Lycopersicum esculentum*)	2.5	9.9
Wheat for grain (*Triticum aestivum*)	6.0	7.1

s = % yield loss per 1 ECe (dS m^{-1}) increase above t (ECe) value

t = salinity threshold ECe (dS m^{-1}), where yield is optimum.

For more information:
Dr Shabbir A Shahid, Salinity Management Scientist
Tel: +971 4 3361100 Ext 305 Mob: +971 50 4134149
Fax: +971 4 3361155
Email: s.shahid@biosaline.org.ae

Soil Salinity
Assessment, Mapping and Monitoring:
Modern Methods

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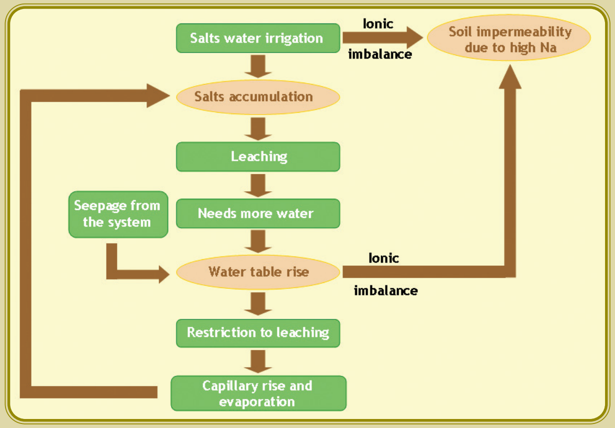
Salinity and sources of salts

Salinity is a general term to designate soil affected by soluble salts, mainly sulphates, chlorides, carbonates along with bicarbonates of sodium, calcium, magnesium and potassium. Parent material, rainfall, irrigation with salty water, sea water intrusion, high water table and poor irrigation and drainage conditions are the main causes of soil salinization.



Hypothetical salinization cycle

Soil salinity measurement and expression

As a standard procedure, salinity is measured as the electrical conductivity of an extract (EC_e) from saturated soil paste and expressed as deci Siemens per meter (dS m^{-1}) or milli Siemens per centimeter (mS cm^{-1}). The older unit milli mhos per centimeter (mmhos cm^{-1}) is now obsolete. All units are equal, that is, 1 dS m^{-1} = 1 mS cm^{-1} = 1 mmhos cm^{-1}.

Soil Salinity Assessment, Mapping and Monitoring

Soil salinity is a major global challenge due to its adverse impact, at the regional, national and farm levels, on environmental sustainability, ecosystems, and agricultural productivity. Salinity undermines soil quality; many plants either fail to grow in saline soils or their growth is retarded significantly, thus soil salinity often restricts options for cropping in a given area. Temporal understanding of soil salinity through assessment, mapping and monitoring helps understand subtle differences across the landscape and agricultural fields, and allows their precise management. Managing saline soils is highly site specific and depends on factors such as site characteristics, nature of soils and local hydrological conditions.

Conventional and Modern Methods

A range of conventional and modern methods are available to assess soil salinity at different levels. The choice of the method depends upon the purpose, size of the area being evaluated, the depth of soil to be assessed, the number and frequency of measurements needed, the accuracy required and the availability of resources. At ICBA the following methods are used.

Remote Sensing and Soil Salinity

Remote sensing acquires information about surface salinity without actually being in contact with it by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. The Remote Sensing Imagery (RSI) provides general salinity information about the reflected area; however, it lacks information about root zone salinity, which requires other conventional (EC meters) and modern methods (EMI and salinity probes) to be used. The combination of salinity maps taken over period of time and Digital Elevation Model (DEM) help predict salinity risk in the area. RSI and GIS, in combination with field validation, have been used in soil salinity mapping of the Abu Dhabi Emirate.

Electromagnetic Induction

Electromagnetic induction (EMI) equipment provides a rapid assessment of the soil's electrical conductivity. The most commonly used in agricultural surveys is EM38. It measures the apparent flow of electrical conductivity through the soil, called the soil's apparent electrical conductivity (ECa) measured in milliSiemens/meter (mS m^{-1}). The EM38 has transmitter and receiving coils. The former induces an electrical current into the soil and the latter records the resulting electromagnetic field.

The ECa is affected by the soil's moisture, salt content, type and amount of clay, textural differences, depth to bedrock, porosity, compactness, organic matter and temperature. In dry sandy desert soil this is not a recommended method. Its depth of exploration in vertical mode is 1.5m and horizontal mode 0.75m. These depths are only indicative; if the soil is very conductive near the surface then the signal will be dissipated and will not read to a greater depth. The EM38 equipment can be calibrated in vertical and horizontal modes and the ECa values are validated with ECe from depth indicative of equipment capability, which is site specific.

Field ECa measurement

Activity Meter with Salinity Probe

The salinity probe is handy equipment easy to use manually in the field and pot experiments to give instant apparent electrical conductivity (ECa) information in mS/cm and g/l. The PNT3000 COMBI + model is commonly used in agriculture, horticulture and landscape sites for rapid salinity assessment and monitoring.

Field EC by salinity probe

The probe provides extended EC-measuring ranges from 0-20 mS cm^{-1} and from 20-200 mS cm^{-1}. The unit includes stainless steel probes of 250, 500 and 750 mm length for direct soil salinity measurements. The 250 mm salinity probe is supplied in a rugged aluminum transport and storage case. It is essential to validate ECa values with ECe from the same fields.

Standard Salinity Measurement Method

A number of modern techniques exist to measure soil salinity; however, for many reasons, the laboratory analysis of extract from saturated soil paste by EC meter is still considered the most common standard technique for assessing soil salinity and other potential hazards. This is due to the amount of water that a soil holds at saturation, is related to soil texture, surface area, clay content, and cation-exchange-capacity.

Lower soil-to-water ratios (1:1, 1:2, 1:5) make the extraction easier, but are less related to field moisture conditions than the saturated paste. The EC measured on different soil:water ratios must be calibrated to ECe by using a factor specific to the soils under study. To keep the root zone salinity below plant threshold ECe, salinity monitoring and management over a period of time is essential.

Root zone soil sampling

Extraction from soil paste