Rapid assessment of soil salinity in tsunami-affected areas.

Experiences from Nanggore Aceh Darussalam province, Indonesia

The 26 December 2004 tsunami in the Indian Ocean inundated large areas of low lying agricultural land. Soils in these areas are now being used for farming again, but some soils are proving too saline for crop production. Indonesian and Australian scientists working in Nanggore Aceh Darussalam have developed procedures to rapidly assess the salinity of tsunami-affected land and to assess the extent of leaching that has occurred since the tsunami.

Fig. 1. Tsunami affected farmland in Lho Nga, Banda Aceh

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1. Identifying the risk of soil salinity in tsunami-affected areas

The level of soil salinity in soils affected by the tsunami varies widely. The type and vigour of plant growth can sometimes be a visual guide to the severity of soil salinity. Plant growth is often patchy in saline soils (Fig.2) and the most salt-tolerant species may be the only plants that survive (Fig.3). Accumulation of salt crystals on the soil surface and puffy dry soils also indicate salinity. However if the soil has been cultivated there may be no visual indicators of the degree of soil salinity.

Fig 2. Poor establishment of crop on saline land in Pante Raja, Pidie. The EM38 instrument shown is used to assess the salinity level of this soil.

Fig 3. Salt-tolerant grass in tidal-affected land in Brembang village, Pidie

Soil salinity assessment by soil sampling and laboratory analysis

Laboratories commonly assess soil salinity by measuring the electrical conductivity (EC) of water extracts of soil samples. EC is commonly expressed in units of deciSiemens per meter (dS/m). The value of soil EC increases with increasing salinity level. Different laboratories may use different ratios of soil to water eg saturated paste (ECe), a 1:2 soil to water ratio, or a 1:5 ratio. Care must be taken when interpreting laboratory data because the different ratios of soil to water will give different laboratory results even though the soil salinity is the same. Soils with an ECe greater than 4 dS/m are classed as saline because the growth of many crops is reduced at this level of salinity.

Soil salinity assessment in the field using electromagnetic induction

In the field soil EC can be assessed indirectly using electromagnetic induction (EM) methods such as the EM38 instrument shown in Fig.2.

The EM38 measures the average EC of the soil *in-situ* to a depth of approximately 1 m in the field. EM38 measurements increase with increasing soil salinity, clay content and moisture content. They can provide a guide to level of salinity for different texture classes of soils and can be used to guide soil sampling for laboratory analysis.

The EM38 instrument can take two types of measurements: vertical, with the instrument sitting vertically on the soil surface (EMv) (Fig. 4), or horizontal with the instrument lying on its side (EMh) (Fig. 5). The EMv measurement is more sensitive to soil below 0.45 m than the EMh measurement. The EMh measurement is more sensitive to soil above 0.45 m than the EMv measurement. The two measurements can be compared to indicate how deeply salt may have penetrated the soil.

The assessment method can be used to
- classify soil salinity risks into low, medium or high risk
- evaluate effects of salinity on crop production.
- Indicate the extent of salt leaching.
- Indicate soil sampling locations

Fig.4. EM38 measurement in vertical mode

Fig.5. EM38 measurement in horizontal mode

Table 1: EM38 ranges for different salinity classes and soil textures

Main soil texture class in 0-1 m	Average EM38 reading (ie EMv+EMh)/2 in dS/m		
	Non-saline*	Slightly saline*	Saline*
Sandy soils	<0.4	0.4-0.7	>0.7
Loamy soils	<0.7	0.7-1.1	>1.1
Clay soils	<1.0	1.0-1.5	>1.5

*Non-saline is equivalent to average profile ECe< 2 dS/m; Slightly saline is equivalent to average profile ECe between 2 and 4 dS/m, Saline is equivalent to average profile ECe greater than 4 dS/m

The EM38 has measured EC in farmers' fields in eastern Nanggore Aceh Darussalam (NAD) province, Indonesia. The measurements have identified several risk factors associated with the most saline land and these are outlined in the table below.

Table 2: Salinity risk factors

Risk factor	Risk of soil salinity affecting crop production		
	LOW	MEDIUM	HIGH
Duration of inundation with sea water	Less than 1/2 day	½ day – 3 days	Greater than 3 days
Soil permeability	Low eg puddled clays with shallow watertable	Moderate eg non puddled loamy soils	High eg sandy soils
Inundated by tidal water	-	Tidal water only moderately saline	irregularly covered by tidal water of high salinity
Number of irrigated rice crops since the tsunami	No information for more than 2 rice crops	1-2	0
Depth and salinity of shallow watertable	No data, but likely to low risk if below 2 m in dry season and EC<2 dS/m.	No data, but likely to be medium risk if 1-2 m from surface in dry season and EC 2-4 dS/m.	Less than 1 m from surface in dry season. EC > 4 dS/m.

2. Estimating the degree of sea water infiltration and salt leaching by comparing the horizontal (EMh) and vertical (EMv) measurements made using the EM38 instrument.

Soils normally do not have high salinity levels, so have low EM readings. Normal soils also are often higher in moisture at depth and so often have EMv readings that are greater than EMh.

When non-saline soil is flooded by saline water it will have more salinity in the surface horizons than in sub-soil horizons Fig 6a. The inundation will increase EM readings and usually result in EMh being greater than EMv.

Leaching of salinity to subsoil depth with non-saline water (eg rainfall) will lower EM readings and eventually result in EMv being greater than EMh (Fig 6b and 6c). A guide to interpreting the relative magnitude of EMv and EMh measurements is given in Table 3 .

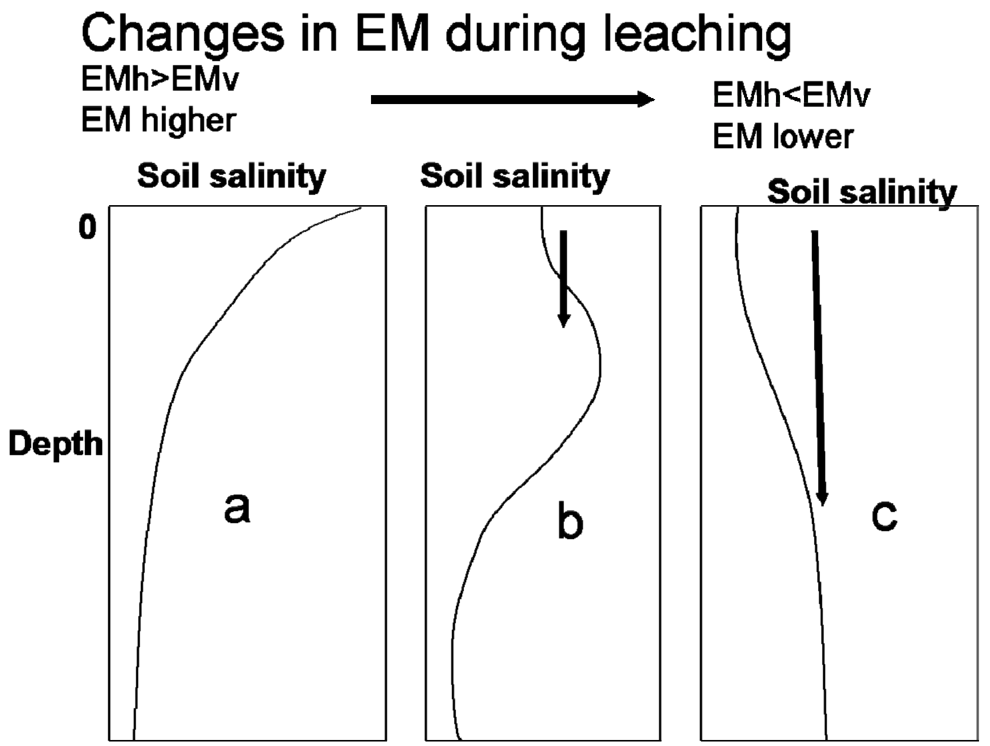

Fig. 6 Soil salinity profiles and EM readings (a) after tsunami and infiltration of sea water (b) after some leaching, (c) after greater leaching.

Table 3: Interpreting different combinations of EMh and EMv readings

Comparison of EMh and EMv	Average EM38 reading (ie EMv+EMh)/2		
	Low*	**Medium***	**High***
EMh>EMv **Indicates soil affected by sea water**	Little infiltration, salt mostly at or closer to the soil surface. Could also indicate perched wet soil.	Shallow infiltration, salt mainly in upper 0.3 m of soil.	Deep infiltration, salt throughout upper 1m of soil profile with highest salt concentration near surface.
EMh~=EMv	Indicates soil salt levels are normal (at pre-tsunami level) or approaching normal	As above but after some leaching.	As above but after some leaching.
EMh<EMv	Normal	As above after more leaching. Salinity is highest below 0.3 m.	As above after more leaching. Salinity is highest below 0.3 m.

- Values of low, medium and high vary with the soil texture profile.

Authors

Dr Peter Slavich
NSW Department of Primary Industries
Wollongbar, Australia
email: peter.slavich@dpi.nsw.gov.au

Dr Malem McLeod
NSW Department of Primary Industries
Tamworth, Australia
email: malem.mcleod@dpi.nsw.gov.au

Dr Natalie Moore
NSW Department of Primary Industries
Grafton, Australia
email: natalie.moore@dpi.nsw.gov.au

T Iskandar
BPTP
Banda Aceh, Indonesia
email: irhas_bptp@yahoo.com

Dr Achmad Rachman
Indonesian Soils Research Institute
Bogor, Indonesia
email: arbb1@yahoo.com

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