FAO FIELD GUIDE

20 THINGS TO KNOW ABOUT THE IMPACT OF SALT WATER ON AGRICULTURAL LAND IN ACEH PROVINCE

United Nations Food and Agriculture Organization

This draft manuscript – to be issued shortly as an FAO publication – aims to provide a brief guide on the subject of soil contamination by salt as a result of tsunami inundation of agricultural land in coastal areas of Aceh province (Nanggroe Aceh Darussalam). It does not claim to be an exhaustive treatment of the subject, but merely a starting point for further discussion.

The UN's Food and Agricultural Organization (FAO) carried out limited soil testing and land classification exercise in Aceh in January and February, and has prepared these initial results and suggestions in an informal format. FAO, together with UNOCHA, is offering its services both as a source of technical information, and as the mediator for a forum on the topic. The overall aim is to help the recovery of livelihoods in agricultural areas affected by the tsunami. A further comprehensive soil salinity field survey is now being carried out by 12 field teams in Aceh Province, with preliminary results expected in late March.

What is salt contamination?

Water is taken up by the fine roots of plants through the process of **osmosis**, which involves the movement of water from regions of low salt[1] concentration (such as the soil) to regions of high salt concentration (such as the inside of root cells). When salt concentrations in the soil are high, the movement of water from the soil to the root is slowed down. When the salt concentrations in the soil are higher than inside the root cells, the soil will draw water from the root, and the plant will wilt and die. This is the basic way in which salinization affects plant production.

The damaging effects of salt on plants are caused not only by osmotic forces, but also by **toxic levels of sodium and chloride**. Fruit crops and woody ornamentals are especially sensitive to high levels of these elements. Also, the high pH value (a measure of the acid/alkaline balance) caused by excess sodium may result in micronutrient deficiencies.

Plants vary in their sensitivity to salt. Those with the lowest salt tolerance include tomatoes, onions and lettuce. At the other extreme are halophytes, which occur most frequently in salt marshes, beaches and other saline environments.

Soil salinization is a common problem in areas with low rainfall. When combined with irrigation and poor drainage it can lead to permanent soil fertility loss. This type of salinity is a common factor of many drought-induced humanitarian crises.

Soil salinization as a feature of rapid-onset disasters is however limited exclusively to tsunamis. Because of this, FAO is aware that many humanitarian organizations working in Aceh may not have previously encountered the phenomenon, and there may be a lack of accessible information on identifying and dealing with salt-affected soils.

Fortunately, Aceh Province is endowed with abundant rainfall, which is not common in most areas with soil salinity problems. While the land rehabilitation efforts should make the most of this advantage, other conventional treatments, e.g. appropriate drainage, deep rooting crops, gypsums, might be introduced when and where appropriate.

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[1] So-called soluble salts are composed mainly of Sodium (Na^+), Calcium (Ca^{2+}), magnesium (Mg^{2+}) chloride (Cl^-) and sulphate (SO_4^{2-}). Magnesium sulphate (MgSO4) and sodium chloride (NaCl, table salt), are among the most common soluble salts.

Twenty things to know about soil salinity for land rehabilitation in Aceh Province

PART I: THE PROBLEM

1 How does salt affect plant growth and what are the symptoms?

Salt affects plant growth mainly through: (a) toxicity from excessive uptake of salt substances such as sodium, (b) reduced water uptake, known as water stress and (c) reduction in uptake of essential nutrients particularly potassium. Early signs of salinity damage are (a) darker leaves than the normal color of bluish-green, (b) smaller leaves and (c) stems with shorter spaces between leaf nodes. When the problem gets more serious, leaves (a) become yellow (chlorotic) and (b) are affected by "burning" (firing, browning) and the death of leaf edges.

2 Clay and silt sediment is the problem, not salt water itself

It is true that sea water in the tsunami brought salt to the soil surface, but most land was inundated by the tsunami for a relatively short period, and most of the salt will be, or has already been, washed away by abundant rainfall. Rather, the recent FAO survey has found that residual high content of salt is in the layers of **clay and silt** left behind by the tsunami waves. The clay/silt layer can be identified easily by cracks that spread across the surface of the soil. In many areas, trenching or digging down to a depth of just 20 cm will reveal a fine grey layer.

3 Difficulties with the clay/silt layer

Salt in the soil is best washed away by fresh water, but because this clay/silt layer is relatively impermeable, the filtration process, called **leaching**, is slow. When cracks appear, the rainfall runs into these cracks and desalinization is even slower. In some relatively dry zones the salt has already accumulated on the surface and crystallized. As a result the salinity problems may persist for a long period unless measures are taken to remove the salt by **flushing** and/or leaching.

PART II: ANALYSIS

4 Observation

Looking at a field carefully will reveal clues concerning soil salinity. **Cracking** is a clear sign of clay/silt sediments. Visible **salt accumulation** on the surface indicates shortage of rainfall and this may be a disadvantage for reclamation. **Vegetation** is obviously a good sign of recovery. If there is neither clay/silt sediment nor vegetation, it may mean that saline water is trapped below the surface and is hindering plant establishment (called **waterlogging**).

5 EC meter

An **electronic conductivity meter** (EC meter) provides more accurate information on soil salinity. The reading (mS/cm: milli-Siemens per centimeter) corresponds to the amount of electrolytes in solution, and therefore, the higher the value, the more salt there is. The cost of EC meters varies considerably ranging from US$ 50 to US$ 500 per unit. It is essential that they measure from zero up to at least 20mS/cm (or 19.99 mS/cm as seen in many catalogues). One important thing – **the electrode must be calibrated before use**, so please read the instructions carefully.

6 Measurement protocol

There is a rigorous scientific protocol for measuring EC of the soil, but the following procedure is acceptable for practical field estimate purposes. Mix one portion (weight) of soil and five portions of distilled water (mineral water can be used instead, but not well water). Shake for one minute and let the mixture stand for a couple of minutes (formally it is 30 minutes but it does not make a big difference) before dipping a pre-calibrated electrode into the solution and taking a reading.

7 How to obtain the salinity value of rice paddy soil

As the roots of the paddy reach about 20 cm below the surface, take a core or spade sample from this zone. Alternatively, take samples from separate layers (i.e. clay/silt, sand and original soil) and mix them. In this case, be careful that the ratio of the each sample matches that of the depth of each layer. Also the salinity of the clay/silt layer alone should be measured. Measure according to the above procedure, then multiply by 8 to obtain 'EC in saturation extract' or EC(e). This multiplier would be valid for typical paddy soil in Aceh Province and a higher value (10 – 14) should be applied for sandier soil. If you are not sure about the soil texture, you may apply both figures for assessment.

8 What does the value mean?

For rice:

- If the EC(e) is less than 4, the yield loss will be less than 10%
- If the EC(e) is more than 4, the yield loss will be 10 – 20%
- If the EC(e) is more than 6, the yield loss will be 20 – 50%
- If the EC(e) is more than 10, the yield loss will be more than 50%

For other crops: sensitive plants (such as papaya, mango and banana) are affected at about 2, and the tolerant plants (e.g. coconut, tamarind) are only affected at 8-10 or more.

9 What is the ideal level?

For rice cropping, an EC(e) value of less than 4 at the time of transplanting is the best for root formation. If this is achieved and if subsequent water management is appropriate, there will be no salinity problem throughout the cropping season.

PART III: SOLUTIONS

10 Clean water is THE solution

Clean water is the single indispensable item for desalinization. The following table shows the amount of water infiltration for leaching (note: NOT RAINFALL, as some of it is lost through **surface evaporation**, which may be up to 1,500mm per year in this region, and/or **surface runoff**) needed to reach an EC(e) below 4 from various initial EC(e) values. Given the abundant rainfall in Aceh Province (1,600 mm per year in Banda Aceh, 2,000 mm in Aceh Timur and 3,500 mm in Aceh Barat), the outlook is quite positive. However, be sure that the water actually passes through the root zone to do the job. In addition, some areas on the east coast are actually quite dry and a more cautious approach may be needed.

Table. Water required to reach EC(e)=4 in the root zone (20cm depth)

Initial EC(e) value (mS/cm)	Required water (mm)
10	315
15	430
20	540
25	650
30	765

11 Good drainage infrastructure is equally essential

Good **drainage** is as important as clean water to effectively remove salt from a field. Unless the porous nature of the soil and good drainage allow free percolation of water and drainage from the field, leaching may be only partially successful even with the best quality water. Ideally, opening up drainage blocked by silt is another crucial element of recovery. Improving surface drainage by digging ditches inside the paddy field is an effective alternative. Quick **flushing** with or without mixing may also be considered under some circumstances. For high value upland crops growing in wet conditions, a **raised bed** is recommended to ensure favorable conditions for plant roots.

12 Sources of clean water

Here 'clean' means water with low electric conductivity, and with an EC value of less than 0.5 mS/cm. Water up to 2.0 mS/cm is acceptable, but the leaching effect would be lower. To test this, just dip the electrode into the water without soil. Rainwater is ideal since its EC value is almost 0. Some simple water harvesting schemes will also enhance the rainwater use efficiency. Many irrigation canals on the east coast, if functioning, have water of satisfactory quality, but it is best to check the EC value. Be careful about using water from shallow wells, because ground water may have become salty either by tsunami inundation or by subsurface infiltration from nearby aquaculture ponds: the EC value may be up to 10 mS/cm or more. Borehole water may be more acceptable but it is likely to be in demand for human consumption and is more costly to pump.

13 Breaking of clay/silt layer / extra mixing

One effective option to accelerate salt removal is to break the surface layer by cultivation, either with or without mixing it with the soil underneath. Under upland conditions, this will improve percolation. Under paddy conditions, mixing will actively release the salt into the water, which should then be removed through surface flushing. In rain-fed dry areas, this can be done during the dry season when the soil is hard and work is easier, so as to help leaching when the next rainy season starts.

14 Removal of surface layer is impractical and costly

It may be tempting to try to remove the surface clay/silt layer as the quickest way to get rid of the salt. However bear in mind that just one centimeter of sediment per hectare equals 100 cubic meters. One cubic meter is approximately 15 full wheel barrows, and a standard large truck load is eight to ten tons. This option can only be justified under exceptional circumstances, such as clearing for high-value cash crops. In this case, the economic cost / benefit should be calculated first. In addition, land should be carefully prepared so there is no intrusion of saline water from surrounding land. Appropriate disposal of saline soil is also a problem; coastal dumping may be affective from a salinity point of view, but carries other environmental risks.

15 Gypsum

Gypsum replaces sodium ions in the soil with calcium, and as a result, actively removes the sodium and improves soil percolation. This option is applicable only when the pH of the soil is higher than 8.5 (i.e. a sodic soil) and when simple mechanical breakdown of the compacted clay/silt layer is not effective. Gypsum is available in Aceh and its cost varies from $100 to $200 per hectar/requirement.

16 Chemical fertilizer is NOT the solution

Unfortunately, fertilizers do not solve the salinity problem. Fertilizers are just plant nutrients and do not remove salt from the soil. However, organic fertilizers and mulching may help reduce soil salinity by improving soil structure and therefore percolation.

17 Additional efforts

Some techniques such as cropping systems, good fertilizer and water management may help reduce soil salinity, but none of them can replace leaching by clean water.

18 Alternative crops

Salt tolerant crops may be a practical option during the recovery process. The following is a brief list of salt tolerant crops. However, keep in mind that the introduction of new crops is not easy. A careful assessment of[i] adaptability, market, and technical constraints needs to be carried out, and expert advice will be essential.

List of Crops with High / Medium Salt Tolerance

	High Tolerance	**Medium Tolerance**
Field crops	Barley, Cotton	Rye, Wheat, Safflower, Lupin, Soybean, Oats, Millets, Sorghum, Rice, Peanut
Fruit	Date palm	Pomegranate, Fig, Olive, Grape, Rockmelon, Mulberry
Vegetables	Beetroot, Kale, Asparagus, Spinach	Tomato, Broccoli, Cabagge, Cauliflower, Sweet corn, Broad bean, Squash, Pumpkins, Cucumber
Pasture plants	Rhodes grass, Couch, Panic, Kikuyu, Sorghum, Almum, Pangola, Wimmera ryeglass, Lucerne, Phasey bean, Siratro, Buffel, Sabi, Guinea	Berseem clover, Snail medic, Barrel medic, Blycine, Perennial ryegrass, Strawberry clover, Paspalum, Sudan grass, Phalaris, Reed canary
Ornamentals	Carnation, Clematis	Bougenvillea, Chrysanthemum, Hibiscus, Oleander, Stock

19 Careful monitoring is essential

Although the above points provide guiding principles and tips for soil reclamation, it is important to monitor the land by observation and by salinity checks.

NEED FURTHER SUPPORT, HAVE MORE QUESTIONS?

20 Contact information

FAO can provide training and further information on soil salinity issues. Please contact the following FAO offices in Aceh Province or in Jakarta for further enquiries:

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