SALINITY DYNAMICS OF TSUNAMI AFFECTED SOILS IN THE COASTAL AREA OF WEST ACEH

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Abstract
Soil salinity was feared as one of the most serious problem caused by the Dec. 2004 tsunami in Aceh. The objectives of this study were to obtain a time series data of soil and water salinity and recommending possible approaches to mitigate the negative effects. Monitoring of soil and water salinity was carried out along the coast of West Aceh for three years since the tsunami. Soil samples were collected from selected tsunami affected area representing both mineral and peat soils, and the upland and wetland (the coastal swale formerly used as paddy fields) areas. Electric conductivity (EC) was determined using a glass electrode of 1:5 soil-water suspension. This study revealed that soil EC in general declined rapidly by natural leaching processes because of high (>3000 mm) annual rainfall and coarse soil texture in this district. A year after tsunami, soil salinity in upland mineral soil declined to 0.05–0.35 dS/m within 0-20 cm depth and tends to decreased further in the two successive observations. The EC of wetland ranged from 0.03 - 0.40 dS/m. In the concave areas and lagoons, we still found points with EC of 2.12 – 2.7 dS/m. Peat soil has an advantage with the enrichment of bases and its EC stayed within 0.02 – 0.16 dS/m down to 40 cm depths. For areas with somewhat high EC, selection of tolerant crops seems to be the most realistic solution.

Key words: salinity, electric conductivity, tolerant crops

Introduction

The tsunami hitting Aceh on 26 December 2004 has directly and indirectly caused significant effects on physical, chemical, and biological conditions of agricultural lands. The waves directly undermined soil surface, encapped soil surface with the sea mud, and damaged paddy fields, irrigation networks, and other infrastructures (Agus et al, 2005). The waves also physically damaged vegetation, including agricultural crops. Although it may have not necessarily damaged the crops, the salty sea water also killed sensitive crops such as cacao (Appleton et al, 2002). Indirectly parts of agricultural lands are (temporarily) abandoned because the owners either have been killed or engaged in many other non-farm activities post tsunami.

Soil salinity was feared as one of the most serious problem post tsunami. Soil salinity is the property describing the concentration of soluble salts in soils and expressed by electric conductivity (EC) value. EC is measure of the ability of the solution to carry a current, and measured in deciSiemens per meter (dS m^{-1}). Salinity problems are caused from the accumulation of soluble salts in the root zone.These excess salts reduce plant growth and vigor by altering water uptake and causing ion-specific toxicities or nutrient imbalances (Cardon et al, 1976). In humid regions salinity problems are less likely because rainfall is sufficient to leach soluble salts from the soil, but even in higher rainfall areas, salinity problems occur. In some areas with high water tables, problems may occur with surface evaporation leaving salts to accumulate. Yields of most crops are not significantly affected where salt levels are 0 to 2 dS/m. Generally, a level of 2 to 4 dS/m affects some crops. Levels of 4 to 5 dS/m affect many crops and above 8 dS/m affect all but the very tolerant crops (Cardon et al, 1976; NRCS, 2005).

Soil salinity in the west coast of Aceh increased sharply due to sea water inundation and sea mud deposition. The sea water, with high salt content, caused escalation of salt in the soil, damaging the soil aggregate, and affected the cation balance in the soil (Appleton, et al, 2002). Physically, the soil hardened and cracked when dry and dispersed when wet. The high salt content caused des-osmosis of fluid from the plant tissue and thus wilted the plants. However, the salt content in the soil quickly dropped because of natural leaching process, especially in West Aceh District with a relatively coarse soil texture and high rainfall (>2500 mm). According to Lamond and Whitney (1992), these soils are easy to reclaim for crop production if adequate amounts of low-salt irrigation water or rainfall are available, and internal drainage of the soil is good.

Lowland rice affected by the tsunami has been producing empty grains while in other areas significant yield increase has been observed. In other affected areas, peanuts' vegetative growth thrived, but the pods were empty. This seems to be caused by calcium deficiency due to imbalance of calcium relative to magnesium and sodium and/or micronutrient deficiency (Agus et al, 2007)

Monitoring of soil and water salinity was carried out along the west coast of West Aceh for three years since the tsunami. The objectives of this study were to obtain a time series data of soil and water salinity and recommending possible approaches to mitigate the negative effects.

Methods

Soil samples were collected from selected tsunami affected area in 4 sub-district in the coastal area of West Aceh District namely Sub-district Meurebo, Johan Pahlawan, Samatiga And Arongan Lambalek. Soils sampling site determined base on soil variability within sequent from the coast to the inland area representing both mineral and peat soils, and the upland and wetland (the coastal swale formerly used as paddy fields) areas. Soil sample taken once a year regularly in 3 consecutive years, then analyzed in ISRI Laboratory. Electric conductivity (EC) was determined using a glass electrode of 1:5 soil-water suspension.

Research finding

The EC value of sea water that inundated west coast of Aceh during tsunami is about 60 dS m^{-1}. There is no EC data just after tsunami, but, we can assume that the EC value was > 20 dS m^{-1}. The first study by ISRI was carried out 6 months after tsunami. This study revealed that soil EC in general declined rapidly by natural leaching processes because of high (>3000 mm) annual rainfall and coarse soil texture in this district. High salinity was observed 6 months after tsunami, especially on the swale and lagoons (Fig 1). A year after tsunami, soil salinity in upland or dryland mineral soil declined to 0.05–0.35 dS/m within 0-20 cm depth and decreased further in the successive observations. This pattern were different compared to the lowland part. The EC of lowland ranged from 0.03 - 0.40 dS/m in 2006 observation, somewhat decreased in 2007 and increased in the following observation. Sea water intrusion through water ways and poor drainage might have caused the salt content increased.

In the concave areas and lagoons, we still found points with EC of 2.12 – 2.7 dS/m. It's due to water trap and poor drainage so that soluble salt could not leach easily. Peat soil has an advantage with the enrichment of bases and its EC stayed within 0.02 – 0.16 dS/m down to 40 cm depths, due to high buffering capacity of peat. For areas with somewhat high EC, there were some effort to minimize salinity impact namely developing drainage canal, amelioration, irrigating the crops with fresh water and planting tolerant crops. Among these options, selection of tolerant crops seems to be the most realistic solution

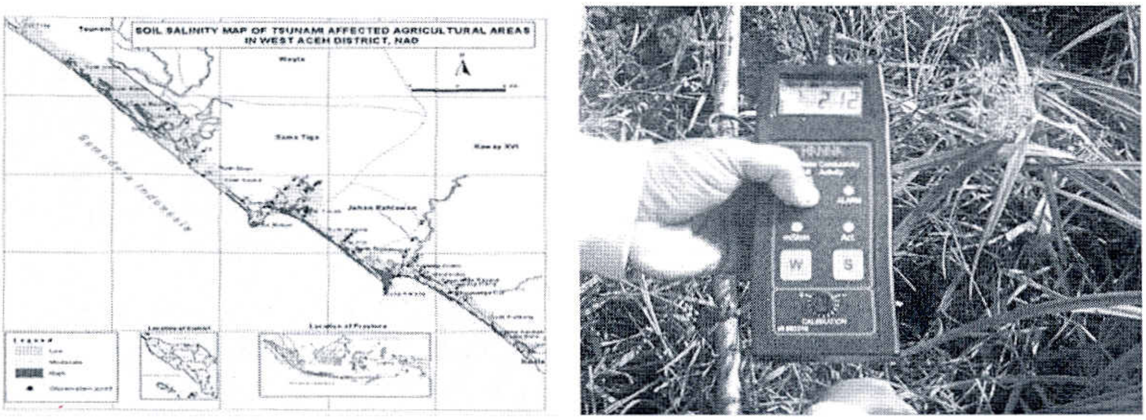

Fig. 1: The EC map of the coastal area of West Aceh 6 months after tsunami (left) and measuring of EC directly in the field (righ)

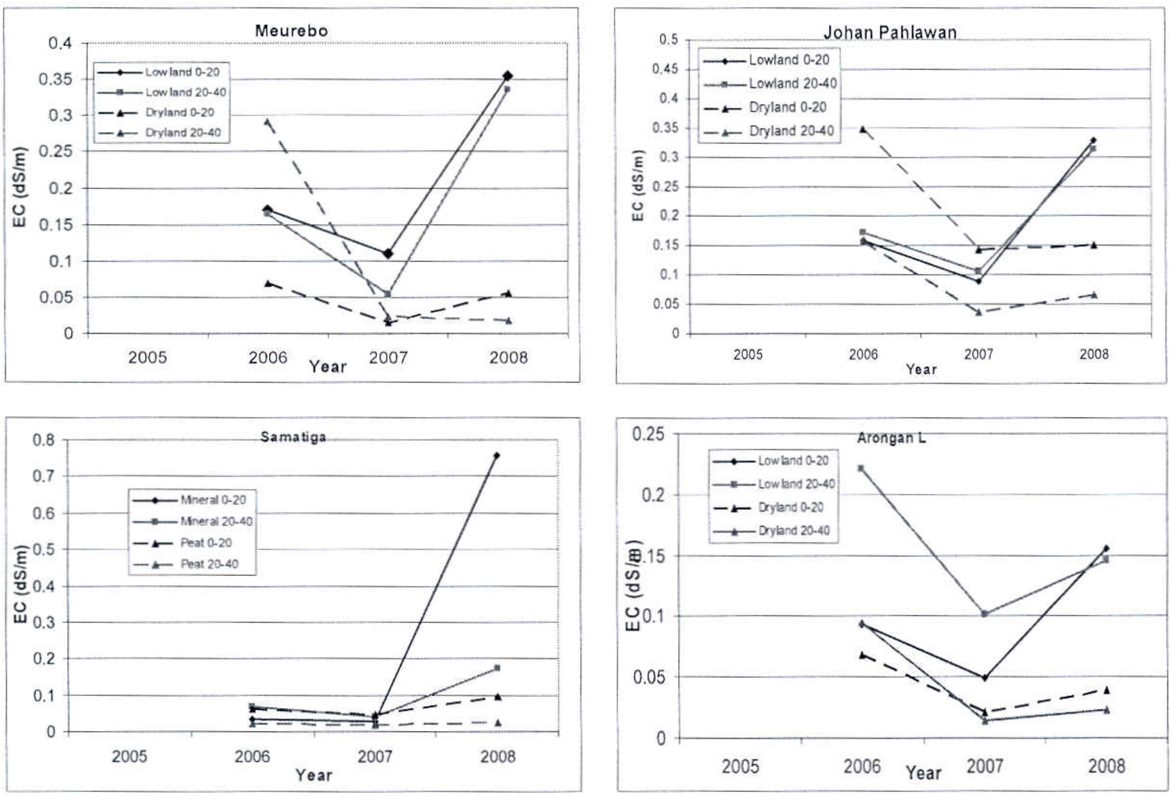

Fig. 2: Salinity dynamic of tsunami afected area at 4 sub district.

The observation of ground water and surface water salinity in some areas indicated that the salt content, in general, had decreased to <2 dS m^{-1}, the level most crops tolerate. The exceptions were ground water and surface water in Kuala Bubon which is very close to the coastline.

Table 1: The EC of soil, ground water and surface water at selected area of West Aceh.

Site Sampling	EC (dS/m)		
	Soil	Groundwater	Surface water
Arongan	0		2,4
Kubu		0,2	
Seunebok Teungoh	0,05	0,1	
Kuala Bubon	-	4,2	12
Paya Lumpat	0,29	-	-
Aloe Raya	2,79	-	-
Suak Nie	0,25	0,01	-
Gunung Kleng	0,16	0,7	2,12
Gunung Kleng 2	0,17	0,7 – 1,0	1,05
Peunaga Cot	0,1	0,3	0,05

Source: Subiksa et al, 2007

Conclusion

1. Soil salinity in the coastal area of West Aceh has declined to below critical level a year after tsunami due to high rainfall and sandy soil texture.
2. Soil salinity in dryland or ridge landform declined countinously during 3 consecutive years, whereas soil salinity in the swale landform or lowland formerly used as ricefield move up and down because influencing by saline water intrusion through natural creeks.
3. Soil salinity in the concave landscape or lagoon have still relatively high due to water trap and poor drainage.

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