Resilience, Rights and Resources: Two years of recovery In coastal zone Aceh

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TRANSFORMING LIVES AND LANDSCAPES

The salt leached out and the soil fertility changes after tsunami

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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. The waves also physically damages vegetation, including agricultural crops. Although it may not necessarily damaged the crops, the salty sea water also killed cacao crops. 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.

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. 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 coarse soil texture and relatively high rainfall.

Besides containing Na, the sea mud also contain Ca, K, Mg, phosphate, organic matter, and perhaps various micronutrients. Unlike Na, bases such as Ca, K, and Mg can not easily leach, such that soil fertility several months after tsunami improved following the leaching of Na.

This article explain briefly on the findings on salinity, and changes in soil fertility on tsunami affected soils.

Methods

This activity included the observations of soil and water properties, vegetation, and adaptation of selected perennial crops on the affected soil. Soil quality observation included the electric conductivity (EC), texture, organic matter content, contents of P and exchangeable bases, cation exchange capacity, and exchangeable Al. The points of observation was based on the transects from the coast to the inland on the affected (A zone) and non affected (B zone) areas.

In general, soils with the EC < 2 dS/m could be considered as having been intensively leached such that its salinity is no longer detrimental to most plant. This is based on assumptions that tsunami waves carried materials with EC of > 40 dS/m and during a few months after tsunami, the affected soil had an EC of 8 to 20 dS/m.

The change in soil properties, especially for Ca, Mg, K, and P concentrations, were compared to the data of Land Resources Evaluation Project (LREP) 1990. The change in soil fertility were also based on observation of perennial and annual crop performances.

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Research findings

1. Salt Leaching

Crops have different tolerance to salinity. Most agricultural crops can not grow under soil EC of > 4 dS/m. During the tsunami, the wave brought mud containing sea water with the EC of > 40 dS/m as far as 5 km from the coastal line. The sea water flooded the land for about 5 hr and receded again to the sea except on some concave lagoons.

Part of the Na from the sea water is adsorbed on the exchange site, but since the soil has a low cation exchange capacity (CEC) while the concentration of salt was very high, only a small portion of Na is adsorbed. The rest existed in the form of free salt that can easily move with the water movement. Even the adsorbed Na ion is easily leached because of weak adsorption of this mono-valence ion.

Observation and soil analysis conducted in June 2006 (1.5 years after tsunami) indicated that the salt content in soil, soil water, and surface water has been below the critical level (Table 1). Salts in the soils relatively rapidly leached because of high rainfall and sandy loam soil in West Aceh, except in the old and newly formed lagoons, which remained under the salt influence. For most perennial crops the current soil salinity in general are non limiting , with the EC of > 2 dS/m.

Table 1. Electric conductivity of soil, soil water, and surface water at selected sites in West Aceh, based on June 2006 observation.

Site	EC (dS/m)		
	Soil	Soil water	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	2,04
Gunung Kleng 2	0,17	0,7 – 1,0	1,05
Peunaga Cot	0,1	0,3	0,05

*Accumulation of sea mud; ** From well

2. Change in Soil Fertility

The sea water that flooded the west coast of Aceh, contained salts of Ca, K, Mg, besides Na salt. These cations were adsorbed in the exchange sites replacing some of the already adsorbed cations. The addition of these salts caused an increase in soil pH and EC. The increase in soil pH was caused by the replacement of H by cations and thus releasing OH- into the soil solution. If the proportion of Na is too high in the soil, it affects the cation balance in the soil, such as that happening in the first few months alter tsunami. From the soil physical properties the peptization process, i.e. dispersion of soil aggregate occurred and the soil particles filled in the soil pores causing soil hardening and crusting when dry (Figure 1).

Figure 1. Soil and tsunami mud mixture forming crusts on soil surface.

The ideal proportion of cations on the exchange complex is Ca 65%, Mg 10%, K 5% and H 20% (McLean, 1977). Na cation is not included because it supposed to be a very low constituent in the exchange complex. Analysis of selected sites indicated that the cation proportion was far from the ideal condition. Na and Ca cations were very high, but K and Ca were relatively low after tsunami (Tables 2 and 3). Both total K and exchangeable K were low after tsunami. This seems to lead to K deficiency because not only the total amount of cations determine the amount of plant uptake, but also the proportion. The ideal K/Mg ratio is >0.2; otherwise, the absorption of K will be deterred.

Table 2. Nutrient content and cation composition in the exchange complex of mineral soils in Gunung Kleng, Suak Segading, Suak Sueke, and Kubu villages based on LREP (1990) and 1.5 years after tsunami (June 2006)

Soil property	**Depth**	**Gunung Kleng**		**Suak Segading**		**Suak Sueke**		**Kubu**	
		LREP,1990	**2006**	**LREP,1990**	**2006**	**LREP,1990**	**2006**	**LREP,1990**	**2006**
P_2O_5 HCl 25% (ppm)	0–20cm 20–40cm	<10 10 - 20	42 39	<10 10 - 20	40 28	<10 10 – 20	38 52	<10 10 - 20	30 23
K_2O HCl 25% (ppm)	0–20cm 20–40cm	41 - 60 41 - 60	12 9	41 - 60 41 - 60	7 5	41 - 60 41 – 60	11 14	41 - 60 41 - 60	18 11
Exch.K. cmol/kg	0–20 cm 20–40cm	0,1 – 0,2 0,3 – 0,5	0,02 0,02	0,1 – 0,2 0,3 – 0,5	0,13 0,08	0,1 – 0,2 0,3 – 08	0,13 0,11	0,1 – 0,2 0,3 – 0,8	0,22 0,08
Exch. Na cmol/kg	0–20cm 20–40cm		0,57 0,33		1,24 0,87		1,45 0,82		0,31 0,57
Exch. Ca cmol/kg	0–20cm 20–40cm		1,07 0,82		3,13 2,09		1,75 1,15		3,31 2,30
Exch. Mg cmol/kg	0–20cm 20–40cm		0,58 0,22		1,98 1,21		3,07 1,64		3,10 2,59
KTK cmol/kg	0–20cm 20–40cm	< 5 < 5	4,48 2,81	< 5 < 5	6,22 5,37	< 5 < 5	4,33 2,81	< 5 < 5	14,3 10,5
KB (%)	0–20cm 20–40cm		93 50		100 79		100 100		48 53

Soil P also increased significantly compared to that as presented in LREP (1990). This may caused by enrichment from the sea and/or soil fertilization effects. The similar trend was also observed in peat soils (Table 3).

Other variable that has changed was the base saturation. The increase in Mg and Na replaces H+ from the exchange complex and affected soil pH although insignificantly. For the peat soils the base saturation was also high on tsunami affected soils, while in Paya Lumpat village, which was unaffected by tsunami, the base saturation remained low.

Table 3. Nutrient content and cation composition in the soil exchange complex in peat soils in Suak Nie, Peunaga Cot, and Paya Lumpat villages based on LREP (1990) and 1.5 years alter tsunami (June 2006).

Soil property	Depth	Suak Nie		Peunaga Cot		Paya Lumpat	
		LREP,1990	2006	LREP,1990	2006	LREP,1990	2006
P_2O_5	0–20cm	10-20	48	10-20	26	10-20	63
HCl 25%	20–40cm	10-20	76	10-20	13	41-60	49
(ppm)							
K_2O	0–20cm	41-60	14	41-60	9	41-60	14
HCl 25%	20–40cm	41-60	36	41-60	9	41-60	9
(ppm)							
Exch.K	0–20 cm	0,6 – 1,0	0,22	0,6 – 1,0	0,14	0,6 – 1,0	0,17
(cmol/kg)	20–40cm	0,6 – 1,0	0,57	0,6 – 1,0	0,18	0.1 – 0,2	0,11
Exch. Na	0–20cm		0,86		2,43		0,27
(cmol/kg)	20–40cm		2,49		1,10		0,34
Exch. Ca	0–20cm		4,19		16,99		1,08
(cmol/kg)	20–40cm		7,18		5,44		1,17
Exch. Mg	0–20cm		3,82		2,13		1,24
(cmol/kg)	20–40cm		4,54		2,16		0,78
KTK	0–20cm	> 40	105,1	> 40	107,1	> 40	77,4
(cmol/kg)	20–40cm	> 40	92,9	> 40	101,3	> 40	79,8
KB	0–20cm		9		20		4
	20–40cm		16		9		3

The data facts and farmers expression in the field suggested that perennial crops such as coconut and kirny performed better after tsunami as indicated by the greener leaves and more fruits.

Analysis of selected yellowish coconut leaves (unaffected by tsunami) exhibited Ca, Mg, S and Cu concentrations tat was lower that the critical levels (Table 4). This yellowish symptom is an indication of Mg and S deficiencies. After tsunami, the sea water brought various kinds of nutrients, including the deficient ones and thus corrected the some of the deficiency problem.

Other fact indicated that paddy field affected by tsunami underwent the harvest failure because of empty seeds. This is especially happened on those paddy fields receiving encapment of the sea mud and those undermined by the waves. The mud which is rich in organic C seems to have absorbed the high valence cations such as Cu, Zn and Fe, forming the ligand complex, making these cations unavailable for plants. Thus the unproductive crops seems to have underwent copper deficiency, but further research is needed to verify this hypothesis.

Table 4. Yellowish, tsunami unaffected, coconut leaves analysis, analyzed in June 2006.

Macro nutrients			Micro nutrients		
Nutrient	Value	Critical level *	Nutrient	Value	Critical level **
N (%)	1,51	1,7	Fe (ppm)	94	80
P (%)	0,11	0,10	Al (ppm)	59	-
K (%)	1,45	0,45	Mn (ppm)	59	50
Ca (%)	0,15	0,50	Cu (ppm)	4	7
Mg (%)	0,24	0,35	Zn (ppm)	31	21
Na (%)	0,16	-			
S (%)	0,02	0,15			

Sources: * De Geus, -   ; ** Jones *et al*, 1991

KEY MESSAGE

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The research bulletins are summary results of collaborative activities of ICRAF and partners in the "Recovery and Resilience of Livelihood and Natural Resources", mainly in West Aceh, after the Tsunami of 26th December 2004. These bulletins were prepared, first in Indonesian language, for a workshop in Meulaboh on 30 November 2006. The primary objective was to share relevant result findings and observations among government and non-government organisations and individuals involved in the post-tsunami recovery in West Aceh. The workshop and preceding research activities were supported by Ford Foundation Indonesia, EU Asia Pro-Eco Program and CGIAR.

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