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Menganalisis dan Mengelola Kemasaman Tanah dan Bahan Organik Tanah Rawa Lebak

Analyzing and Managing Soil Acidity and Soil Organic Contents of Lebak Swamp

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ABSTRACT

The research aimed is to provide information about soil acidity and soil organic contents of lebak swamp. Study sites are located in lebak swamp in District OKI of South Sumatra. The research method is an intensive survey by making soil profiles. Soil profiles were surveyed and described intensively. Data were analyzed with SPSS version 21 to see the relationship between soil acidity with other characters. All soils belong to relatively little developed because silt/clay ratios ranged from 0.24 to 0.29, while the homogeneity indices (fine sand/coarse sand ratios) throughout the soil profiles varied from 0.48 to 0.84. This means that all of the soil profiles are originated from a homogeneous river alluvial. It will only be very effective liming to raise soil pH if followed or together with the addition of organic matters. Lime and organic matters together will move or change the buffering system of the low activity clay minerals to neutralize soil acidity and the pH values will increase.

Key words: Analyzing, managing, acidity soil, soil organic contents, lebak swamp

ABSTRAK

Penelitian ini bertujuan untuk memberikan informasi mengenai kemasaman tanah dan bahan organik rawa lebak. Lokasi penelitian terletak di lahan lebak yang berbahan induk aluvial marin di Kabupaten OKI Sumatera Selatan. Metode penelitian adalah survey intensif dengan membuat profil tanah. Data penelitian dianalisis dengan program SPSS versi 21 untuk melihat hubungan antara kemasaman tanah dengan karakter tanah lainnya. Semua tanah penelitian tergolong sedikit berkembang karena debu/liat rasio berkisar 0,24-0,29, sedangkan Indeks homogenitas (pasir halus/pasir kasar rasio) di seluruh profil tanah bervariasi 0,48-0,84. Ini berarti bahwa semua profil tanah berasal dari bahan induk yang homogen (alluvial marin). Tindakan pengapuran akan sangat efektif untuk menaikkan pH tanah jika diikuti dengan penambahan bahan organik tanah. Pemberian bersama-sama kapur dan bahan organik akan mampu mengubah sistem penyangga mineral liat aktivitas rendah untuk menetralkan kemasaman tanah dan nilai-nilai pH akan meningkat.

Kata kunci: Menganalisis, mengelola, keasaman tanah, bahan organik tanah, rawa lebak

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INTRODUCTION

Around 40-50 % of the land surface of South Sumatra province belongs to flat swamp (mostly consisting of tidal swamp and *lebak* swamp). The most important factors affecting the soil forming processes of swamp soils are parent material and climate condition. The most important parent materials are river alluvial (claystone, sandstone, shale, schist and others) occupying about 60 % of the total flat swamp. Other parent material types are basic igneous rocks form Bukit Barisan mountain locating in the central and the western part of the Sumatra Island (Armanto and Wildayana, 2016).

Characteristics of Young Alluviums are deposits of some sand and gravel with some clay and peat. These deposits, which can be equated with Young Alluvium (Sub Alluvium recently), is determined as Holocene with age <10,000 years. Based on the typology of land, lebak swamp can be divided into six typologies, namely (1) lebak lebung (2) deep lebak, (3) middle lebak, (4) terrace lebak, (5) shallow swamp and (6) dry land (Armanto, 2002; Apriadi *et al.*, 2014).

Most of the soils belong to acid and hydromorphic soils which occupy about 90% of the swamp and they have been developed under the humidity regime of udic or ustic. The soils are largely dominated by Entisols, Inceptisols, Ultisols, Gelisols and Histosols. Approximately 25-30% of the soils are utilized for agricultural purposes, especially for paddy fields. Furthermore, around 40% are used for the annual tropical crops, especially oil palm and rubber (Firmansyah *et al.*, 2016; Wildayana *et al.*, 2016).

Research of lebak swamp has been very much conducted and has already resulted in many innovations and agricultural technology to be able to overcome some various constraints of physical, chemical and biological aspects of lebak swamp. However, there are still many limiting factors, so innovations and agricultural technology of lebak swamp still require holistic and comprehensive approaches as well as socioeconomic factors. In addition there are also constraints of the regional diversity, thus development of innovation and technology of lebak swamp demand site-specific approach. The objective of this study is to analyze and to manage soil acidity and soil organic contents of lowland swamp

MATERIALS AND METHODS

Research sites are located in lebak swamp in District OKI of South Sumatra. The selected research locations are based on the similar soil parent materials (alluvial, sandstone, clay stone and other) by using geology maps with 1:250,000 scale. The most common rock types are river deposit, sandstone, clay stone and others. All alluvial soils were intensively surveyed, soil profiles were described intensively. Composite soil samples were collected and then analyzed intensively in the laboratory. All data collected from the fields and laboratory were analyzed by using SPSS program version 21 in order to see the relationship between soil acidity with the other soil characters.

RESULT AND DISCUSSION

Result and discussion will focus on theme of particle size-distributions, weathering indices and stage, statistics of soil organic C, soil reaction and statistics of pH values. All these parameters will be related to one another, so it is able to explain analyzing and managing soil acidity and organic contents of lebak swamp.

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Particle Size-Distributions

According to field tests and particle-size distributions the soils are classified as sandy clay to clay. The differences in clay content between A horizons (depths of 0-20 cm, 41.18%) and B-horizons (depths of 35-60 cm, 43.99 %) exceed 2.81%. In the soils, sand is achieving percentage of 29.54-47.088%, silt ranges 10.03-15.24% and clay contents are in the range of 41.18-55.22%. All sand and silt fractions decrease with the depths and clay increases with the depths (Table 1).

Table 1. Average soil variability of lebak soils (N = 225) and their assessment*/

Soil Parameter	Soil depths				
	0-20 cm	20-35 cm	35-60 cm	60-90 cm	90-120 cm
Soil texture class	Sandy clay	Sandy clay	Clay	Clay	Clay
Soil fractions					
1) Coarse sand (%)	30.95	28.84	29.16	30.25	15.18
2) Fine sand (%)	16.13	13.70	14.85	18.30	14.36
3) Silk (%)	11.74	12.06	12.00	10.03	15.24
4) Clay (%)	41.18	45.40	43.99	41.42	55.22
Silt/clay ratio	0.29	0.27	0.27	0.24	0.28
Fine sand/coarse sand	0.52	0.48	0.51	0.60	0.84
C-Organic (%)	1.78 (l)	1.14 (l)	0.06 (vl)	0.30 (vl)	0.27 (vl)
N-Total (%)	0.15 (l)	0.11 (l)	0.06 (vl)	0.04 (vl)	0.04 (vl)
C/N ratio	11.86 (m)	10.36 (l)	10.00 (l)	7.5 (l)	6.8 (l)
pH-KCl	4.47 (a)	4.34 (va)	4.20 (va)	4.09 (va)	4.05 (va)
P-Bray I (ppm)	18 (m)	10 (vl)	8 (vl)	5 (vl)	4 (vl)
Ca (cmol(+)/kg soil)	0.72 (vl)	0.55 (vl)	0.32 (vl)	0.10 (vl)	0.06 (vl)
Mg (cmol(+)/kg soil)	0.12 (vl)	0.10 (vl)	0.08 (vl)	0.07 (vl)	0.07 (vl)
K (cmol(+)/kg soil)	0.09 (vl)	0.08 (vl)	0.05 (vl)	0.04 (vl)	0.03 (vl)
Base saturation (%)	7.82 (vl)	4.91 (vl)	4.83 (vl)	2.50 (vl)	2.31 (vl)
CEC (cmol(+)/kg soil)	4.68 (vl)	4.18 (vl)	3.39 (vl)	3.21 (vl)	3.10 (vl)

Source : Compilation of Laboratory Analysis Data (2016)
Explanation: a (acid), va (very acid), vl (very low), l (low), m (middle),
*/ Assessment is based on the general nature of tropical soils (PPT, 1983).

Clay migration under forest is higher than in cultivated soils because no perturbation and liming was given. Thus, the forest subsoils are more clayey than those in cultivated soils are. Due to soil cultivation and elluvial horizons (Al-and E-horizons) are often ploughed and mixed with decapitated surface soils. This disturbs clay migration. Clay and gravel fractions have also similar contents. The E-and B-horizons have almost similar thickness. It was concluded that river alluvial was deposited in similar thickness before the soil development began.

Weathering Indices and Stage

Weathering stage of soils can be defined by various criteria. Among the used criteria are the silt/clay ratio and mineralogy of the clay fraction. It is based on the fact that more weathered soil, the lower the silt content is found. Regardless of limitations, because the problem of changes in lithology, the ratio of silt/clay can be used successfully to obtain weathering stages of soils studied, as follows: (1) Recent stage if the ratio of silt/clay is calculated more than 1, (2) Intermediate stage if the ratio of silt/clay is determined in the range of 1 to 0.2, and (3) advanced stage where the ratio of silt/clay is less than 0.2. Based on these criteria, almost all soils belong to intermediate development stage since the ratio of silt/clay ranged from 0.24 to 0.29.

Coarse fine to coarse sand ratios of the soils indicated that the skeletal content was relatively homogeneous in all horizons, while the soil of arable soils revealed a significant change of the fraction >2 mm, especially in the Ap horizon. In general, fine-sized mineral is more sensitive to chemical damage from large-size mineral (rough minerals) because the surface area of the small particles are larger, thus it provides the opportunity of a larger chemical destruction. For example quartz sand size is very resistant to chemical degradation, if the size of the clay quartz, the size of the clay is very sensitive to weathering. Homogeneity index (fine- to coarse sand ratio) in the entire profile varies from 0.48 to 0.84. It seems all the soil profiles developed from homogeneous parent material (river sediments). The homogeneity indices show slightly increased to the depths, it is mostly caused by geological stratification and soil development process.

Statistics of Soil Organic Carbon (C)

Organic C, total N and C/N ratios. The C/N ratios varies in most cases ranging of 6.80-11.86. Organic C and total N decrease both significantly with depth, except for M horizons. Here a slight maximum is found at a depth of about 20-35 cm pointing to the fact of a buried Ah-horizons. No extended decay of organic matter seems to have happened in the M horizons, though the C/N ratio is not a mineralization-limiting factor.

The organic C values (N = 225) in topsoils (0-20 cm) have a range of 0.59-5.37% with total means of 1.78% (without extreme values of peats). The mean values, the variances, SD and CV decrease regularly with decreasing the depths. This decrease is related to the additions of organic C by litter and vegetation in the topsoils and also other factors may also have impacts (Table 2).

Table 2. Depth dependent of Organic C (%) of soil samples (N = 225)

Depth (cm)	Range	Mean	Variance	SD	CV (%)
0-20	0.59-5.37	1.78	51.03	0.87	48.72
20-35	0.47-1.48	1.14	42.54	0.46	45.36
35-60	0.28-1.13	0.60	35.05	0.54	87.47
60-90	0.25-0.53	0.30	23.56	0.28	78.16
90-120	0.15-0.35	0.27	11.36	0.25	75.08

Explanation: SD: Standard deviation, CV: coefficient of variation

Organic C remains in topsoils from decomposed litter and crop residues, therefore a sharply decreasing depth function can be observed in most profiles of both soils. The soils contain generally low organic C and total N except in the first two layers. Low organic C and total N are caused by low clay contents of the soils which showed low capacity to hold both elements. Organic C and total N decrease both significantly with depth. Here a slight maximum is found at a depth of about 0-10 cm pointing to the fact of organic matter in Ap-horizon.

Application of soil organic material is suggested to manage soil acidity problems because soil organic materials can increase soil cation exchange capacity and at the same time, base saturation increases also. If base saturation increases, thus relative amounts of "acid cation" will decrease. Besides that, application of the organic materials is able to make strong bond, which is named as "chelates," with aluminum. Chelation complex reduces the solubility of aluminum and acidity of the soils. If soils are susceptible to manganese toxicity, it is not recommended to add organic matter.

Soil pH (Soil Reaction)

As we know that soil reaction can be defined as important indicator of soil acidity or alkalinity, it ranges from 0-14 and pH 7 is named as neutral. Values of pH under 7 is called acidic and above 7 is called alkaline. The soils showed that the pH value is very low ranging 4.05-4.47. Only slight changes in pH values were observed in all soil profiles. Values of pH are almost homogenous in all horizons. The highest pH values are determined at the depths of 0-20 cm.

Not significantly different pH values because of clay found in these soils is dominated by kaolinite clay minerals. Clay mineral of kaolinite has a low activity with the charge varying pH, which causes a high buffering against changes in pH due to liming and fertilization. Only in the Ap horizon (soil pH 4.47), where there are a lot of humus that can affect and improve the exchange complex, thus the pH value can be increased by one to two units higher than the bottom layer. The soil acidification effect is revealed, but pH-differences are much less pronounced, both between land uses and within the profiles. The reason must be searched for in the low activity clays with pH-variable charges, which induce a high buffering against pH changes by lime fertilization. Only in Ap horizons, where humus enhances the quality of the exchange complex may the pH rise to one unit by fertilization, but greater differences within the fields point to a still heterogeneous lime application within the short cultivation period of 10 years.

Statistics of pH Values

The pH-KCl values (N = 225) decreased slowly with depth (Table 3). Changes of variance, SD and CV were small except in topsoils. The highest variance and CV in topsoils are associated with liming and fertilizer use. The probability plot of pH-KCl values at different soil depths (N = 225) is given in Figure 1. This frequency analysis is plotted against a sum probability axis (S). The pH values tend to be higher and are skewed to the right in topsoils, but generally a very narrow pH range is given for all layers and positions due to the special buffering system of the low activity clay minerals predominating in these soils. The importance of organic matter in topsoils for the enhancement of the fertility and liming is revealed by the wide pH-KCl range in soils of 0-20 cm depth. Only with the assistance of organic matter may liming rise the pH of these acidified soils above a pH of 5.

Therefore, it will only be very effective liming to raise soil pH if followed or together with the addition of organic matters. Lime and organic matters together will move or change the buffering system of the low activity clay minerals to the right direction and the pH values will increase. This phenomenon is presented in Figure 1.

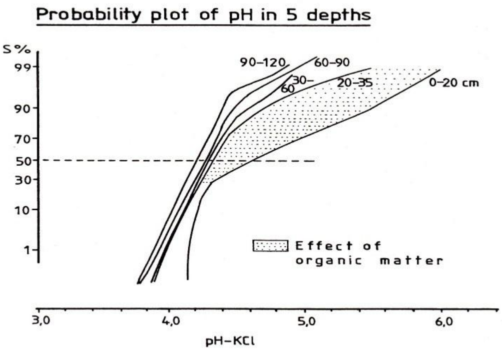

Figure 1. Probability plot of pH-KCl at 5 Depths of soil samples (N = 225)

Table 3. Depth dependent of pH-KCL statistics of soil samples (N = 225)

Depth (cm)	Range	Mean	Variance	SD	CV (%)
0-20	4.13-6.56	4.47	0.09	0.37	7.86
20-35	3.94-5.76	4.34	0.07	0.26	6.23
35-60	3.79-4.55	4.20	0.06	0.25	5.84

60-90	3.82-4.35	4.09	0.04	0.24	6.34
90-120	3.57-4.21	4.05	0.04	0.22	5.29

Explanation: SD: Standard deviation, CV: coefficient of variation

Liming materials can be applied to neutralize soil acidity because liming materials are able to react with hydrogen ions in the soil solution to form water. Some examples of liming materials are dolomite (calcium and magnesium carbonate), calcium carbonate, calcium hydroxide (hydrated lime), calcium oxide (quicklime), calcium and magnesium silicates any others.

Ca, Mg, Na, K, and P are available are highly variable (CV >35%). electrical conductivity, acidity exchange, effective cation exchange capacity and base saturation sufficient (medium) variable (CV between 15 and 35 %). Total nitrogen and pH are the most variable. Calcium, potassium, organic carbon, total nitrogen and available P were highly variable (CV >35%), sodium and acidity sufficient exchange (medium) variable, while the electrical conductivity is at least (low) variable (CV <15%). Calcium, total nitrogen, electrical conductivity and effective cation exchange capacity were moderately (medium) variable, while Na, K and pH were least (low) variable. These results agreed with those reported by previous workers.

CONCLUTIONS

All soils belong to relatively little developed because silt/clay ratios ranged from 0.24 to 0.29, while the homogeneity indices (fine sand/coarse sand ratios) throughout the soil profiles varied from 0.48 to 0.84. This means that all of the soil profiles are originated from a homogeneous river alluvial. It will only be very effective liming to raise soil pH if followed or together with the addition of organic matters. Lime and organic matters together will move or change the buffering system of the low activity clay minerals to neutralize soil acidity and the pH values will increase.

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