

Effect of Several Ameliorants on the Chemical Properties Improvement of Toba Highlands Peat Soil in North Sumatera- Indonesia

Edy Tumanggor, Sarifuddin, Kemala Sari Lubis, Benny Hidayat*

Agro technology Program Faculty Agriculture, University of Sumatera Utara, Indonesia 20155

*Corresponding author: bendayat@gmail.com

Abstract— Peatland is a potential land farming for increasing food abundance. This study aimed to determine the effect of ameliorants (sea water, volcanic ash, zeolite and CaCO_3) to improvement of Toba Highlands Peatlands chemical properties. This research used factorial complete randomized design with two factor treatments consist of ameliorant application and washing frequency, with four combination those are (A0) Sea water, (A1) volcanic dust plus sea water, (A2) zeolite plus sea water, (A3) CaCO_3 plus sea water with 2 replications. The results showed that application of ameliorant influenced significantly to increase soil pH, electric conductivity, carbon organic, N total, K-exchangeable and Ca-exchangeable. The frequency of washing increase of soil pH significantly.

Keywords— ameliorant, washing, sea water, volcanic ash, zeolite, peat soil

I. INTRODUCTION

Peatlands are marginal land for agriculture because of their low fertility, very acidic pH, and poor drainage conditions. Indonesia's peatland area is estimated to range between 17-21 million Ha. Accurate data on the extent of peatland is difficult to find because of the limited survey and mapping of peatland in Eastern Indonesia. With a large enough area which ranges from 9-11% of the whole land area in Indonesia, it is difficult to avoid the development of agriculture into this marginal land (Agus *et al.*, 2008).

In Sumatera Utara Province, in addition to the lowlands, peatlands are also found in the highlands. This highland peatland is located in the Toba highlands located in three sub-districts, LintongNihuta Sub-district, Doloksanggul Sub-district and Pollung Sub-district, these three Sub-districts are in HumbangHasundutan District. This highland peatland is quite unique because it is in the highlands which are not affected by beaches or rivers. The total area of peatland in HumbangHasundutan District is 6289.08 ha spread in Pollung Sub-district 1663.73 ha, 1812.15 ha in Lintong Ni Huta and 2813.2 ha in DolokSanggul Sub-district. Types of peatland cover are forests, non-vegetation areas, etc. (Sitangganget *et al.*, 2013).

The type of peat soil in HumbangHasundutan District includes topogen peat type with a depth of 60 - 100 cm which is used by the community as a cultivation area for horticulture and food crops. Research on highland peatlands in agriculture utilization is still very few. According to local farmers, farmers' production on peatlands is very low in line with slowing plant growth (Purba.2017).

Improving the productivity of peat soils, there are constraints such as soil acidity, cation exchange capacity (CEC) and a relatively high C / N ratio and a low number of bases exchange (Na +, K +, Ca2 +, Mg2 +) plus the presence of organic acids in soil solutions which are partially toxic to plants (Purba. 2017).

In the utilization of peatlands, it is necessary to apply intensification in the form of soil properties improvement so that the efficiency of land use can be increased. The efforts that can be made are by utilizing several types of soil ameliorant materials such as sea water, volcanic sand, lime and zeolite to increase the productivity of peat soil. Research on peatlands has shown that application of a combined treatment of volcanic sand, zeolite and seawater can increase tillers and paddy production in line with the increasing of soil acidity and soil electrical conductivity (Firlana *et al.*, 2013).

Based on the description above, it is necessary to conduct a research on the effects of several ameliorants, namely volcanic ash, zeolite and lime (CaCO_3) which are flowed by seawater on the chemical properties improvement of Toba highland peat soil.

II. MATERIALS AND METHODS

This research was carried out in screen house and analyzed at the Laboratory of Chemistry and Soil Fertility and Research and Technology Laboratory of the Faculty of Agriculture, University of North Sumatra Medan. The research was started from November 2017 to December 2017.

The material used in this research was peat soil from HumbangHasundutan District, LintongNihuta Sub-district

as an object of observation, Amelioran used was Zeolite, volcanic ash from the area of Mount Sinabung, Karo district, lime (CaCO_3) and sea water taken at Pantai Cermin, Serdang Bedagai District as ameliorant material, PVC was used as soil medium, ion-free water was used to wash peat soil after incubation and other supporting materials. The tools used in this research were pH meter to measure the acidity of soil solution, electro conductivity meter to measure the electrical conductivity of soil solution, atomic absorption spectrophotometer (ASS) to measure bases exchange, sieve to sift volcanic sand, scales used to weigh materials, laboratory equipment and other supporting tools used during the research. This research used Factorial Completely Randomized Design (CRD) with two factors. Factor 1 was mixing peat soil with various sources of ameliorant consisting of 4 levels of treatment, namely; (A0) leachate of sea water (1 liter), (A1) volcanic sand 100 grams + leachate of sea water (1 liter), (A2) zeolite 100 grams + leachate of sea water (1 liter), (A3) lime CaCO_3 100 grams + leachate sea water (1 liter). Factor 2 was the leaching frequency consisting of 3 levels of treatment, namely; P0 without leaching, P1 was washed with ion-free water 2 times (1 liter) and P2 was washed with ion-free water 4 times (1 liter). 12 combinations of treatments were obtained with 2 replications so that there were 24 experimental units.

The research media was made from a 4-inch Polyvinyl chloride (PVC) pipe, with a base made of gauze attached under a PVC pipe. Next, put a pebble measuring ± 2 cm below the gauze. Finally, peat soil which has been mixed with ameliorant material was added into PVC media. Furthermore, the soil that has been mixed with ameliorant material was put into the prepared PVC, then leached with 1 liter of sea water per treatment unit. Leached sea water was collected and leached several times until the remaining leach water that comes out below the PVC run out. After leaching with sea water, all treatment units were incubated for 4 weeks. After 4 weeks leaching was done with 3 levels of treatment factors, i.e. without leaching, 2 times and 4 times using ion-free water. After the leaching frequency process was finished, soil samples were taken for analysis.

III. RESULTS AND DISCUSSION

The results of the analysis of variance showed that there were effects of ameliorant application on some chemical properties of Toba highland peat soil. These were shown from the significant differences in the observed parameters.

Soil Acidity (pH)

Addition of ameliorant in the form of sea water, volcanic ash + sea water, zeolite + sea water and lime CaCO_3 + sea water as a whole increased the pH compared to the initial soil pH of 3.48. Some ameliorant material application and leaching frequency also the interaction of both have a significant effect on soil pH. Ali and Sedaghat (2007) stated some benefits of mineral materials as ameliorant by previous researches, including steel slag and zeolite can serve to increase the soil pH as well as lime, providing elements of Ca, K and P, and can reduce the toxic effects of Al on sour soil. The frequency of leaching was able to wash organic acids during the decomposition process; Riniet *al* (2009) stated that peat water is very acid from the decomposition process that is happening on peatlands that produce organic acids.

Electrical Conductivity

Some ameliorant material application had a significant effect on soil electrical conductivity. This is due to the amelioration of volcanic ash, zeolite and CaCO_3 can increase the concentration of salt in the soil. Electrical Conductivity was increasing because salt concentration also increased. Electric current delivered by salt solution under standard conditions will increase if there is an increase in salt concentration in the soil solution (Rahmawati, *et al.*, 2009). The effect of leaching frequency did not give a significant effect on the change in electrical conductivity. This was likely to occur because the accumulation of salt in the soil formed an organic peat compounds with the organic acids.

Table.1: The Average Value of Soil Acidity due to the provision of several ameliorants and leaching frequency

Treatments	Leaching			Average
	P0 (0 Times)	P1 (2 Times)	P2 (4 Times)	
A0 (Sea Water)	3.69 e	3.62 f	3.89 d	3.74 d
A1 (Volcanic Ash + Sea Water)	3.89 d	3.94 bcd	3.91 cd	3.91 bc
A2 (Zeolite + Sea Water)	3.89 d	3.91 cd	3.97 bc	3.92 b
A3 (CaCO_3 + Sea Water)	3.94 bcd	3.995 b	4.01 a	3.98 a
Average	3.85 b	3.87 b	3.95 a	3.89

Note: numbers followed by different letters are statistically different ($P < 0.05$)

Table.2: The Average Value of Electrical Conductivity due to Ameliorant application and Leaching Frequency

Treatment	Leaching			Average mmhos/cm
	P0 (0times)	P1 (2 times)	P2 (4 times)	
A0 (Sea Water)	0.12	0.12	0.14	0.13 b
A1 (Volcanic Ash + Sea Water)	0.16	0.15	0.15	0.15 a
A2 (Zeolite + Sea Water)	0.14	0.15	0.16	0.15 a
A3 (CaCO ₃ + Sea Water)	0.17	0.15	0.14	0.15 a
Average	0.15	0.14	0.15	0.14

Note: numbers followed by different letters are statistically different (P<0.05)

Cation Exchange Capacity (CEC)

The application of ameliorant or its combination with the leaching frequency had no significant effect on the cation exchange capacity (CEC) of the soil. Previous land CECs were classified as very high based on BPPM (1982) criteria. Changes in the value of cation exchange capacity (CEC) of peat soils occur because the rate of decomposition of peat changes. The CEC value was also

influenced by the reaction of ameliorant material given toward the changes in soil pH and negative charge on soil colloids. Ridho (2014) stated that changes in CEC values are caused by an increase in pH and a factor of fertility and soil productivity, namely the higher the CEC, the higher the base cation which is bound by the soil so that the fertility level is higher.

Table.3: The Average Value of Cation Exchange Capacity (CEC) due to Ameliorant Application and Leaching Frequency.

Treatment	Leaching			Average me/100g
	P0 (0 times)	P1 (2 times)	P2 (4 times)	
A0 (Sea Water)	21.27	21.28	20.90	21.15
A1 (Volcanic Ash + Sea Water)	21.52	21.01	21.04	21.19
A2 (Zeolite + Sea Water)	21.27	20.64	21.05	20.99
A3 (CaCO ₃ + Sea Water)	22.58	25.94	24.26	24.26
Average	21.66	22.22	21.81	21.90

Note: numbers followed by different letters are statistically different (P<0.05)

C Organic, N total and C / N ratio

Table.4: The Average Value of C organic, N total and C / N ratio due to some ameliorants application and leaching frequency

Treatment	C organic	N total	C/N Ratio
A0 (Sea Water)	58.77 a	1.09 a	54.31
A1 (Volcanic Ash + Sea Water)	54.37 b	0.99 b	54.96
A2 (Zeolite + Sea Water)	52.74 c	0.95 c	55.54
A3 (CaCO ₃ + Sea Water)	50.30 d	0.94 c	53.75

Note: numbers followed by different letters are statistically different (P<0.05)

Ameliorant application had a significant effect on C organic in the soil. Treatment of A0 (sea water), A1 (volcanic ash + sea water), A2 (zeolite + sea water), and A3 (CaCO₃ + sea water) can reduce C organic in the soil which had an organic C content of 58.77% in A0 (sea water), but the C organic content was very high overall. The increase in the C-organic content indicates that the overhaul is not perfect because the decomposition process is so low that N immobilization occurs which increases the C-organic content (Nurhayati, 2008).

Nitrogen content in peat soil changes, namely a decrease in total N, but overall the total value of N is very high. The decreasing in nitrogen content occurs because ameliorant was able to increase the rate of peat decomposition so that changes in N organic to N inorganic (NH₄⁺ become NO₃⁻) and leached or evaporated. In the process of decomposition, nitrogen in the soil decreases because it is used by microorganisms (Rajagukguk, 2001).

The C / N ratio of highland peat soil in this research ranged from 53.75% to 55.54% and was very high. Changes in the C / N ratio are strongly influenced by the

duration of incubation and the rate of soil decomposition, also influenced by the characteristics of the peat itself, namely the change from anaerob to aerob allows a decrease in the C / N ratio (Buckman and Brady, 1982).

Bases Exchange (K, Ca, Na, Mg)

The application of ameliorant had a significant effect on K-exchange and Ca-exchange but did not give a significant effect on Na-exchange and Mg-exchange. The leaching treatment has no significant effect on the value of K, Ca, Na and Mg exchanges of peat soil.

The application of ameliorant treatment had a significant effect in increasing the value of K-exchange and Ca-exchange. The increasing was occurred because the

ameliorant material administered contained bases exchange. Overall, the bases exchange content was still very low. Agus and Subiksa (2008) stated that the presence of cations in peat soil is easily replaced by other cations because the absorption complex in organic colloids is very weak and causes cations to be easily washed out. The effect of ameliorant treatment tends to increase base saturation. This occurred because of the addition of cations (Ca, Na, Mg and K) in the soil, compared to before the application of ameliorant in addition to a decrease in the value of soil CEC. Hanafiah (2005) stated that Ca available is very much related to base saturation and CEC, where if Ca is increased, the CEC and base saturation are also increased.

Table.5: The Average Value of Bases Exchange (K, Ca, Na, Mg) due to Some Ameliorant Application and Leaching Frequency.

Treatment	K exchange	Ca exchange	Na exchange	Mg exchange	Base Saturation
A0 (Sea Water)	1.05 bc	1.71 b	2.01	2.87	37.53
A1 (Volcanic Ash + Sea Water)	1.05 b	1.77 b	1.88	3.85	43.05
A2 (Zeolite + Sea Water)	1.32 a	1.76 b	1.67	3.39	42.49
A3 (CaCO ₃ + Sea Water)	0.99 c	2.52 a	1.55	7.98	64.14

Note: numbers followed by different letters are statistically different (P<0.05)

CONCLUSION

1. Ameliorant application of CaCO₃ plus sea water was able to increase pH, electricity conductivity and Ca-exchange of Toba highland peatland, while Zeolite plus sea water was able to increase K-exchange rate.
2. The application intensity of ion-free water as much as 4 times can increase the pH of Toba highland peat soil.
3. The administered Interaction of CaCO₃ plus sea water with 4 times leaching was able to increase the pH of Toba highland peat soil.

REFERENCES

- [1] Agus, F., & I.G. Subiksa. (2008). Lahan Gambut: potensi untuk pertanian dan aspek lingkungan. Balai Penelitian Tanah (Indonesia Soil Research Institute). Badan Litbang Pertanian. World Agroforestry Centre. Bogor.
- [2] Ali, M. T. & H. S. Sedaghat. (2007). Converter Slag as a Liming Agent in The Amelioration of Acidic Soils. International Journal of Agriculture & Biology. 09-05: pp.715-720.
- [3] Balai Penelitian Tanah. (2011). Pengelolaan Lahan Gambut Berkelanjutan, Bogor.
- [4] Buckman, H.O & N.C. Brady. (1982). *Ilmu Tanah*. Bhratara Karya Aksara. Jakarta. pp.788.
- [5] Firlana. (2013). Efek Air Laut, Zeolit dan Bahan Vulkan Terhadap Sifat Kimia Tanah Gambut. Jurnal (Online). <https://www.neliti.com>.
- [6] Hanafiah, A. L. (2005). *Dasar-Dasar Ilmu Tanah*. PT. Raja Grafindo Persada. Jakarta. pp.305.
- [7] Hartatik, W., I.G.M Subiksa., A. Dariah. (2011). Sifat Kimia dan Fisika Tanah Gambut. Dalam Pengelolaan Lahan Gambut Berkelanjutan. Balai Penelitian Tanah, Bogor.
- [8] Nurhayati. (2008). Tanggapan Tanaman Kedelai di lahan gambut terhadap pemberian beberapa jenis bahan terbaik antanah. *Tesis*. Universitas Sumatera Utara.
- [9] Purba, D. (2017). Klasifikasi Tanah Gambut di Dataran Tinggi Toba. Retrieved from Jurnal (Online). <http://www.jurnal.usu.ac.id>. : 13 Juni 2018.
- [10] Radjagukguk, B. (2001). Perspektif Permasalahan dan Konsep Pengelolaan Lahan Gambut Tropika Untuk Pertanian Berkelanjutan. Pidato Pengukuhan Jabatan Guru Besar pada Fakultas Pertanian Universitas Gadjah Mada, Yogyakarta.
- [11] Rahmawati, N, & Rosmayati. (2010). Penapisan Varietas Kedelai (*Glycine max* L. Merrill) toleran cekaman salinitas. Program Doktor Ilmu Pertanian. Fakultas Pertanian Universitas Sumatera Utara.
- [12] Ridho, M. (2014). Pemberian Amelioran Terhadap Status Hara, Pertumbuhan dan Produksi Padidi

Lahan Gambut Dataran Tinggi. Retrieved from Jurnal (online).<http://www.jurnal.usu.ac.id>.

- [13] Rini, N., Hazli, S., Hamzar., B.P. Teguh. (2009). Pemberian *Fly Ash* Pada Lahan Gambut Untuk Mereduksi Asam Humat dan Kaitannya Terhadap Kalsium (Ca) Dan Magnesium (Mg). *Jurnal Teroka*. 9(2): 143-154.
- [14] Sitanggang, G.T., Rahmawaty., A. Rauf. (2013). Pemetaan Potensi Karbon di Lahan Gambut Topogen Pada Berbagai Kecamatan di Kabupaten Humbang Hasundutan, Provinsi Sumatera Utara (Mapping Potential Carbon In Peat Topogenat Humbang Hasundutan District). Vol 2, No 2, pp. 93-98.