

# Changing of Sumatra backswamp peat properties by seawater and zeolite application

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**Abstract.** This research attempts to improve the properties of backswamp peatsoil originated from Asahan District, North Sumatra Indonesia by adding sea water and zeolite using factorial randomized block design with volume of sea water as first factor, consisting of without seawater, 500 ml, 1000 ml and 1500 ml and second factor are dosages of zeolite consisting of without zeolite, 100 g, 200 g each 10 kgs of wet peat soil. at green house in faculty of agriculture University of Sumatra Utara (USU) Medan, Indonesia. The result showed that the application of seawater decreased pH, C/N and Cation Exchange Capacity and increased of base saturation of peat soil. Adding of zeolite minerals can buffered the increasing of acidity and Electric Conductivity caused by sea water application. Interaction seawater + zeolite decreased of C/N and increased of percent of base saturation.

## 1. Introduction

Indonesia's peatlands cover about 21 million hectares [1], unfortunately, to use for agriculture purpose there are some problems of the physical constraints such as excess of water and low bulk density, chemical constraints include high acidity, carbon-nitrogen high in C/N ratio and cation exchange capacity, availability of macro and micro nutrients are low and organic acids which are poison for the plants. High cation exchange capacity and low of bases exchangeable resulted lower in the availability of the base cations . The base saturation should be increase to 20-30% , to fulfill the plants requirement [2]. In fact the technology has not gained enough in a comprehensive and environmentally to manage of peatlands as a medium to plant growth.

Some researches had been done to improve peat soil fertility, among others, by mixing peat with mineral soils, liming and iron on soybean [3], giving Na and some micro elements on rice yield [4], ameliorant with high abundance of iron mineral soil [5], a high abundance of iron mineral soil material enriched high-grade iron [6], by liming [7], application of steel slag in combination with a compound fertilizer and manure [8] in rice plants and the applied of fly ash in Acasia plant [9] and soil with pyrite combined with washing of soil in rice [10].

In terms of numbers, with area of 5.8 million km<sup>2</sup> of marine waters, or 70% of the territory Indoneia, seawater available in abundance and easy to obtain [11]. Sea water also has a content of dissolved elements are quite high as 1,272 ppm Mg, S 884 ppm, 400 ppm Ca, 380 ppm K, although the content of Na and Cl are also quite high at 10,561 ppm and 18,980 ppm Na Cl [12]. Therefore sea water is potential as an alternative ameliorant to poor soil nutrients such as peat. Beside of that generally lowland peat are close to coastal areas even directly adjacent to the beach. However, the use



of seawater as an ameliorant have a challenge that is high salinity. Furthermore to decrease the level of salinity, Na and Cl dissolved to an extent that does not interfere with the growth and production of crops is an effort that must be done. Research of [4] showed that Na can replace some of the functions of Cu in the binding of organic acids that are poisoned (phenolic and carboxylic) of peat material. The production of food crops (rice, pulses and sweet potato) was higher in tidal peatland than inland peat [13]. IR 64 rice variety grown on peat tidal (marine peat) and given a high abundance of iron ameliorant also gave the highest results than those grown on brackish peat and fresh water peat in Central Kalimantan [14]. Losing of carbon (C) through the emission of CH<sub>4</sub> and CO<sub>2</sub> released is also the lowest in the wetland peat affected sea water (1, 97 tons C / ha / yr) than in peat transition (1.99 tons C / ha / yr and peat influenced freshwater only (2.09 tons C / ha / yr) [14].

Zeolite is a mineral of aluminosilicate hydrate with tetrahedron crystalline structure in which the silicate or silicate was substituted aluminum as the core and four oxygen atoms on all four sides to form a tetrahedron and bind to each other to form a series of tetrahedron tectosilicate [15]. The use of zeolite in agriculture, such as to improve soil acidity, increasing the content of ammonium in the rice soil as well as a soil conditioner to increase crop yields [15]. The use of zeolite as ameliorant on peat has not been known including sorption properties (ion exchange), dehydration-rehydration and its ability to increase the buffering capacity of the soil, especially in soil with acidity and salinity problems.

This trial aims to determine the effect of sea water which is combined with the mineral zeolite to improved physical-chemical properties and soil buffering capacity to reduce fluctuations in salinity and acidity of peat soil.

## 2. Materials and Methods

The experiment was conducted in the glasshouse, Laboratory of Research and Technology at Faculty of Agriculture USU Medan on april to september 2011.

The peatsoil samples had taken from Rawasari, Aek Kuasan, Asahan Distric North Sumatra Indonesia (02°42'33,9" N dan 99°46'34,3" E). Sea water taken from Pantai Cermin, Serdang Bedagai Distric and zeolite obtained from PT. Dunia Windu Medan.

The tools used are plastic as container pots for plant media, scales, measuring cups, pH meter, EC meter and atomic absorption Spectrophotometer.

This study used factorial randomized block design consist of two treatments with the addition of sea water each 4 dosage and zeolite mineral with 3 dosage with 3 replications.: Factor I: Volume of seawater which consists of: A0 = 0 ml of sea water + 2000 ml fresh water; A1 = 500 ml of seawater + 1500 ml of fresh water; A2 = 1000 ml seawater + 1000 ml of fresh water; A3 = 1500 ml of sea water + 500 ml of fresh water each pots Factor II: Dosage of zeolite consists of: Z0 = 0 g / pot; Z1 = 100 g ; Z2 = 200 g each pot. Analysis of mean separation using Duncan's Multiple Range Test 5% [16][17].

The numbers of 10 kgs of wet peatsoil (equivalent to 10 liters) with bulk density (BD) 0.13 g / cm<sup>3</sup> put in a black plastic pot as plant media, then gave zeolite mineral powder and sea water then stirred to be paste conditions. During the incubation period, paste condition is maintained by adding free ion water and then soil sample carried out to laboratory for soil analysis.

The parameters measured are: pH (pH meter) 1: 2.5 [22] and electric conductivity (EC) (EC meter) 1: 2.5 [18] were measured every week; ratio of C/N (C-Walkley and Black; N-Kjedahl) and cation exchange capacity (CEC) (extract Ammonium Chloride 1 N) [19], [20] was measured every month and percent of base saturation by calculated until 3 months observation respectively.

## 3. Results and Discussion

Soil properties of back swamp peat soil before application seawater and zeolite mineral are listed in this following table.

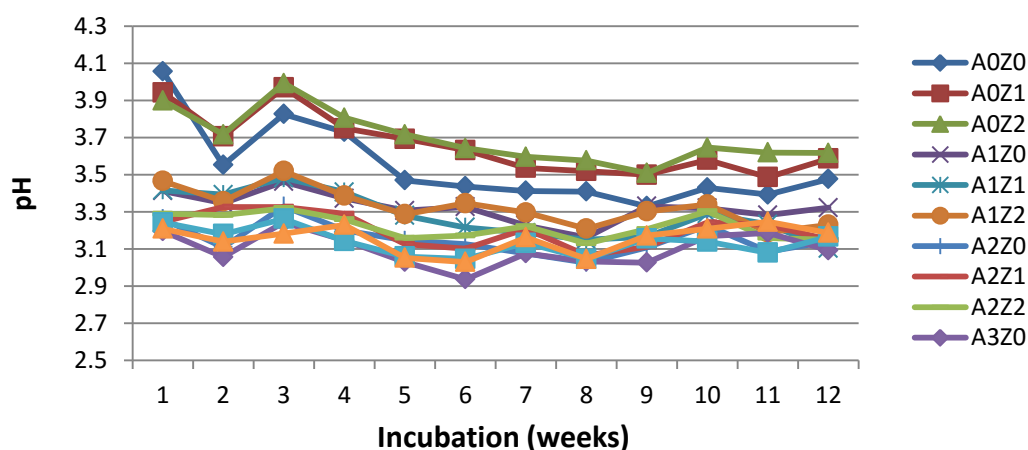
**Table 1.** The nature of the soil before application

No.	Parameters	Unit	Result
1	pH H <sub>2</sub> O	-	3.79
2	EC	(dS/m)	0.56
3	K-exc	(me/100 g)	0.008
4	Na-exc	(me/100 g)	0.190
5	Ca-exc	(me/100 g)	0.140
6	Mg-exc	(me/100 g)	0.250
7	CEC	(me/100 g)	111.040
8	Base Saturation	(%)	0.530
9	C-org.	(%)	20.580
10	N-tot.	(%)	0.550
11	C/N	-	37.420

### 3.1. Soil Acidity (pH)

The higher concentration of sea water progressively decrease soil pH, especially between A0 (without seawater) to A1 (sea water 500 ml / pot) and A1 to A2 (sea water 1000 ml / pot) and A2 to A3 (sea water 1500 ml / pot) although the decline was not as big as between treatment A0 to A1. The existence of zeolite without the addition of sea water raised the pH of the soil, but with sea water, the addition of zeolite particularly Z1 (100 g / pot) is able to buffering of decline in soil pH zeolite treatment, even 200 g / pot zeolite (Z2) is able to raise the soil pH compared Z0 (without zeolite) although the pH value is still lower than the initial pH of peat.

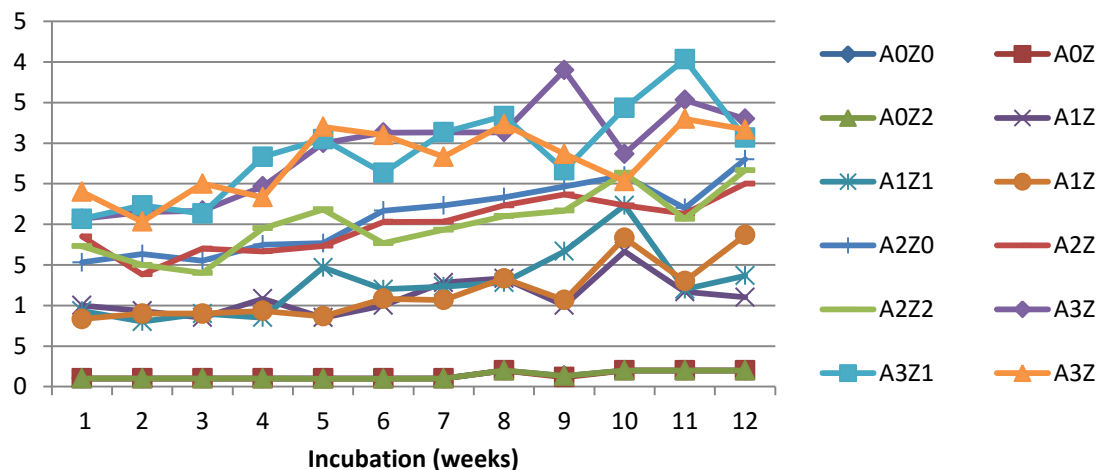
The period of incubation for each sea water treatment and zeolite lowered the pH of peat soil gradually (**Fig. 1**).

**Figure 1.** Changing of pH after sea water (A) and zeolite (Z) application

### 3.2. Electrical Conductivity (EC)

The higher concentration of sea water increased EC and the period of incubation period also effected it. Highest EC increasing at 11<sup>th</sup> week and then decreased at 12 week of incubation.. The addition of zeolite particularly in the treatment Z2 (200 g / pot) is able to reduce the value of EC especially at 3<sup>rd</sup> month of incubation (**Fig. 2**).

The experimental results showed that the application of sea water with higher concentrations due to soil acidity, increasing as well as the value of the electric conductivity. The addition of zeolite able to slightly increase the soil pH, and reduce of soil EC increasing due to sea water application. This shows the role of the zeolite as ion exchanger material capable of supporting the changes in pH and EC of peat soil.

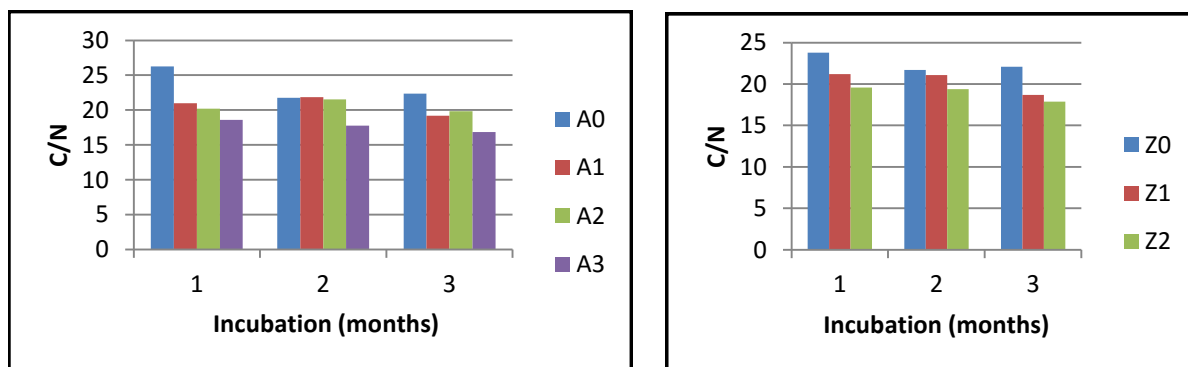


**Figure 2.** Changing of EC after sea water (A) and zeolite (Z) application

### 3.3. The ratio of C-org and N-total (C/N)

Application of sea water with concentration of A3 (150 ml / pot) significantly decreased the ratio of C/N since the 1<sup>st</sup> to 3<sup>rd</sup> months incubation to control. While giving the zeolite also significantly decreases the ratio of C / N peat at 1<sup>st</sup> and 3<sup>rd</sup> months of incubation (Fig. 3)

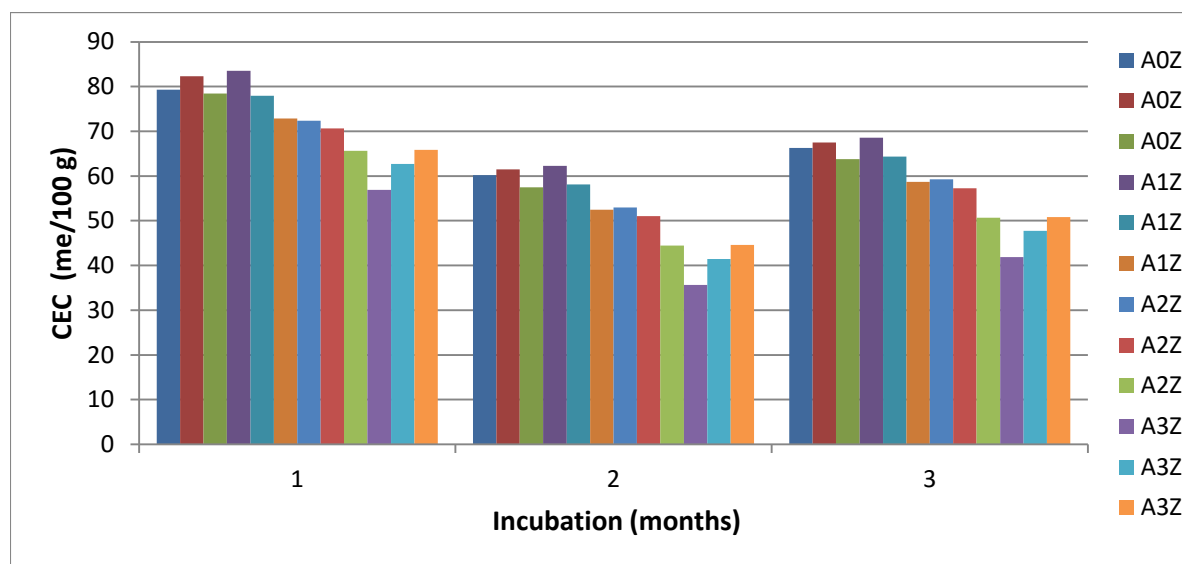
Seawater and zeolite, significantly increasing the C / N peat because of a decline in the amount of C in the peat. These results indicate that both seawater and zeolite does not play a role in increasing levels of N in the soil due to both the material does not contain significant amounts of N, but the sea water and zeolite role in lowering organic C, especially in the treatment of A3 (1500 ml sea water) and Z2 (200 g zeolite). Respiration rate as an indicator of the rate of decomposition of the peat soil indicate that the low water level and complex bond carbon chains are the most important factors slowing down the rate of decomposition of peat but polyvalent metal-containing material is not significant [21]. Zeolite was role to decline of C/N peat ratio by binding water molecules in the peat material.



**Figure 3 .** Changing of C / N ratio after seawater (A) and zeolite (Z) application

### 3.4. Cation Exchange Capacity (CEC)

Application of sea water significantly decreased of soil CEC for 1<sup>st</sup> to 3<sup>rd</sup> months incubation, and not significant for zeolite but interaction both sea water and zeolite significant effect lowered CEC during 3 months incubation (Fig. 4).

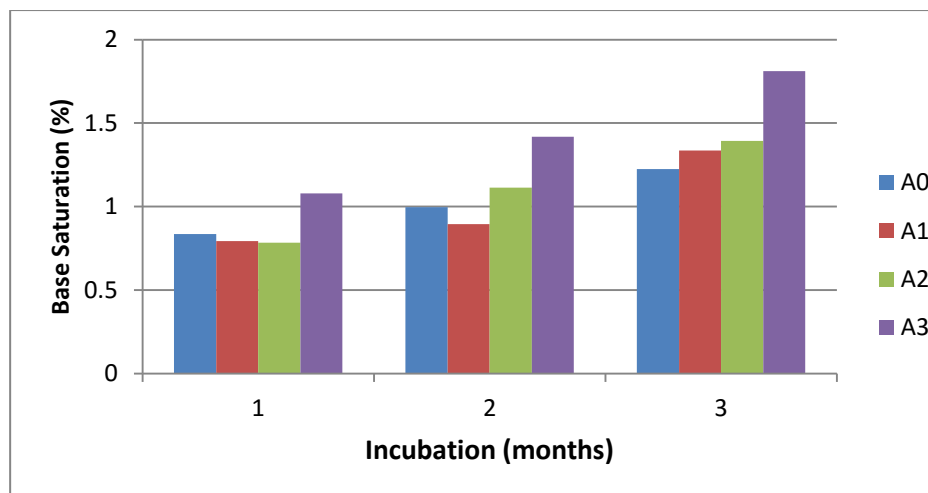


**Figure 4.** Changing of cation exchange capacity after sea water (A) and zeolite (Z) Application

Application of sea water significantly decrease soil CEC with lowest CEC at 2<sup>nd</sup> month incubation. The combination of the highest concentration of 1500 ml sea water/pot without zeolite (A3Z0) produce lowest CEC because its treatment also resulted in the lowest pH. Peat's colloid is entirely organic and variable charged. Changed highly acidity will decreasing the amount of negative charge on the surface of colloid so CEC will be lower also [22]. The correlation between EC versus CEC at 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> month had close correlation value ( $r$ ) - 0, 875; -0.862 and - 0.877 respectively. This proved that the cations are present in sea water is capable of forming a complex bond with organic colloids and consequently the amount of negative charge that is active to be reduced and lowered the soil CEC. The combination of sea water 500 ml (A1) and 100 ml (A2) with the zeolite (Z1 and Z2) showed decreasing of soil CEC but the treatment of sea water 1500 ml (A3) with zeolite (Z1 and Z2) showed an increasing. This seems contradictory when viewed as a function of zeolite as ion exchanger material that has a large high CEC. This is thought to occur because of the influence of zeolite in influencing soil CEC offset by changes in a negative charge on the colloidal organic peat soils due to changes in pH. Tan [15] states that 50 % of organic acid's CEC contributed by the carboxyl group and began to dissociate to release of  $H^+$  ions at pH 3 to 5.5. Declining of CEC occurs by reaction of bases in sea water with the COOH group to form salts of COONa R- and R-COOK and polyvalent cation forming coordination bonds with organic molecules such as humic [23].

### 3.5. Base Saturation (BS)

Application of sea water significantly increase percent of base saturation (BS) for 3<sup>rd</sup> month of incubation and sea water concentration concomitant with the base saturation (Fig. 5). Giving of zeolite does not affect to base saturation for 3 months incubation.



**Figure 5.** Changing of base saturation after sea water (A) application

Sea water, especially at the highest concentration, increasing of base saturation. The highest in base saturation occurs at 3<sup>rd</sup> month incubation. The increasing in base saturation is in line with the decrease in soil CEC as well due to the increase in the number of bases the exchange itself.

#### 4. Conclusion

Application seawater as ameliorant able to improve some properties of peat soils to be more suited to the needs of plant growths such as lowering the C / N ratio and the CEC were too high and to increase the percent of bases saturation as essential plant nutrients. On the other hand application of sea water is also gives the effect of a less favourable by soil pH decreasing and electrical conductivity increasing whom would interfere plant growth.

Application of zeolite as a material that functions as an ion exchanger capable to buffering a decrease in soil pH and increase electrical conductivity due to the giving of sea water,

A combination of seawater and zeolite provide better conditions on the properties of physico-chemical properties of peat soil in accordance with the requirements of crops growth unless the value of electrical conductivity is still high for most crops.

#### References

- [1] Wahyunto and Mulyani A 2011 *Pengelolaan Lahan Gambut Berkelanjutan (Sustainable Management of Peatlands)* Balai Penelitian Tanah Bogor
- [2] Sagiman S 2007 Pemanfaatan Lahan Gambut Dengan Perspektip Pertanian Berkelanjutan (*Utilization of Peat Land With Sustainable Agriculture Perspective*) Orasi Ilmiah Guru Besar Tetap Kesuburan Tanah FP Untan. [http://www.untan.ac.id/wp-content/uploads/pengukuhan\\_guru\\_besar\\_23\\_juli\\_2007\\_Saeri\\_Sagiman.pdf](http://www.untan.ac.id/wp-content/uploads/pengukuhan_guru_besar_23_juli_2007_Saeri_Sagiman.pdf). (Diakses 20 Okt 2007).
- [3] Halim A P K S 1989 *Perbaikan tanah gambut pedalaman melalui peningkatan kejenuhan basa untuk budidaya tanaman kedelai (improvement of inland peatland through increased saturation bases for soybean cultivation)* Prosiding Seminar Tanah Gambut Untuk Perluasan Pertanian FP UISU Medan
- [4] Prasetyo T B 1996 Perilaku Asam-Asam Organik Meracun Pada Tanah Gambut Yang Diberi Garam Na Dan Beberapa Unsur Mikro Dalam Kaitannya Dengan Hasil Padi ( Disertasi. PPS IPB Bogor.
- [5] Salampak 1999 Peningkatan produktivitas tanah gambut yang disawahkan dengan pemberian bahan ameliorant tanah mineral berkadar besi tinggi (productivity increasing of peat land



- assisted by provision of ameliorant material of high iron mineral land) *Disertasi* Program Pasca Sarjana. IPB Bogor.
- [6] Mario D M 2002 Peningkatan produktivitas dan stabilitas tanah gambut dengan pemberian tanah mineral yang diperkaya oleh bahan berkadar besi tinggi (productivity increasing and stability of peat land by providing mineral land enriched by high iron material) *Disertasi* Program Pasca Sarjana IPB Bogor
  - [7] Rumbang Nyahu 2003 Polyphenol in peat soil and growth and yield of rice (*Oriza sativa* L.) *Proc. Of Int. Symposium on Land Management and Biodiversity in South East Asia*. Bali, Indonesia 17 – 20 September 2002
  - [8] Suwarno 2003 Utilization of steel slag in wetland rice cultivation on peat soil *Proc. Of Int. Symposium on Land Management and Biodiversity in South East Asia* Bali, Indonesia 17 – 20 September 2002
  - [9] Iskandar, Djajakirana G and Marolop R 2003 The use of fly ash as ameliorant to improve the chemical properties of peat soil in pulau muda, Riau province *Proc. Of Int. Symposium on Land Management and Biodiversity in South East Asia* Bali, Indonesia 17 – 20 September 2002
  - [10] Suastika I W, S Sabiham and D A Suriadikarta 2006 Pengaruh pencampuran tanah mineral berpirit pada tanah gambut terhadap pertumbuhan dan hasil tanaman padi (Effect of mineral mixing on peatlands on growth and rice crops results) *Jurnal Ilmu-ilmu Pertanian Indonesia* Vol. **8** (2)
  - [11] Resosudarmo B P, Dj Hartono, T Ahmad, N I L Subiman, Olivia and A Noegroho 2002 Analisis penentuan sektor prioritas di kelautan dan perikanan Indonesia (Analysis of determining priority sectors in Indonesian marine and fisheries) *Jurnal Pesisir & Kelautan* Vol. **4**(3): 17-28
  - [12] Ilahude A G 1999 *Pengantar ke Oseanologi Fisika (Introduction to Oceanology Physics)* Pusat Penelitian dan Pengembangan Oseanologi LIPI
  - [13] Noor M 2001 *Pertanian Lahan Gambut-Potensi dan Kendala (Peatland Agriculture-Potential and Constraints)* (Yogyakarta: Kanisius)
  - [14] Sabiham S 2010 Properties of Indonesia peat in relation to the chemistry of carbon emission *Proc. Of Int. Workshop on Evaluation and Sustainable Management of Soil Carbon Sequestration in Asian Countries* Bogor Indonesia
  - [15] Mumpton F A 1985 Using Zeolit for Agriculture. [www. Princeton.edu/~ota/disc/2/1985/8512/851210/pdf](http://www.Princeton.edu/~ota/disc/2/1985/8512/851210/pdf).
  - [16] Little T M and Hills F J 1978 *Agricultural Experimentation. Design and Analysis* (New York: John Wiley and Sons)
  - [17] Gomez K A and Gomez A A 1984 *Statistical Procedures for Agricultural research. 2<sup>nd</sup>. Edition* (Yogyakarta: John Wiley & Sons)
  - [18] U S Salinity Laboratory Staff 1954 *Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Hand Book 60* (U.S. Department of Agriculture. Oxford and IBH Publishing Co., New Delhi)
  - [19] ISRIC 1987 *Procedures for Soil Analysis. Second Edition*. Wageningen Netherlands
  - [20] Agus F and Subiksa I G M 2008 Lahan Gambut: Potensi untuk Pertanian dan Aspek Lingkungan. Balai Penelitian Tanah dan ICRAF, Bogor.
  - [21] Edi H and Agus F 2011 Microbial activities as affected by peat dryness and ameliorant *Am. J of Environ. Sci.* Vol **7**(4)
  - [22] Uehara G and Gillman G 1981 *The Mineralogy, Chemistry and Physics of Tropical Soils with Variable charge Clays*. WestviewPress Colorado.
  - [23] Stevenson F J 1994 *Humus Chemistry. Genesis, Composition, Reaction* (New York: John Wiley & Sons)