

# Effect Of Seawater On Physicochemical Characteristics Of Sumatra Lowland Peat

Sarifuddin, Zulkifli Nasution, Abdul Rauf, Budi Mulyanto

**Abstract:** With an area of 21 million hectares, which is equivalent to almost 11% of Indonesia's land, Peatlands have significant potential as agricultural and plantations area despite having a lot of problems such as excess water and bulk density is low, acidity, the ratio of carbon-nitrogen and cation exchange capacity is high, availability of macro and micro nutrients are low and the presence of organic acids that are poisoned. On the other hand, as archipelago country, sea water is abundant and contain dissolved bases are high enough to be used as ameliorant for peat. This study was conducted by leached of peat soil that is placed in the PVC pipe with 10 cm in diameter and 50 cm in length by fresh water; sea water + fresh water (brackish) and sea water and incubating them for 4 and 8 weeks. The experiment use randomized block design non factorial and Duncan multiple range test in 1 and 5%. The results showed that leaching by flowed vertically of freshwater, brackish water and sea water on peat and incubated them for 4 and 8 weeks were able to increase the rate of decomposition is characterized by decreasing the ratio of C/N, decreasing CEC and rising exchange bases. But the acidity lowered more than 4 and EC also increase up to 4 dS/m.

**Keywords:** Seawater, Physicochemical characteristics, Sumatra lowland peat

## 1. INTRODUCTION

Indonesian peatlands is quite large with a broad range between 18-27 million hectares, the area are about 73% of the area of Asia peatland, which is equivalent to 50% of the world's tropical peat. Mainly distributed in Sumatra (35%), Kalimantan (32%), Sulawesi (3%) and Papua (30%) [11];[2];[10];[18]. Peat land in Sumatra Utara province consists of lowland peat (backswamp peat) covering an area of 325 295 ha distributed along the east coast of Sumatra island and plateau peat (highland peat) covering 6,289 ha in the highlands of Toba [8];[13]. Constraints on the physical properties of peat those are bulk density is low, subsidence and irreversible drying. This obstacle can be managed by making advance arrangements drainage and groundwater would happen peat decomposition that causes the peat to become more dense and the water table in peatlands are not too deep. Low bulk density on peat soil can also be improved by providing the mineral soil on peat soil. Chemical constraints on peatlands include acidity, carbon-nitrogen ratio and high cation exchange capacity, availability of macro and micro nutrients are low and organic acids that are poison for the plants. High cation exchange capacity and the low exchange bases resulted smaller in the availability of bases. That base saturation should be increased up to 20-30% to be available for plants [12]. Sea water has dissolved salts of various compounds in different types and concentrations derived from various types of rock and soil drifting through surface runoff and underground streams.

The main source of salt in the ocean is the result of weathering of rocks on land, from volcanic gases and hydrothermal circulation holes [6];[4]. Sea water is a complex mixture of 96.5 % water, 2.5 % salts and small amounts of other materials including dissolved inorganic and organic materials, particles and little atmosphere gas. Most six elements contained in seawater is chloride (Cl), sodium (Na<sup>+</sup>), sulfate (SO<sub>4</sub><sup>-</sup>), magnesium (Mg<sup>2+</sup>), calcium (Ca<sup>2+</sup>) and potassium (K<sup>+</sup>). Based on density, the ions reach 99 % of all salts in seawater. Inorganic carbon, bromide, boron, strontium and fluoride including other dissolved compounds in seawater [3]. Soils in the lowlands, especially the coastal areas periodically experiencing tidal process due to the tide either overflow of river water, a mixture of river and sea water (brackish water) or sea water, especially during high tide. Several observations indicate that the lands are affected by sea water as acid sulphate soils and peat, change soil properties different from the properties of soil that do not undergo the influence of the tide [7]. This experiment aims to get more information of how the influence of fresh water (river water), brackish water and sea water supplied through the vertical flow in a span of 4 and 8 weeks of incubation on changes in physical-chemical properties of peat that will be an important influence on peat soil fertility and plant growth.

## 2. MATERIALS AND METHODE

The research conducted at the Laboratory of Soil and Research and Technology Faculty of Agriculture USU Medan, conducted in May 2009. Peat soil originated from Lingga Hara Baru Village. Bilah Hulu Labuhan Batu, which is an area of oil palm plantations. The sea water is taken from Pantai Cermin Serdang Bedagai. Fresh water taken from upstream Denai river, Sumatera Utara province. PVC pipe with 10 cm in diameter and 50 cm in length as a container of peat that will be leached, plastic bottles for leaching residual water container and empty infusion bottles as containers of leach water. This study uses a completely randomized factorial design consisting of two treatments and 4 replicates. The first factor are type of water consisting of: A1 = fresh water (1000 ml). A2 = Brackish water (500 ml fresh water + 500 ml Seawater and A3 = 1000 ml.seawater. Second factor are time of incubation consisting of P1 = 4 weeks and P2 = 8 weeks of incubation. The mean

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difference test using Duncan multiple range test at 1 and 5%. (Little and Hill, 1978). Containers of peat soil in the form of the PVC pipe with length of 50 cm and a diameter of 10 cm with its bottom closed. Small hose as leaching of residual water flow to be accommodated by the container/plastic bottles. Peat soil that is inserted into the pipe up to 40 cm of the length of the pipe, and then leached with each treatment as much as 1 L solution through the flow of water trickling through a small hose that is hanging. After 4 and 8 weeks of treatment in accordance with the length of incubation, small hose valve to the water flow is opened so that residual leaching water can flow entirely into the storage container and the valve is closed then soil samples were taken for laboratory analysis, as presented in Figure 1. Measured parameters are : pH and electric conductivity (EC) (1: 2.5) [15], C/N (Walkley and Black and Kjeldahl); exchange bases, and cation exchange capacity (CEC) (extract 1 N ammonium acetate pH =7) [7], analyzed after 4 and 8 weeks incubation.

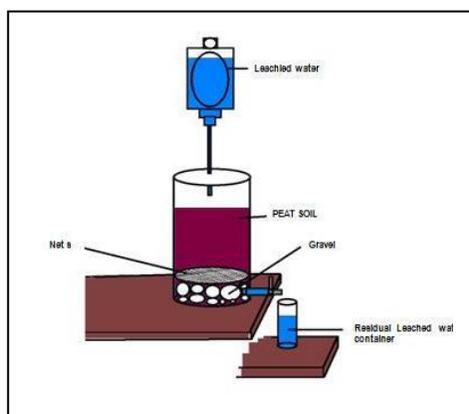


Fig. 1 Schema of Water Leaching on peat in PVC pipe

### 3. RESULT AND DISCUSSION

#### 3.1 Acidity ( pH ) and Electrical Conductivity ( EC)

Analysis of variance showed that the water kind and time of incubation and its interaction effect significantly on the acidity ( pH ) and electrical conductivity ( EC) of peat as indicated in Table 1. The pH value of peat diminished by leaching with seawater and brackish water ( fresh water + sea water ) while the value of EC opposite effect that is increasing due to leaching with sea water and brackish water (Table 2).

Table 1. Kind of waters and time of incubation on pH of peat

Treatment	Time of Incubation		means
	4 weeks	8 weeks	
	pH		
Fresh water	3.92 c	4.42 a	4,17 aA
Sea water + fresh water	3.74 d	3.93 c	3,64 bB
Sea water	3.55 e	4.03 b	3,79 cC
means	3,74 bB	4,13 aA	

This is due to ion exchange reaction between alkali cations derived from seawater with H ions derived from colloidal organic functional groups thereby increasing the concentration of H ions in the soil solution. Another factor that hypertonic seawater is able to extract the organic acids contained in peat material that increases the release of organic acids. This process not only affect the soil acidity but will affect other soil properties. Salinity levels measured as electrical conductivity (EC) showed increase in line with the increase in the concentration of sea water and the time of incubation. The concentration of dissolved ions and reaction time seems to be the most important factor to these parameters.

Table 2. Kind of waters and time of incubation on EC of peat

Treatment	Time of Incubation		means
	4 weeks	8 weeks	
	EC		
	---- dS/m ----		
Fresh water	0.07 e	0.20 e	0,14 cC
Sea water + fresh water	1.78 d	3.78 b	2,78 bB
Sea water	3.05 c	5.10 a	4,00 aA
means	1,63 bB	3,03 aA	

#### 3.2 Exchangeable Bases

Results of analysis showed that kind of water and time of incubation have significant effect on the increase in Na – exchange, but do not significant in interaction as shown in Table 3.

Table 3. Kind of water and time of incubation on Na – exchange

Treatment	Time of Incubation		Mean
	4 weeks	8 weeks	
	---- me/100g ----		
Fresh water	0,23	0,31	0.27 cC
Sea water + fresh water	0,33	0,47	0.40 bB
Sea water	0,39	0,55	0.47 aA
means	0.31 bB	0.44 aA	

Meanwhile the Na and K - exchange rise sharply due to the leached of a mixture of sea water and brackish water but Mg exchange does not show significant increase between the brackish water and sea water as shown in Table 4.

Table 4. Kind of water and time of incubation on K and Mg-exchange

Treatment	K- exchange	Mg exchange
	----- me/100 g -----	
Fresh water	0.20 cC	0.53 bB
Sea water + fresh water	0.64 bB	0.76 aA
Sea water	0.87 aA	0.77 aA

The contribution of dissolved salts in seawater turned out in line with the increase in bases on adsorption complex and each cation has reactivity and different bond strength of the

negative charge of colloids. Numbers of Na-exchange is lower than K and Mg exchange occurs because of the layer of water (hydrates) of Na and Ca thicker than K and Mg so that affinity sorption Na <K and Ca <Mg so that colloids will bind K and Mg in advance [13]. Na numbers are quite abundant in seawater, but at 4 and 8 weeks of incubation the number of Na lower than the cations K and Mg, possibility Na cation has weaker strength of bind so the speed of the reaction equilibrium will longer be achieved. In addition the nature of Na ions are also more easily leached [1].

**Table 5.** Kind of water and time of incubation on Ca-exchange

Time of Incubation	Ca-exchange --- me/100 g ---
4 weeks	0.06 bB
8 weeks	0.30 aA

The kind of water not significant on Ca - exchange but time of incubation high significantly increase Ca - exchange with the highest at 8 weeks of incubation as shown in Table 5. Increased Ca- exchange after leaching and incubation 8 weeks showed evidence that reaction rate of Ca ion adsorption is slower than Na, K and Mg ions. It is thought to have contributed to increase in pH at 8 weeks incubation. Calcium began to occupy the complex sorption and reach equilibrium and H ions are leached along the water leaching. Leaching with seawater also donated ion K in the soil solution resulting in increased K exchange on peat sorption. Existence of leaching with sea water resulting in increased concentrations of bases exchange in solution peat soil, consequently the composition of the bases of exchange on sorption complex has a definite pattern, After leaching, and incubation for 4 weeks at the complex composition of cations sorption is Mg> Na> K> Ca for fresh water; Mg> K> Na> Ca for brackish water and Mg> K> Na> Ca to seawater. At 8 weeks of incubation, the composition of the cations is Mg> Na> Ca> K for fresh water; Mg> K> Na> Ca for brackish water and K> Mg> Na> Ca to seawater. The composition of the complex cation adsorption before leaching is Mg> K> Na> Ca. These results indicate that leaching either with brackish water and sea water for 8 weeks incubation is able to change the composition of the cations contained in the sorption complex with K cations most adsorbed. Widjaya-Adhi [17] studied cations arrangement on alluvial soil sorption complex found Ca> Mg> Na or K for fresh water; Mg> Ca> Na or K for brackish water and Na> Mg> Ca or K to seawater. The order of forming ion adsorption strength flocculation is Fe<sup>3+</sup>> Al<sup>3+</sup>> H<sup>+</sup>> Ca<sup>2+</sup>> Sr<sup>2+</sup>> Mg<sup>2+</sup>> K<sup>+</sup>> Na<sup>+</sup>> Li<sup>+</sup> [14].

### 3.3 C/N, CEC and Base Saturation

Results of analysis shows the effect of incubation time high significantly reduce the value of C/N and CEC and significantly increased the soil base saturation as given in following Table 6.

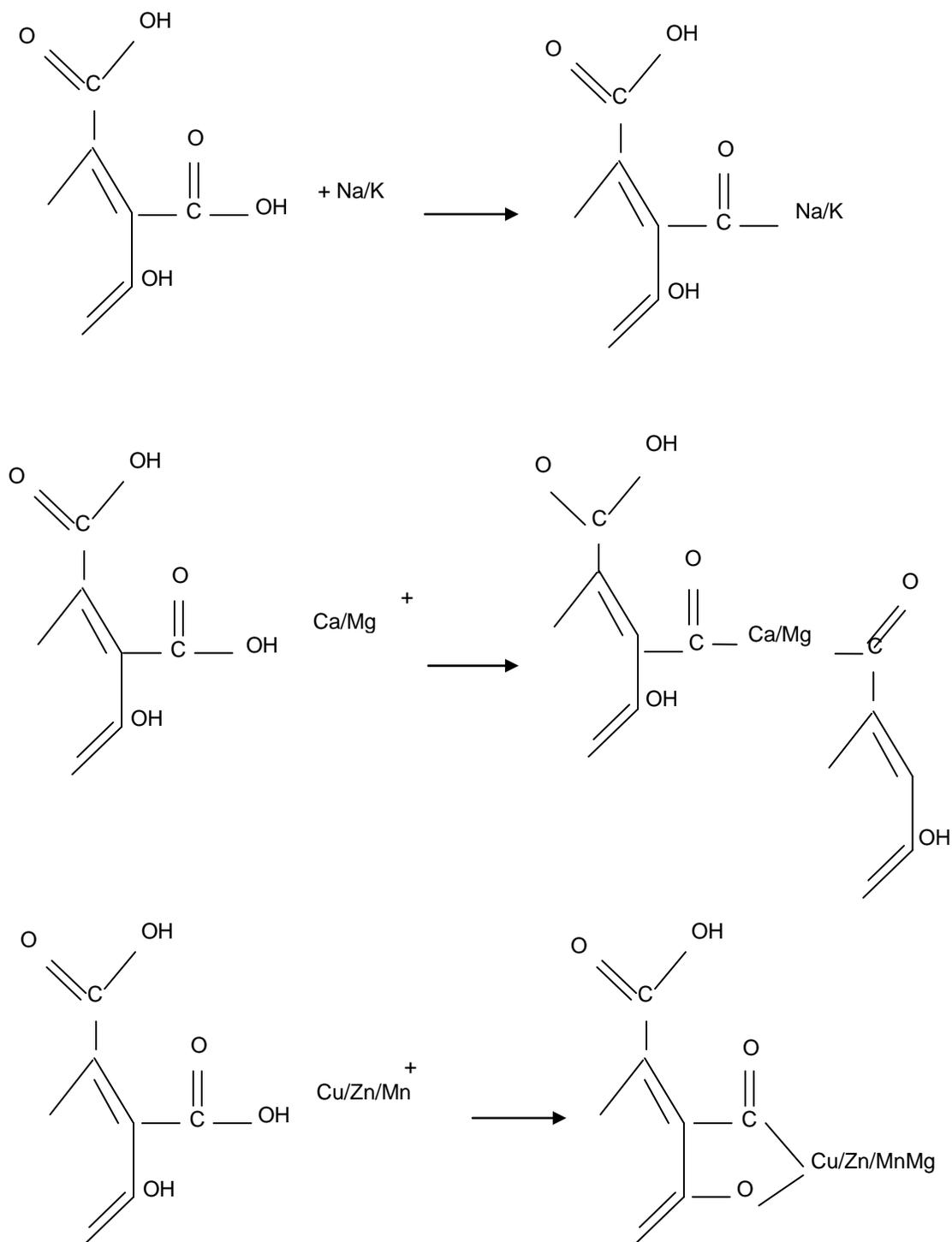
**Table 6.** Kind of water and time of incubation on C/N, CEC and Base Saturation

Time of Incubation	C/N	CEC me/100 g	Base Saturation %
4 weeks	14.48 aA	40.13 bB	2.99 b
8 weeks	9.68 bB	55.02 aA	4.41 a

The ratio C/N decreases with 8 weeks incubation time while the CEC declined sharply in the incubation of 4 weeks compared to the value of CEC before treatment (108.88 me/100 g) but light increased at 8 weeks. Base saturation increased at 4 weeks incubation and growing at 8 weeks of incubation. It can occur because of reaction between bases in seawater with the COOH group to form salts R-COONa and R-COOK and with polyvalent cations form coordination bonds with organic molecules such as humic [14]. The illustrations presented in Fig. 2. Stevenson [14] states that a negative charge primarily on open carboxyl group binds to cations Na, K, Ca and Mg by electrostatic bonding to produce salt. Consequently these cations will be easy to take back if there is a change of balance in the soil solution and subsequent CEC will increase (Fig. 2.a b). This is different from the polyvalent metal bonding for example Cu<sup>2+</sup>; Zn<sup>2+</sup>; Mn<sup>2+</sup> which forms coordination bonds formed metal organic complexes (chelate) occupied by a ligand donor group formed internal ring structure (Figure 2. c). But the Prasetyo's study [9] found that Na can replace some of the Cu functions in binding organic acids that are poisoned. These results indicate that the sea water increasing the rate of decomposition of peat is reflected in declining of C/N those are 14.48 at 4 weeks and 9.68 at 8 weeks incubation, while also lowering the value of the CEC nearly 50 % of the initial CEC. In organic colloid, the charge increases with increasing ionization of COOH and OH-phenol group [14]. This condition is desirable to reduce constraints on the use of peat land for cultivation which lowers of C/N and CEC that is too high. The decline in peat soil CEC can occur because of a decline in soil pH so that the colloidal organic with variable charge is also declining negative charge density so that the value of the CEC will be low also [14]. The formation of the double bond (bidentate) between divalent cations with functional groups can also reduce the number of active sorption on colloidal. Changing the water system as a result of the peat reclamation also cause changes in the amount and composition of functional groups contained in the peat. The study of Utami et al. [16] suggests that the drying of peat caused a decline in the number of carboxyl and phenol functional groups so that CEC also be lower.

## 4. Conclusion

Provision of seawater can increase the number of bases exchange on peat, but increase in acidity (pH) and electrical conductivity (EC) also. Provision of sea water can also increase the rate of decomposition of peat in the form of a decrease of C/N and cations exchange capacity (CEC) and increasing the base saturation. The results of this study showed a positive effect on the provision of sea water in order to improve the quality of the peat soil fertility although further research needs to be done to control the acidity and salinity properties to an extent that does not inhibit the growth of plants.



**Fig. 2.** Reaction of functional group of R-COOH with Na/K by electrostatic bond (a), with Ca/Mg (b) and Chelate reaction with polyvalent metals (c).

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