

The Influence of Peat Layer on Hydrogen and Aluminium Concentration Originating from the Substratum Sulphidic Materials

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ABSTRACT

Much of peatland in Indonesia has sulphidic materials as substratum. Soil acidity and metal elements in peatland may originate from the sulphidic materials which occur underneath of the peat layer. Peat soil buffering capacity and chelating ability of the peat materials regulate the soil acidity and metal solubility in the peatland. The study was aimed to examine the influence of peat thickness and land hydrological conditions on the concentrations of exchangeable aluminium (Al) and hydrogen (H) in the peatland. The study was carried out on peaty acid sulphate soil, deep peat, moderate peat and shallow peat. Exchangeable Al and H were observed in the wet season, transition from wet to dry season and dry season. The results showed that exchangeables of Al and H were mainly originated from sulphidic material which were occurred underneath of the peat layer. Peat layer had an important role on the solubility of Al and H in the peatland. Peat thickness had influence on exchangeable-Al and H, 50 cm of the peat thickness (shallow peat) was the critical for peat function to reduce the Al and H solubility in the peatland. Hydrological condition factor did not influence on the solubility of Al and H.

Keywords: Aluminium, hydrogen, peatland, sulphidic materials

INTRODUCTION

About 280.000 km² of the peatland is found in the tropical areas. Within tropical peat, Indonesia has 55 % of the peatland (Page *et al.* 2008). Most of the peatlands in Indonesia occur in low altitude coastal and sub-coastal situations (Rieley and Page 2005). Based on the geographic condition of peat formation, the sulphidic materials are often found under the peat layer.

The majority of peatlands in Borneo are in dome form. This convex shape causes varying water table fluctuation. The fluctuation of groundwater table in ombrogenous peat depends mainly on rainfall. Page *et al.* (2006) summarized that between wet dan dry season, water table fluctuations in ombrogenous peatland reach 0.2 – 0.6 m or even 1.0 m. Water table fluctuations in peatlands may influence metal ions and nutrient concentrations in peatland (Koretsky *et al.* 2007; Kaczorek *et al.* 2009; Sapek *et al.* 2009).

About 1.5 millions ha peatlands in Central Kalimantan was affected by *Mega Rice Project* (MRP) (Rieley *et al.* 2008). The changes in natural properties had triggered peatland fire and increased peat mineralization rate and disturbed ecosystem stability. Harvey and McCormick (2009) stated that peat oxidation has a large contribution in the changes of water quality and mineral which are sensitive to changes. Acidification of the river water around the peatland caused by pyrite oxidation that originating from the sulphidic material beneath the peat layer.

In 1997, about 61.5% of the peatland in Central Kalimantan was burned and caused loss of peat layer about 40 - 100 cm and decreasing in groundwater level to 70 cm (Bechteler and Siegert 2004). The depletion and disappearance of the peat layer may lead to the changes in environmental condition. The peat layer acts as a protective sponge that keeps the underlying mineral subsoils (Rieley *et al.* 2008). Anda *et al.* (2009) showed high of Al concentration in the water and low water pH on canal around the ex MRP project (Dadahup), indicated that the depletion and disappearance of the peat layer reduced environmental quality.

The objective of this study was to investigate the influence of peat thickness and hydrological condition on concentration of exchangeable-Al and H in the peatland.

MATERIALS AND METHODS

Site Description

The research was conducted on the peaty acid sulphate soil and three conditions of ombrogen peatlands, i.e. deep, moderate and shallow peat with sulphidic material as the substratum mineral. Each study site was spread in one area and each of them were separated by tertiary channels. The extent of each study site determined at least 1 to 2 ha. The study site was at Pangkoh IX, Pulang Pisau District, Central Kalimantan, with 8 m elevation and geografic positions at South (S): 2 52.240 and East (E): 114 05.409 for deep peat, S: 2 52.372 and E: 114 05.811 for moderate peat, S: 2 52.609 and E: 114 06.088 for shallow peat and S : 2 52.369 and E: 114 06.034 for peaty acid sulphate soil, respectively. The study site was 10 km west of Kahayan river and 20 km east of Sebangau river. This site was covered by shrubs and rubber plants. This research was part of a research series conducted for two years, and the data discussed in this paper derived from second year observation.

Soil Sampling Points

Soil sample was collected with using peat borer according to interlayer (the border layer of peat and mineral layer) and soil horizon status. The sampling depth were (in cm) 25, 50, 75, 95, 115 and 135 for shallow peat; 50, 100, 120, 135 and 155 for moderate peat; 50, 150, 200, 225, 245 and 265 for deep peat, and 25, 50 and 75 for peaty acid sulphate soil, respectively (Figure 1). In each study site, sampling points were replicated three times.

There was sapric peat material only on the shallow peat, whereas sapric and hemic peat material were found in moderate and deep peat. The humification stage was determined in the field using by von post method. Exchangeable Al and H (extracted with 1 N KCl pH 7) were observed in June of 2010 (transition from wet to dry season), September of 2010 (peak of dry season) and January of 2011 (peak of wet season).

RESULTS AND DISCUSSION

Exchangeable Aluminium

The presence of sulphidic materials under of peat layer influenced the exchangeable aluminium (Al) concentration in the peat layer (Figure 2, 3 and 4). Exchangeable Al concentration increased with increasing soil depth. The gradation pattern of

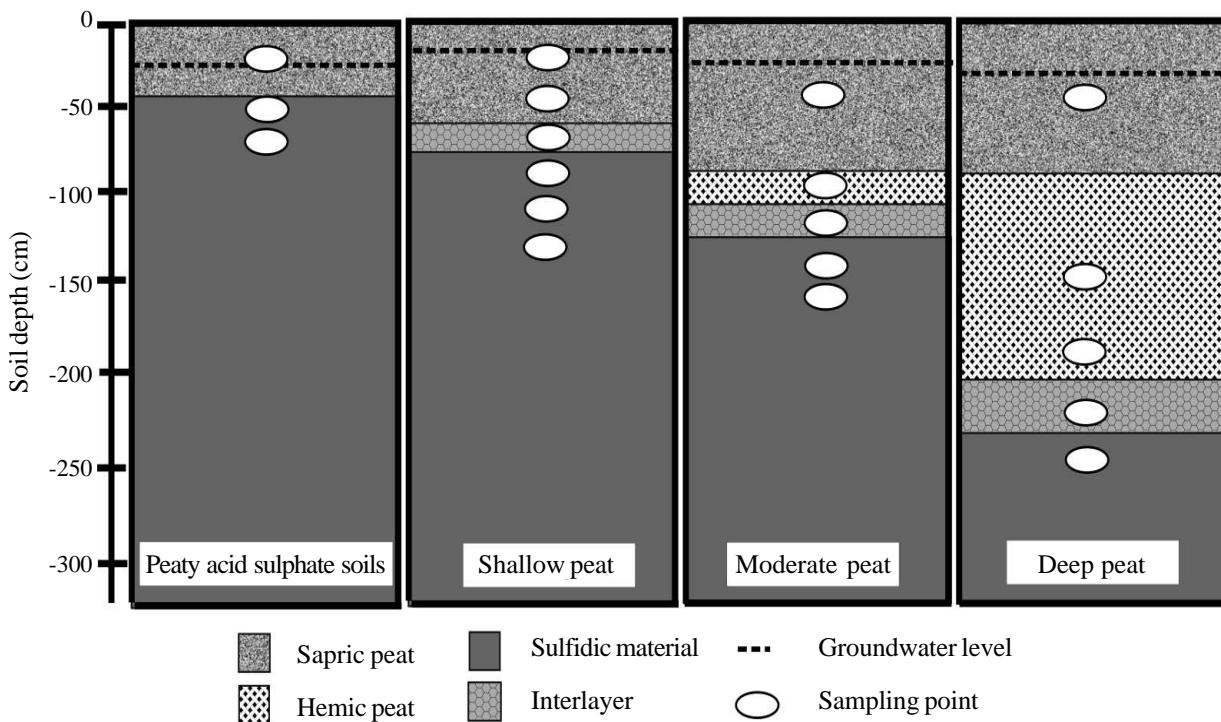


Figure 1. Soil profile and sampling points in peaty acid sulphate soil, shallow peat, moderate peat and deep peat.

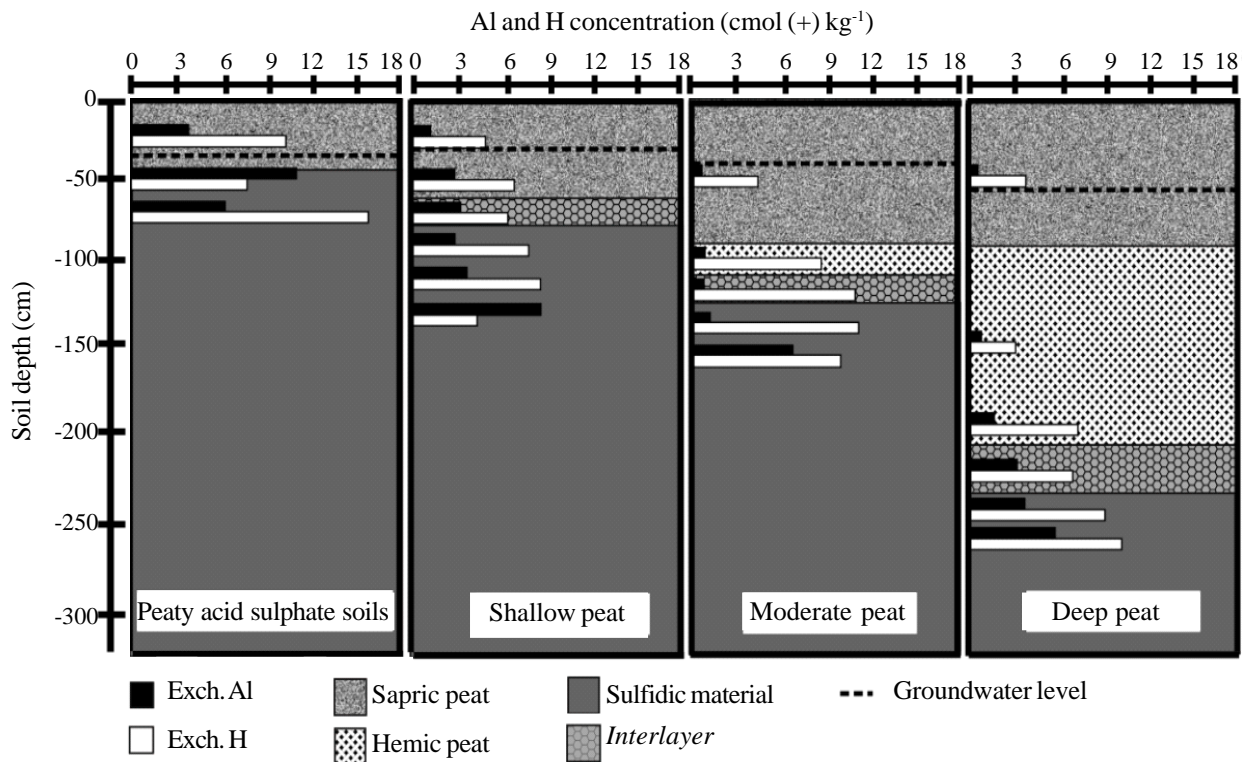


Figure 2. The concentrations of exchangeable Al and H in peaty acid sulphate soil, shallow, moderate and deep peat at the wet season.

exchangeable Al concentration indicated that sulphidic material has role as a source of Al in the peatland with sulphidic material substratum. Similar pattern of exchangeable Al concentration had been reported by Kurnain (2005) and Iyobe and Haraguchi (2008) who measured Al in the peat soil of Central Kalimantan.

The presence of sulphidic material underneath of peat layer caused higher exchangeable Al concentration in peatland with sulphidic material substratum compared to exchangeable Al concentration in the peatland with quartz mineral substratum. Exchangeable Al concentrations in this research (1.45 – 3.54 cmol(+) kg⁻¹) were higher than that in peatland with quartz mineral substratum (1.22 – 1.38 cmol(+) kg⁻¹) (Masganti 2003).

The interaction between the layers of peat and the underlying sulphidic materials influenced the exchangeable Al concentration. The role of sulphidic material against the exchangeable Al concentration in the peat layer can be observed based on the thickness of the peat layers. In this research, exchangeable Al concentration in the shallow peat was higher than moderate peat. This condition showed the influence of the peat thickness on the dynamics and movement of Al ions in the peat layers. Aluminium tends to be more easily dissolved in a peatland with thinner peat layer, although peat

has a large fixation ability on metal ion but low affinity of the peat for Al compared to Fe (Saragih 1996). This condition may cause the high content of exchangeable Al in the shallow peat.

Aluminium in peat soil may originated from sulphidic material layers. Concentration is very high in sulphidic material layer but low in peat layer due to chelation by humic substances contained in peat. The depletion in peat layer will potentially release of Al to surrounding environment. For this reason, the existency of peat layer must be conserved.

Figure 2 shows that disappearance of peat layer may increase exchangeable Al concentration. Exchangeable Al concentration in shallow peat (1.45 – 5.47 cmol(+) kg⁻¹) was lower than peaty acid sulphate soil (3.71 – 9.56 cmol(+) kg⁻¹). This result was similar to an experiment conducted by Koli *et al.* (2010), they reported that Al concentration in the peaty soil was higher than in peat soil. High content of organic compound in peat leads to higher of Al in the peat layer chelated by these compound. This condition is reflected by low exchangeable Al concentration in peat layer.

The depletion in peat layer leads to increase in exchangeable Al concentration. High of exchangeable Al concentration in shallow peat showed that 50 cm of the peat thickness (shallow peat) was critical for peat to reduce the Al solubility

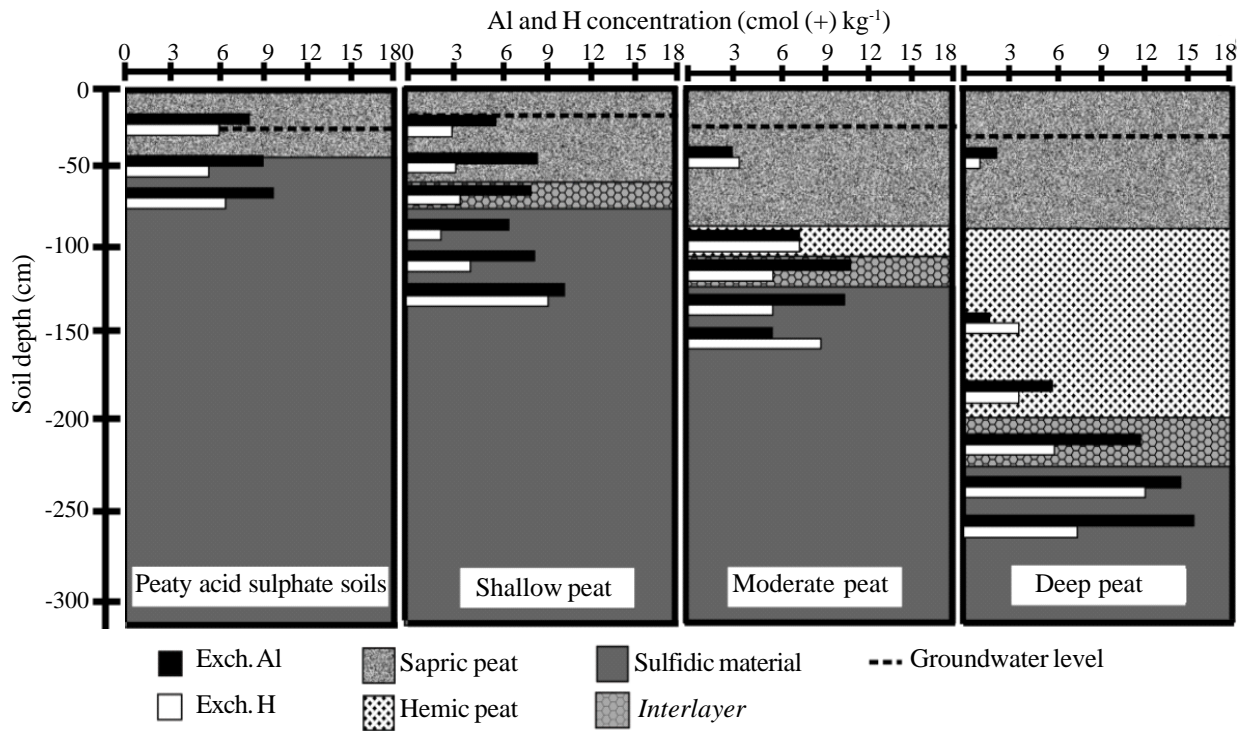


Figure 3. The concentrations of exchangeable Al and H in peaty acid sulphate soil, shallow, moderate and deep peat at the transition from wet to dry season.

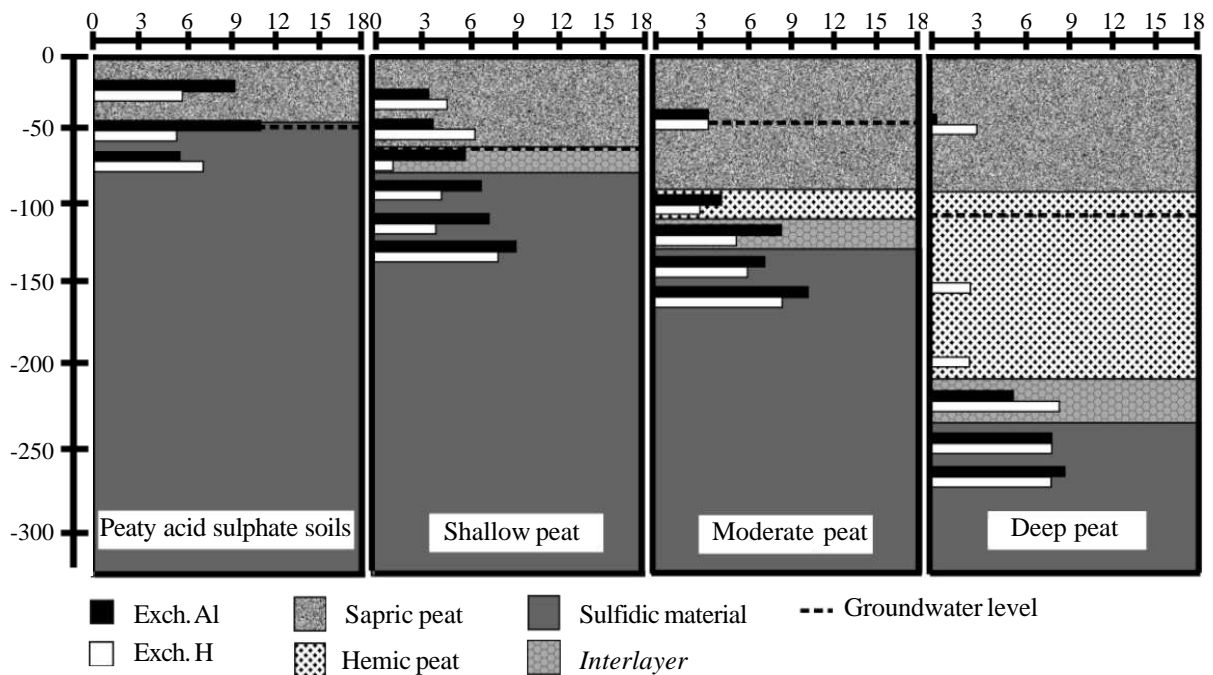


Figure 4. The concentrations of exchangeable Al and H in peaty acid sulphate soil, shallow, moderate and deep peat at the dry season.

in the peatland. The thinner peat will decrease the retention power for the Al ions. This condition leads to the increasing concentration of dissolved Al in the peat layer.

Figure 2, 3 and 4 showed that hydrological condition factor did not influence exchangeable Al concentration in the peatland with sulphidic material as substratum. Data in this research showed

different condition with experiment conducted by in the peatland. The thinner peat will decrease the retention power for the Al ions. This condition leads to the increasing concentration of dissolved Al in the peat layer.

Figure 2, 3 and 4 showed that hydrological condition factor did not influence exchangeable Al concentration in the peatland with sulphidic material as substratum. Data in this research showed different condition with experiment conducted by Kaczorek *et al.* (2009), that concluded that ground water level influenced Al concentration in bog iron ores from Poland. This difference may be caused by low concentration of iron in this research (data not shown), according to Kaczorek *et al.* (2009), ground water level might influence iron oxides reduction. The content of Al is mainly related to the content of iron oxides.

Exchangeable Hidrogen

The exchangeable H in the sulphidic material layer was higher than that in the peat layer (Figure 1, 2, and 3). Its concentration pattern was similar to exchangeable Al concentration. According to Haraguchi *et al.* (2005), soil acidity in the peat layer was more affected by organic acid that contained in the peat. Functional moieties of organic acids such as fenolic and carboxylic may dissociated and release H ion to the solution. According to Tan (2003) carboxylic groups from humic acid start to dissociate their proton at pH 3.0 (pKa), and ranges of soil pH in this research were 4.30 – 5.00 (complete data not shown). Data in this research showed different results with the experiment who conducted by Haraguchi *et al.* (2005). Figure 1, 2 and 3 indicate that H ion was mainly originated from sulphidic material beneath the peat layer. According to Hikes *et al.* (2010), H ion may move to peat layer with groudwater table movement. Some indication may be seen from: (1) Exchangeable H concentration in sulphidic material layer was higher than peat layer and exchangeable H concentration was lower in the deep peat than in compared to shallow peat or moderate peat; (2) Exchangeable H concentration in peaty acid sulphate soil was higher than in shallow peat. Hydrogen ion may be originated from pyrite oxidation in the sulphidic material. The occurence of pyrite oxidation was reflected in Eh value which indicated oxidative condition even though the soil was in waterlogged conditions as showed by Fahmi *et al.* (2010).

The exchangeable H concentration in peaty acid sulphate soil was higher than shallow peat (Figure 2, 3, and 4). This indicated that the depletion

in peat layer increased the exchangeable H concentration in the soil surface. This fact showed that 50 cm of peat thickness was the critical limit for the peat layer as organic material to reduce H concentration in the peatlands.

Nevertheless, the presence of peat layers had an influence also on exchangeable H concentration in the peat layer with sulphidic material as substartum. Part of the exchangeable H ion may be originated from the dissociation of organic acids in the peat materials as stated by Haraguchi *et al.* (2005).

CONCLUSIONS

Peat thickness had influence on exchangeable Al and H concentrations. Thickness of 50 cm of the peat thickness (shallow peat) was the critical for peat to reduce the Al and H solubility in the peatland. Whereas hydrological condition factor did not influence the exchangeable Al and H concentrations in the peatland with sulphidic material as substratum.

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