Characteristics and classification of coastal peat in conservation forest at Labuhanbatu, Sumatera Utara, Indonesia

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Abstract. This study is a survey research that aims to characterize and classify coastal peat soils in the conservation forest located in Sidomulyo Village, Bilah Hilir Subdistrict, Labuhanbatu District. Soil analysis was carried out at the Research and Technology Laboratory of the Faculty of Agriculture, Universitas Sumatera Utara. The observations were carried out by drilling the peat soil using an Eijkelkamp drill with 3 depth layers of peat soil, then the morphology and chemical properties of the soil were observed and classified according to the Key to Soil Taxonomy, 2014. The results showed that the ash content in the surface layer was higher than the deeper layers, but pH, C-organic, EC and CEC were not much different at all layers. Based on soil taxonomic, peat in the study area is Hydric Haplohemist for sub group category.

1. Introduction

Peat soil was formed from the accumulation of organic matter such as the remains of plant tissue over a long period of time [1]. Peat soil have irreversible drying characteristics so it cannot absorb water when flooded. Peat soils have subsidence character also due to shrinkage of peat volume by drainage and a decomposition process [2]. Commonly peat soils were found in lowlands formed in a sunken topography and inundated by water that does not easily disappear [3].

This topography is in a flat area and is usually in the lowlands. This condition causes the decomposition of organic matter to be slower than the hoarding process, resulting in an accumulation of organic material which is getting thicker over time. Peatlands are commonly found in tidal swamp areas and in low swamp areas [4].

Peatland is a natural resource that has several functions such as hydrological and environmental functions [5]. Peat characteristics are largely determined by the thickness of the peat, the substratum or mineral soils under the peat, its maturity, and the presence or absence of enrichment from the surrounding river overflow. Land characteristics should be used as a reference for the direction of peatland use to achieve high and sustainable productivity, in accordance with Presidential Decree No. 32/1990, in which peat with >3 m thickness is used for conservation areas.

The use of peatland began in the 1900s in line with population growth and limited agricultural land, which led to the choice being directed to peatlands for both agricultural and residential purposes. Peatlands require different management from other lands [6] so that irresponsible use of peatlands will
cause the loss of a valuable resource since it is nonrenewable. Therefore, it is necessary to implement governance in protecting peatland conservation forest areas by issuing a government policy, namely a moratorium on the opening of new peatlands. This was done as a repressive measure for the use of timber and natural forests [7]. Regulation concerning the conversion of natural forests and peatlands in Indonesia is Act number 6/2013 Postponement of granting new licenses and improving management of primary forests and peatlands.

2. Materials and methods
This research was conducted in conservation peat forest area owned by PT. Hari Sawit Jaya (Asian Agri) at Sidomulyo Village, Bilah Hilir Sub-district, Labuhan Batu Regency (N 02°24.069° E 100°00.884°). Soil analysis was carried out at Research and Technology Laboratory of Faculty of Agriculture, Universitas Sumatera Utara.

A representative peat profile was identified with filling the profile observation form and guidance by Key to Soil Taxonomy (2014), and taking peat samples for 3 depth layers. Each sample and analyzed for: Bulk density (BD) with ring sample, pH NaF and pH H₂O (1:2.5) with pH meter, C-Organic with Walkley & Black method, Electrical Conductivity (EC) (1:2.5) with EC meter, Ash content with Muffle furnace and Cation Exchange Capacity (CEC) 1 N NH₄OAc pH 7 extraction.

3. Results and discussion
The location of representative profiles for peat soil in conservation peat forest land can be seen in Figure 1.

![Figure 1. Location of peat soil samples in conservation forest area.](image-url)

3.1. Characteristics of peat
Observation of soil morphology for 3 depth layers of peat covers soil colour, consistency, topographical type, and layer boundaries as seen in Table 1.
Table 1. Physical characteristics of peat soils in conservation forest.

| Horizon | Depth (cm) | Level of Maturity | Soil Colour | Bulk density (g/cm$^3$) |
|---------|------------|-------------------|-------------|------------------------|
| Oa      | 0-60       | Sapric            | 5YR 2.5/2   | Dark reddish brown     | 0.17       |
| Oe1     | 60-90      | Hemic             | 5YR 2.5/2   | Dark reddish brown     | 0.16       |
| Oe2     | 90-130     | Hemic             | 10R 2.5/2   | Reddish black          | 0.16       |

Table 2. Physical characteristics of peat soils in conservation forest (continue).

| Horizon | Consistency                | Topography | Layer boundaries |
|---------|----------------------------|------------|------------------|
| Oa      | Slightly sticky, slightly plastic | Flat       | Diffuse          |
| Oe1     | Slightly sticky, slightly plastic | Flat       | Diffuse          |
| Oe2     | Slightly sticky, slightly plastic | Flat       | Diffuse          |

Table 3. Chemical characteristics of peat soil in conservation forest.

| Horizon | Depth (cm) | pH H$_2$O | pH NaF | DHL | Ash content | C-organic | CEC |
|---------|------------|-----------|--------|-----|-------------|-----------|-----|
| Oa      | 0-60       | 3.50      | 6.45   | 67.00 | 4.10        | 24.24     | 108 |
| Oe1     | 60-90      | 3.52      | 6.50   | 77.00 | 1.30        | 21.76     | 103 |
| Oe2     | 90-130     | 3.38      | 6.44   | 63.00 | 1.00        | 21.94     | 133 |

3.2. Classification of peat

The soil profile description of peat is as follows:

**Location**: Sidomulyo Village, Bilah Hilir sub district, Labuhanbatu Regency, Sumatra Utara, Indonesia

**Code**: Profile of conservation peat forest

**Coordinate**: N 02°24.069° E 100°00.884°

**Soil Taxonomy Classification**: Hydric Haplohemist

**Physiography**: Basin

**Slope Characteristics**: 0-3% (flat-slightly flat)

**Elevation**: 15 m asl

**Gamut thickness**: > 3 m

**Parent Material**: Wood Material

**Epipedon**: 0-60 cm Sapric, 60-130 Hemic

From the profile observations, the level of maturity both in top and subsurface layer of peat soil is different. In the upper surface layer, the maturity level is sapric with 0.17 g / cm$^3$ bulk density value and in subsurface layer, the maturity level is hemic with 0.16 g / cm$^3$ bulk density value. Thus, the deeper of peat soil layer is lower in bulk density value and the level of maturity. Likewise, the soil colour changed in hue from 5YR at surface and subsurface layer (Oa and Oe1) to 10R at lower layer (Oe2). It was indicated that the deeper in peat layer is brighter in colour. The lower of BD in peat need attention for cultivation because BD is related to the ability of peat soil to withstand plant loads, penetration of plant roots. low BD implies low load-bearing capacity of plants [8].
Table 4. Description of the peat soil profile.

| Profile cross-sectional image | Horizon | Depth     | Description                                                                 |
|-------------------------------|---------|-----------|------------------------------------------------------------------------------|
|                               | Oa      | 0-60 cm   | Dark reddish brown (5YR 2.5/2), maturity level: sapric, consistency: slightly sticky; slightly plastic, diffuse limit: flat. |
|                               | Oe1     | 60-90 cm  | Dark reddish brown (5YR 2.5/2), maturity level: hemic, consistency: slightly sticky; slightly plastic, diffuse limit: flat. |
|                               | Oe2     | 90-130 cm | Reddish black (10R 2.5/2), maturity level: hemic, consistency: slightly sticky; slightly plastic, diffuse limit: flat. |

For chemical characters in Table 2 showed pH-H₂O for each layer is not different and classified as acidic. The highest ash content found at surface layer and the lowest in subsurface because mineral enrichment from sea water tidal and river overflowing around the peatlands in surface layer, while C-organic, EC and CEC do not differ greatly in each layer of peat. Difference stage in maturity is influenced by the seawater and river runoff carrying soil minerals so that the surface layer has a faster decomposition rate than the subsurface and deeper layers [9].
The ash content in surface layer is higher than surface and deeper layers. Seawater and river runoff affects the ash content of peat also. The abundance of minerals and other elements makes peat fertile due to the river or sea sediments [2].

The cation exchange capacity has a high value for each layer. It is influenced by organic matter formation was composed by lignin fractions and humic compounds. The higher in lignin fraction and humic compounds will higher in CEC [8].

The C organic is concomitant with organic matter content and organic matter is parent materials that forms the peat. The organic fraction in peat consists of humic compounds around 10% -20% consisting of lignin, cellulose, hemicellulose, protein and other compounds [2].

Based on the 2014 Key to Soil Taxonomy, the peat in conservation forest has the following soil classifications: Order: Histosol, Sub Order: Hemist, Great Group: Haplohemist, Sub Group: Hydric Haplohemist [10].

4. Conclusions
Peat soil in conservation forests has a sapric maturity at the surface layer and a hemic maturity at the subsurface to the bottom layer. The ash content in the surface layer is higher than the bottom layers due to sea water tidal and river runoff around the peatlands. The classification of peat soil in conservation forest is Hydric Haplohemist by the 2014 Soil Taxonomy.

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