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Classification of tropical lowland peats revisited: The case of Sarawak

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ABSTRACT

The mapping and classification of peats, particularly those in the tropics, have lagged far behind that of peats in temperate areas and that of mineral soils. Classification systems based on Keys to Soil Taxonomy and the World Reference Base for Soil Resources (WRB) although universal are believed to be more suitable for temperate peats. This study compares these classification systems with the latest Malaysian classification system for classifying and characterising tropical peats. The three classification systems were then tested using five soil map units to compare and evaluate the usefulness and suitability of each system. The results showed that the latest Malaysian classification system has an advantage for classifying and characterising tropical peats. This latest classification describes well the presence of decomposed and undecomposed wood, which is a distinct feature of tropical peat which cannot be adequately described by using the Soil Taxonomy and the WRB. The Malaysian system also supports classification of tropical peats up to soil series and phase level. Both the Soil Taxonomy and the WRB classification can possibly be improved to also describe tropical peats by adopting some of the criteria of Malaysian classification. Such changes will add value to the two systems to be more global in their application for classification on tropical peats which comprises 8% of global peatland. This will be useful in making major land use decisions involving tropical peat conservation and development for agriculture. The findings will also provide an avenue to explore further on the current views on greenhouse gas emission on tropical peatlands.

1. Introduction

In their natural state tropical peat swamp forests are characterised by dense forest vegetation and thick (up to 20 m) peat deposits and a ground water table that is at or close to the peat surface throughout the year (Hirano et al., 2009). Tropical peat soil constitutes over 8% (33–49 Mha) of the world's peat soils (Maltby and Immirzi, 1993) and 60% and 70% of tropical peat soils are found in Indonesia and Malaysia. Land use changes by conversion of tropical peatland for agriculture are becoming more significant. The state of Sarawak, Malaysia, registered an increase in the total planted oil palm area for example from 14,091 ha in 1975 to 839,748 ha in 2009 (Department of Statistics Malaysia, 2011). The increasing use of peatland for agriculture has often resulted in increase in fires and greenhouse gas (GHG) emissions. Therefore there is a need for more scientific studies for appropriate methods for their sustainable management (Silvius and Giesen, 1996). Shier (1985) raised the issue of lack of studies on tropical peat resources as compared to studies of peat resources in temperate zones, which have been well surveyed, classified and quantified. Page et al. (2007) have reported that in the twenty year period since that alert, the level of investigation and documentation of this important resource has not made significant progress. Consequently, very few publications on the mapping and classification of tropical peats are available.

Although tropical peatland is extensive, few studies have attempted to classify tropical peats (Andriesse, 1988; Yonebayashi et al., 1992). Despite major differences in ecological regime, structure, texture and composition among tropical peat deposits and between tropical peat deposits and their temperate counterparts, peat classifications developed in humid temperate regions are commonly used for classification of tropical peat deposits. Wust et al. (2003) explained that existing classification systems (including Von Post system) used for temperate and boreal peat deposits in temperate regions fail to fully characterise tropical peat. This is due to the fact that temperate and boreal peats are often dominated by bryophytes and shrub whereas tropical peatland in contrast have various tree species with root penetration to several metres. Rate of biomass production and decomposition is high resulting from decaying roots and root exudates. Wust et al. (2003) further highlighted the need for a new classification system for tropical peat as most current classification systems had failed to describe tropical peat/s.

International schemes such as Soil Taxonomy — Eleventh Edition (Soil Survey Staff, 2010) and the World Reference Base for Soil Resources (WRB) fail to adequately describe and address the differences

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in tropical peats, especially in relation to their depth, presence of wood and the underlying mineral substratum. Field classification is critical in the evaluation of peatlands for environmental, geological, geotechnical, agricultural, horticultural or energy purposes (Kivinen, 1980). Therefore, a revisit to the subject of peat classification in the tropics is both timely and justified to minimise the differences and improve the existing knowledge in the area of peat classification and enhancing the practical usefulness of the knowledge. The USDA classification system and the WRB have failed because both do not provide criteria to define peats at series and phase mapping levels for tropical peat area.

In an attempt to rectify this failure, Paramananthan (1998, 2010a) has modified the USDA system to suit local conditions. The original Malaysian classification system by Paramananthan (1998) was mentioned in the study by Wust et al. (2003) for evaluation of tropical peat in Tasik Bera, Malaysia and this system had been further modified in 2010. The Malaysian Taxonomy was developed using the same principles of the USDA's Soil Taxonomy i.e. for use in the mapping and interpreting soil surveys. As such it uses morpho-genetic criteria which we see in the field. However, tropical countries in South East Asia, basically being agricultural based countries, the emphasis is on criteria which affect agriculture. This is not like those of temperate peats where the study objectives maybe for coal formation and or mining of the peat. Thus the Malaysia classification uses criteria present mostly within 150 cm as these will affect the crop. However if we are looking at mining the peat or coal formation as in Ireland or Canada, we may need look at much deeper layers. There should be a balance between conservation and development — particularly when good agricultural land is scarce at a global scale. Thus the Malaysian peat classification modifies the Soil Taxonomy (USDA) to suit local conditions and can be applied to most tropical lowland peats. The Malaysian classification system was tested in Malaysia and Indonesia and it appears to work well. A total of 700,000 ha of tropical lowland peat in Southeast Asia were evaluated and mapped using the system to date.

The purpose of this study is to analyse this latest classification system presented in the Malaysian Soil Taxonomy — Revised Second Edition (Paramananthan, 2010a) and to evaluate its applicability for classification of tropical peats in Sarawak, comparing it with the international systems of the USDA Soil Taxonomy and the WRB. The study will further suggest that some of the criteria be used to improve the USDA Soil Taxonomy and the WRB for tropical peatland mapping. The practical usefulness of this Malaysian classification in making major land use decisions for oil palm cultivation will also be explored.

2. Materials and methods

The initial approach was to carry out a literature review on the three classification systems i.e. WRB, USDA classification system and the Malaysian Soil Taxonomy. Differences of the classification systems and its practicality for field applications were explored. The objective was to compare the criteria used at the different categoric levels of the three systems. The lower the categoric level, the more criteria are used. It is also pertinent to note that in the USDA's Soil Taxonomy, the family criteria used are selected on their usefulness for interpreting the soil data for agricultural uses. On the other hand the WRB is more for providing maps on a global scale. To test the usefulness of the three classifications five peat profiles mapped to the phase level in Sarawak, Malaysia were selected as shown in Table 2.

The soils selected were then classified and the classifications compared using the Malaysian Soil Taxonomy, USDA's Soil Taxonomy and the WRB. The study presents a detailed comparison of the Malaysian Soil Taxonomy to the WRB and the USDA Soil Taxonomy to evaluate the adequacy of the three systems for description and classification of the soils.

3. Results and discussion

3.1. Differences in criteria used in the classification of organic soils

A comparison of the criteria used in the three classifications; WRB (FAO, 2006), Keys to Soil Taxonomy, Eleventh Edition (Soil Survey Staff, 2010) and the Malaysian Soil Taxonomy — Revised Second Edition (Paramananthan, 2010a) is given in Table 1. All three systems have the same definition of organic soil material (OSM). The Malaysian classification has an additional criterion of loss of ignition of 65% as this has historical significance. All the three classifications also define fibric, hemic and sapric materials using the rubbed fibric content, but the amounts (1/3, 2/3) used in the Malaysian system differ from those used in Soil Taxonomy (3/4, 1/6) and in the WRB system (2/3, 1/6). Wood is not defined in the WRB, but coarse fragments are defined in both Soil Taxonomy and Malaysian systems. Both the Malaysian system and Soil Taxonomy define a control section, but use different depths; the WRB does not define a control section.

Further differences appear when the classification systems are compared (Table 1). The WRB has only 3 levels; Reference Soil Groups and Prefix and Suffix qualifiers. Soil Taxonomy and the Malaysian Soil Taxonomy each has seven categorical levels — Order, Suborders, Great Groups, Subgroups, Family, Soil Series and Phase. The criteria used at different levels differ, e.g. Suborders and Great Groups. For example, the USDA Soil Taxonomy applies the nature of the OSM at the suborder level while the Malaysian system applies it at the subgroup level. Depth-Ombro and Topo are used to distinguish Great Groups in the Malaysian system but not in the other two systems. Although criteria such as particle size class and mineralogy are defined in Soil Taxonomy for use at the family level, these criteria are only used for Terric subgroups. No clear criteria have been proposed in the USDA Soil Taxonomy for use at the soil series and phase levels for other subgroups. While clear criteria such as the presence/absence and nature of wood are used in the Malaysian classification, they are not used in the other two systems.

3.2. Comparison of the classifications of selected peat soils

In order to interpret and manage agricultural crop and to make decision on land conservation and GHG emissions, it is necessary to map the soils at the phase level so that any criteria that affect yield and management can be identified and mapped. Thus the crucial level of mapping used in Malaysia is the soil series and phase. The soil series and phases used for soil mapping in Malaysia are based on the Malaysian Soil Taxonomy — Revised Second Edition (Paramananthan, 2010a) and the Keys to the Identification of Malaysian Soils Using Parent Materials (Paramananthan, 2010b). In order to compare the usefulness of the three classifications the five profiles selected were classified (Table 2). This table indicates that the WRB (FAO, 2006) can only differentiate these soils by using the Prefix qualifiers — sapric (4) and hemic (1). Even at the Suffix qualifiers level, the WRB cannot clearly differentiate the five soils mapped.

The USDA's Soil Taxonomy distinguishes the shallow (50 cm–100 cm) and moderately deep (100 cm–150 cm) organic soils of Malaysia from the deep and very deep soils. The two shallow soils both belong to the Terric subgroups and subsequently can be further separated at the soil series level using the particle size class and mineralogy classes of the Terric layers which occur between 75 and 100 cm depths. In the case of deeper soils (>150 cm) — non-Terric subgroups, the USDA Soil Taxonomy does not define criteria for use at lower categoric levels.

The Malaysian system clearly differentiates the deep Ombro (>150 cm) from the shallow to moderately deep — Topo (50 cm–150 cm) at the Great Group level. The presence/absence and nature of wood which greatly affect the performance of crops are criteria applied at the soil series level. Thus the classification which includes the presence/absence of wood and its stage of decomposition is helpful for investors to make a decision on land use and suitability for oil palm cultivation.