

Chemical Characterisation of Podzols in Sabah, East Malaysia

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ABSTRAK

Analisis kimia telah dilakukan terhadap tiga sampel podzol dari daerah Tambunan dan Keningau, Sabah. pH, kandungan karbon organik, muatan pertukaran kation, amoun kation boleh-tukar serta amoun logam yang terekstrak dengan HCl 1.0 M adalah berbeza antara horizon. Perbezaan tersebut adalah paling ketara antara horizon E dengan horizon Bh. Kecuali pH, nilai bagi setiap parameter di atas adalah terendah dan tertinggi masing-masing pada horizon E dan Bh.

ABSTRACT

Chemical analyses were carried out on three podzol samples from the Tambunan and Keningau districts in Sabah. The values of pH, organic carbon content, cation exchange capacity and HCl extractable metals vary distinctly between horizons. Such variation was most significant between horizons E and Bh and except for pH, the values for the above parameters were lowest and highest in horizons E and Bh respectively.

INTRODUCTION

Podzols can be found mainly in humid temperate and humid tropical areas, particularly in areas where the parent materials are predominantly of quartz or silicious minerals. In Malaysia, podzols are found in Peninsular Malaysia, Sarawak and Sabah. In Sabah, significant areas occur in the Tambunan, Keningau and Sipitang districts (Acres *et al.* 1975). The general characteristics of podzols have been well described (McKeague *et al.* 1985; Fitzpatrick 1983; Burnham 1984; Duchaufour 1982; Russell 1973; Muir 1961). The profile of a podzol is generally characterised by its clearly defined horizons. An intensively weathered bleached (eluvial) horizon, E, is located immediately below the upper horizon A. Below E is a dark coloured illuvial horizon, Bh, also known as the spodic horizon. A reddish brown coloured horizon, Bh/s, is sometimes found in between Bh and the parent material (horizon C). Podzols are basically differentiated from other soils by the presence of a spodic horizon. Often the spodic (Bh) horizon is overlain by an albic (E) horizon.

The chemical characteristics of podzols are widely reported in several works (McKeague *et al.* 1985; Torrent and Gomez-Martin 1985; Evans 1982; Forth 1978; Townsend 1977; Mohr *et al.* 1972; Andriesse 1969; Burnham 1968; Klinge 1965). However, published chemical data of Malaysian podzols is very limited and confined mainly to podzols in West Malaysia.

Therefore the following study was carried out to assess the chemical characteristics of podzols in Sabah, East Malaysia. The resulting data would be a valuable addition to the existing data on podzols in Malaysia and elsewhere.

MATERIALS AND METHODS

The podzol samples were obtained from Keningau (P1 and P2) and Tambunan (P3) districts in Sabah, Malaysia. The soils are of the Kapayan Association and Brantian Association respectively, both having terrace landform and alluvium parent material (Acres *et al.* 1975). Road construction works currently going on along the Kota Kinabalu - Tambunan - Keningau highway exposed some areas where the soil

was found to be podzols. The podzols at all sampling sites have distinct A, E, Bh, Bh/s and C horizons of varying thickness. Soil samples were taken from the respective horizons without much difficulty since the sites are located along the highway.

All soil samples were air dried and only the < 2mm fractions were used in the chemical analyses. All analyses were carried out in duplicates. Soil pH was measured in a 1:2 suspension in distilled water using a pH meter. Organic carbon was determined according to the Walkley - Black method as described by Nelson and Sommers (1982). Cation exchange capacity was determined by 1.0 M ammonium acetate, and the exchangeable basic cations in the leachate was measured by atomic absorption spectrophotometry. Exchangeable Al and H were extracted with 1.0M KCl (Thomas 1982). The metals Na, K, Mg, Ca, Fe, Mn, Cu and Zn were extracted for two hours using 2.0M HCl (1:20 w/v), and its concentration in the extracts were measured by atomic absorption spectrophotometry. The extractant was randomly chosen but was expected to remove the relatively more soluble fractions of each metal, including the exchangeable and a large proportion of the oxide and organic bound fractions. The amount obtained is presented as HCl - extractable metal.

RESULTS AND DISCUSSION

The chemical characteristics of the soil samples are shown in Table 1. Each soil profile consists

of five distinct horizons, namely A, E, Bh, Bh/s and C horizons. All samples show distinct differences in chemical characteristics between each horizons, particularly between the bleached (E) and the spodic (Bh) horizons.

The pH distribution of each profile follows a similar general trend. It increases to a maximum at horizon E, decreases to a minimum at horizon Bh and then gradually increases again at the lower horizons. Unlike pH, percent organic carbon decreases significantly from 0.51 - 0.97% in horizon A to 0.05 - 0.06% in horizon E. It, however, increases significantly to 1.18 - 1.79% in horizon Bh before decreasing gradually in the lower horizons. The lowest and highest values obtained for horizon E and Bh are in agreement with the observed bleached and dark colour of the respective horizons. This contrasting levels of organic carbon between the two horizons has been reported to be due to mobilization of organic matter from the upper A horizons during intensive weathering and leaching and later deposition in horizon Bh (McKeague *et al.* 1985; Fitzpatrick 1982; Bridge 1982; Russell 1973).

Changes of cation exchange capacity (CEC) down the soil profile at all sites also follow a similar trend as that of organic carbon. The high and low CEC of horizons Bh and E respectively is likely to be related to the significant difference in organic carbon content of the horizons since the organic component of a soil is a well known contributor to soil's CEC. The relationship between the CEC of soils and

TABLE 1
Some chemical characteristics of the respective horizons of the podzol samples P1, P2 and P3

Parameter	P1					P2					P3				
	A	E	Bh	Bhs	C	A	E	Bh	Bhs	C	A	E	Bh	Bhs	C
pH (H ₂ O)	4.8	5.8	3.9	4.3	4.0	4.6	5.1	4.2	4.3	4.3	4.2	4.7	4.0	4.1	4.4
% Organic-C	0.51	0.06	1.79	0.20	0.15	0.95	0.06	1.18	0.61	0.15	0.97	0.05	1.26	1.05	0.33
Exch. Cations (me/100g)															
Na	0.46	0.16	0.51	0.36	0.17	0.39	0.14	0.46	0.33	0.15	0.30	0.16	0.41	0.22	0.18
K	0.04	0.02	0.05	0.04	0.03	0.05	0.01	0.03	0.03	0.05	0.03	0.02	0.07	0.04	0.03
Ca	0.08	0.02	0.06	0.04	0.04	0.08	0.02	0.06	0.06	0.02	0.08	0.02	0.06	0.06	0.04
Mg	0.06	0.01	0.06	0.04	0.04	0.06	0.01	0.06	0.04	0.02	0.06	0.01	0.06	0.06	0.04
H	0.06	0.03	0.53	0.43	0.40	0.11	0.03	0.39	0.29	0.39	0.11	0.02	0.52	1.04	0.71
Al	0.03	0.03	0.39	0.27	0.24	0.03	0.01	0.27	0.27	0.33	0.03	0.03	0.42	0.51	0.48

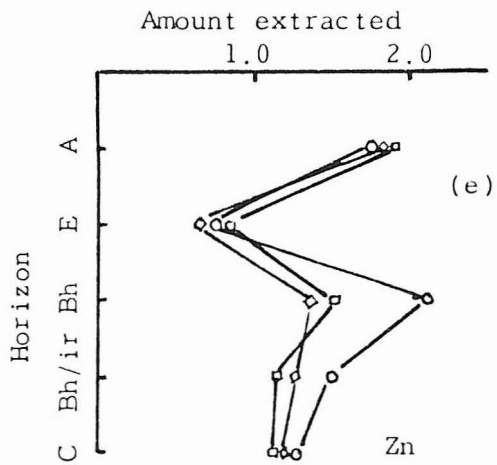
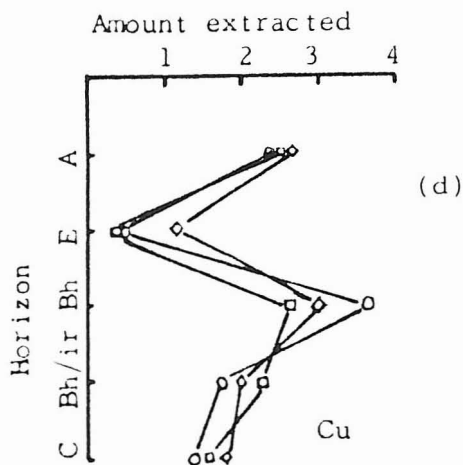
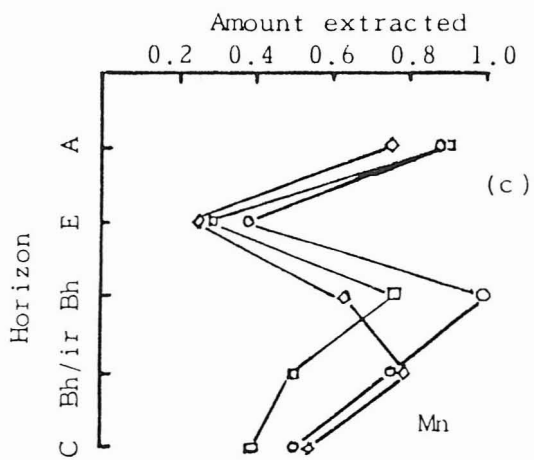
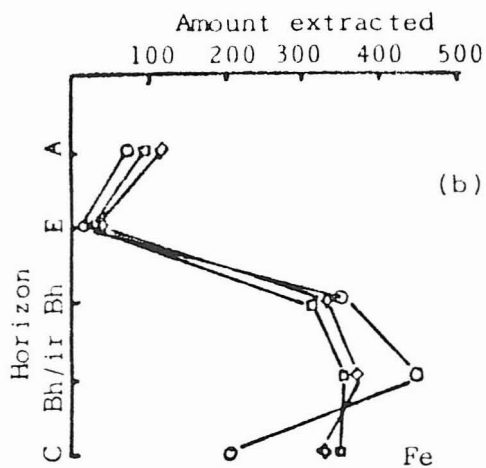
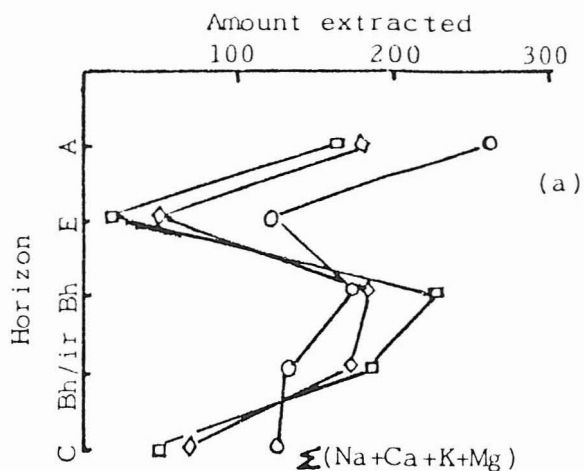


Fig. 1: HCl-extractable basic cations, Fe, Mn, Cu and Zn (in ug/g) for podzol samples P1 (o—o), P2 (◇—◇) and P3 (□—□)

its organic carbon content is well described elsewhere (Brady 1984; Stevenson 1982; Schnitzer and Khan 1972). Differences in mineralogical characteristics could also be a possible factor. The amount of each individual exchangeable basic cation is less than 0.5 me/100g and is generally of the order $\text{Na} \gg \text{Ca Mg K}$. Exchangeable acidic cations meanwhile is of the order $\text{H} > \text{AL}$. The distribution of these exchangeable cations within the profile follow a similar general pattern as that of the organic carbon, and CEC significant differences in levels of exchangeable H and AL are observed for horizons E and Bh. This could be a possible explanation for the higher acidity of horizon Bh compared to horizon E. Apart from direct contribution from the exchangeable H, the exchangeable AL is capable of undergoing hydrolysis in soil solution to produce hydrogen ions (Brady 1984; Russell 1973; Sanchez 1972). The net result could therefore be a high concentration of hydrogen ions in the soil solution and thus higher acidity.

The amount of HCl-extractable Na, K, Mg and Ca is relatively higher than the amount exchangeable but follow a similar distribution pattern within the soil profile. A plot of the sum of HCl-extractable Na, K, Ca and Mg against soil horizon is shown in *Figure 1*, clearly indicating a significant difference between horizon E and Bh with respect to HCl-extractable basic cations. A similar distribution pattern for HCl-extractable Fe, Mn, Zn and Cu was also observed for all podzol samples (*Figure 1*). These results generally indicate that cations or metals have been depleted from horizon E and accumulated in horizon Bh.

Various hypothesis have been proposed for the distinct differences in chemical characteristics, particularly in metal and organic carbon contents between horizon E and horizon Bh. One such hypothesis was related to organic matter (McKeague *et al.* 1985). Soluble humic substances, particularly fulvic acid, produced by microbial attack on plant litter are leached down the soil profile as rain percolate. Due to its acidic nature, these organic substances are thought to be capable of causing the breakdown of soil minerals (including clay minerals) by disrupting the mineral structure and releas-

ing the component elements. The released elements then form soluble complexes (chelates) with the humic substance and are removed from the surface horizons as the solutions percolate downwards. The humic substance could complex with additional metal cations as it percolate downwards and becomes increasingly saturated with metal cations. Its solubility decreases with increasing metal saturation and finally becomes insoluble and is precipitated as it reaches horizon Bh. As a result, deposition of organic matter as well as metal cations take place in horizon Bh after being leached down from the upper horizons.

CONCLUSION

This study shows that the podzol samples have profile chemical characteristics similar to most of the podzols described in the literature. Marked maxima of organic carbon, cation exchange capacity, exchangeable cations and extractable Na, K, Ca, Mg, Fe, Mn, Cu and Zn (in this case, extracted with 2.0M HCl) occur in the Bh horizon relative to the other horizons.

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