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# Chemical and Mineralogical Characteristics of an Organic Soil (Troposaprist) from Sg. Burong, Tg. Karang, Selangor

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## ABSTRAK

*Pada ketumpatan pukal 0.97 cm³ dan pH (tanah atas) lebih kurang 5, menunjukkan bahawa tanah gambut yang dikaji telah ditebusgunakan selepas mengalami program pembaikan. Tetapi, di bahagian bawah, di mana Al berada dengan kuantiti yang tinggi, pH masih rendah. Rendah larut-lesap, kerana aras mata air yang tinggi, menyebabkan pengumpulan bes-bes, terutama Ca dan Na. $pH_0$ yang rendah dan KPK yang tinggi sebagai gambaran tingginya bahan organik dan mineralogi mika-vermikulit-smektit.*

## ABSTRACT

*At bulk density of 0.97 $g/cm^3$ and pH (top soil) of around 5 reflects that the soil has improved after undergoing an ameliorating programme and more than a decade of cultivation. But at depth, pH is still low where Al is present in large quantities. A high water table leads to the accumulation of bases, especially Ca and Na in the lower horizons. Low $pH_0$ and high CEC is the reflection of high amounts of organic matter and mica-vemiculite-smectite mineralogy.*

## INTRODUCTION

Organic soils are widespread in Malaysia, with about 2.5 million hectares, covering about 7% of the land surface (Joseph *et al.*, 1974). Basically, they are composed of woody materials, namely tree stumps, roots and leaves, at various stages of decomposition. Organic soils are characterized by high CEC, a high C/N ratio, low nutrient contents and an acidic reaction (Purushothaman, 1979).

Organic soils can be utilized for crop production with proper management practice. Liming is often advocated to eliminate high acidity. Sometimes too much lime is needed, such as reported by Tay (1969), where 50 ton/ha lime can only raise the pH from 3.62 to 5.97. Under continuous cultivation, organic soils sometimes subside, the water table becomes shallower and consequently dry irreversibly. Physically and chemically this dried organic soils are no longer suitable for agriculture.

Organic soils, under which peats and mucks are included, are soils which are saturated with water for long periods ( $>$ 6 months) annually or are artificially drained and, excluding live roots, (a) have $\geqslant$ 18% organic C if the mineral fraction is $\geqslant$ 60% clay, (b) have $\geqslant$ 12% organic C if the mineral fraction has no clay, or (c) have a proportional content of organic carbon between 12% and 18% if the clay content of the mineral fraction is between 0% and 60% (USDA, 1975).

The purpose of this study is to characterize organic soils which have been partially ameliorated and to propose further cultural practices in order to improve them for crop production.

## MATERIALS AND METHODS

The soils were sampled from DOA peat station, Sg. Burong, Tg. Karang, Selangor. This experimental station was established for the purpose of utilizing peat soils for crop production. The station is now planted with mango, coffee, coconut, vegetables and tapioca, at various stages of development.

The soils have undergone an ameliorating programme (liming and drainage) and continuous cultivation for more than a decade. As it is, the texture is humic clay, with more than 30% organic matter to a depth of 60 cm. The colour of the soil is dark brown (7.5YR 3/2). The water table is about 15 cm below the surface, but during the rainy season, the area floods. The organic matter in the soil is completely decomposed (sapric material).

Bulk samples were collected by means of an auger, while the samples for bulk density were taken by a core sampler. All analyses were carried out on air-dried < 2 mm samples. CEC was determined using 1 N $NH_4OAc$ buffered at pH 7. Bases from the CEC determination were determined by conventional methods. Organic carbon was determined by Walkley-Black method and exchangeable Al was estimated from 1 N KCl extract. pH (1 : 5) was determined in water, while $pH_0$ was determined by the method of Gillman and Uehara (1980).

Potentiometric titration was carried out by titrating 5 g, equilibrated for 2 days in 50 ml 1 N KCl, by 0.1 N KOH, using an autotitrator. The amount of base needed to raise the pH up to 9 was plotted against pH. Clay for XRD analysis was prepared by successive sedimentation after destroying organic matter with $H_2O_2$.

## RESULTS AND DISCUSSION

### *General*

This soil has been under cultivation for quite some time, so its condition is somewhat improved, both chemically and physically. The bulk density is now 0.97 g/cm$^3$, which is close to the bulk densities of top horizon of some mineral soil. Bulk density of raw tropical forest fresh peat is very low, often less than 0.1 g/cm$^3$ (Andriesse, 1972).

The soil material is composed of two main constituents, i.e. organic material and clay. There is some silt, but sand is either very little or absent. This soil has a moderate, medium, crumb structure.

### *Mineralogy*

The mineralogy of Pl (0 – 15 cm) is described by XRD diffractogram given in *Fig. 1.* The Mg saturated sample gave reflections at 12.5 Å, 10 Å, 7.2 Å, 5.0 Å, 3.5 Å and 3.3 Å. Reflections at 10 Å, 5.0 Å and 3.3 Å show the presence of mica, while reflections at 7.2 Å and 3.6 Å show the presence of kaolinite. Mica mixed layers are also present in this soil, shown by the reflection at 12.5 Å.

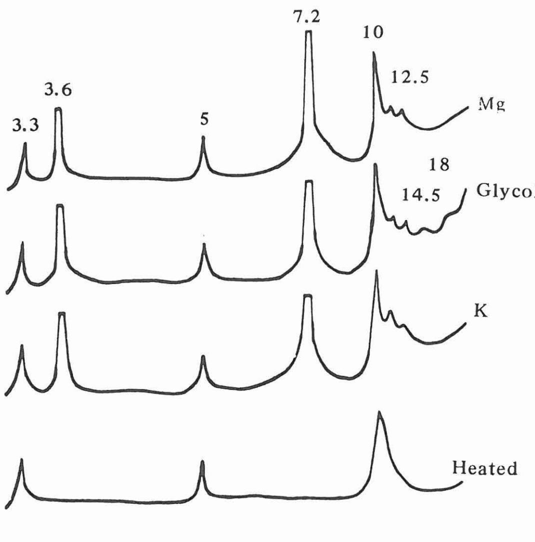


*Fig. 1. X-ray diffractograms of the clay fraction from P1 (0 – 15 cm).*

On glycolation, part of the 12.5 Å reflection has expanded to 14.5 Å and 18 Å. The part that expanded to 14.5 Å is mica-smectite while the part that expanded to 18 Å is smectite. Part of the reflection remained at 12.5 Å on glycolation. This is the second order reflection of mica-vermiculite.

The K saturated sample produced XRD peaks between 14.5 Å and 10 Å. These peaks collapsed on heating at 550°C. Absence of XRD peak above 10 Å on heating points to the absence of chlorite and/or chlorite mixed layers. Prominent peaks at 10 Å, 5.0 Å and 3.3 Å persisted on heating, indicating that large amounts of mica are present in the sample.

Other samples were also studied (Pl 45 – 60 cm; P2 0 – 15 and 45 – 60 cm). All these samples gave more or less similar XRD pattern as Pl 0 – 15 cm. Thus there seems to be no mineralogical difference between P1 and P2.

*Chemical Characteristics*

Organic carbon in the soil is more than 18% except in P2 at 30 – 45 cm depth (Table 1), thus the soil can be classified as Troposaprist (USDA, 1975). The bases in the soil are exceptionally high, especially those of Na and Ca (Table 1). Na is 1 meq/100 g soil or more at depth. This is far too high compared to fertile mineral soil.

According to Sys (1979), the ideal Ca : Mg : K ratio is 75 : 18 : 7. For this soil, K is low as compared to Mg. Similarly, Ca : Mg ratio is too high. Perhaps there is more than enough Ca in the soil. Too much Ca may depress K uptake in maize (Narayanasamy, 1984). Excess of Ca is due to liming over a period of years.

Total bases exceed 50 meq/100 g soil at some depth (P2 0 – 15 cm), giving a base saturation of more than 80%. Fertilizers and lime were applied to maintain crop production for many years. As the area is in the depression, the water table is high and leaching of nutrients is low. Consequently, bases accumulate in the soil. Further addition of nutrients is only necessary in order to correct the imbalance.

One common problem of organic soils in Malaysia is a micronutrient deficiency, especially that of copper and zinc (Kanapathy, 1972). This deficiency is normally corrected by foliar spray of $CuSO_4$ and $ZuSO_4$ respectively. In this soil, Cu content is 7.95 ppm. Other micronutrients detected are Mn and Zn and their respective amounts present are 21.66 ppm and 25.85 ppm. Fe is absent in this soil and will create acute Fe deficiency.

TABLE 1
Bases, CEC and organic carbon in the soils

| Profile | Depth (cm) | Bases | | | | | CEC (meq/100 g) | B.S. (%) | O.C. (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | Na | K | Ca | Mg | Total | | | |
| $P_1$ | 0 – 15 | 0.52 | 0.29 | 26.08 | 2.80 | 29.69 | 54.43 | 55 | 22.40 |
| | 15 – 30 | 1.02 | 0.39 | 39.08 | 2.91 | 43.40 | 62.33 | 70 | 35.00 |
| | 30 – 35 | 1.19 | 0.41 | 30.76 | 2.57 | 34.93 | 57.35 | 61 | 25.40 |
| | 45 – 60 | 1.05 | 0.38 | 21.61 | 1.62 | 24.66 | 61.25 | 40 | 20.00 |
| $P_2$ | 0 – 15 | 0.95 | 0.66 | 48.33 | 4.22 | 54.16 | 64.85 | 84 | 30.40 |
| | 15 – 30 | 1.19 | 0.53 | 34.40 | 2.90 | 39.02 | 61.67 | 63 | 25.26 |
| | 30 – 45 | 0.95 | 0.60 | 22.55 | 1.99 | 26.09 | 45.15 | 58 | 16.56 |
| | 45 – 60 | 1.12 | 0.58 | 20.26 | 2.15 | 24.11 | 50.55 | 48 | 22.36 |

TABLE 2
pH, $pH_o$, Al and specific conductivity in the soils

| Profile | Depth(cm) | pH | $pH_o$ | Al (meq/100 g) | Elec. cond (m mho/cm) |
|---|---|---|---|---|---|
| $P_1$ | 0 – 15 | 4.8 | 3.3 | 0.51 | 0.59 |
| | 15 – 30 | 4.4 | 3.3 | 1.72 | 0.31 |
| | 30 – 45 | 4.3 | 3.2 | 3.91 | 0.48 |
| | 45 – 60 | 4.2 | 2.2 | 10.69 | 0.45 |
| $P_2$ | 0 – 15 | 4.9 | 3.2 | 0.34 | 0.53 |
| | 15 – 30 | 4.3 | 2.2 | 6.03 | 0.53 |
| | 30 – 45 | 4.3 | 2.6 | 11.22 | 0.40 |
| | 45 – 60 | 4.3 | 2.6 | 11.36 | 0.63 |

*Charge Characteristics*

pH in the top soil is about 5 (Table 2). The values become lower with depth. The decrease in pH with depth corresponds with the increase in Al. $pH_o$ is lower than pH in all samples indicating that the soil is net negatively charged (Uehara and Gillman, 1980). The exact amount of net charge has not been determined, but the amount of negative charge (CEC) at pH 7 is available (Table 1).

The CEC is very high, with values mostly at 50 meq/100 g soil or more. This is roughly half of the CEC value of fresh peat soil reported by Joseph *et al.* (1974). The high CEC value is a reflection of high organic matter content and mineralogy; this soil contains mica-vermiculite, mica-smectite and smectite, which are known to be highly charged. Organic matter, which is also highly charged, may have contributed more to the soil CEC.

$pH_o$ is low with values 3.3 or less (Table 2). Low $pH_o$ value is common for soils high in organic matter (Gillman and Bell, 1976) and for soils which have not undergone extreme weathering (Tessens and Shamshuddin, 1983). Thus low $pH_o$ value in this soil is consistent with high organic matter (Table 1) and mica-smectite mineralogy *(Fig. 1)*.

*Soil Buffering*

The top soil (0 – 15 cm) is not buffered at all *(Fig. 2)*. The pH of the soil rose quickly to 8 on a small addition of base. But at depth, the buffering capacity increases. For instance, at 45 – 60 cm depth, it needs 20 meq/100 g soil of KOH to increase the pH to 5.5.

According to Shamshuddin and Tessens (1983), the most important factor controlling buffering action of soil below pH 5.5 is Al. The

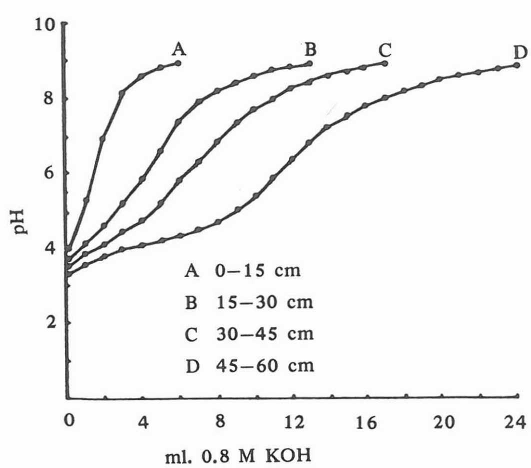


*Fig. 2. Potentiometric titration curves of soil samples from P1.*

importance of Al in controlling soil pH is clearly illustrated in this soil. On the surface, where Al is only 0.51 meq/100 g soil, the soil is not buffered (*Fig. 2,* curve A). On the other hand, the soil at 45 – 60 depth (*Fig. 2,* curve D), is highly buffered; this soil contains 10.69 meq/100 g soil Al. It appears that strong buffering takes place at pH 4 – 5.

Of particular interest to agriculture is buffering action below pH 5.5 as pH 5.5 is the level to which tropical soils are usually limed. Buffering capacity determines whether a particular soil can be economically limed. Liming requirements of the soil can be estimated from the buffer curves (*Fig. 2).* Taking 1 ha of the top 15 cm of the soil (*Fig. 2,* curve A), with bulk density of 0.97 $g/cm^3$, the amount of lime needed to raise the pH to 5.5 is 1.75 ton. The underlying horizon, which is slightly more buffered, the lime requirement is 5.1 ton/ha.

*Management Implication*

The study shows that the soil is slightly acidic in reaction, which needs to be limed to make it more suitable for crop production. A liming rate of about 3 ton/ha is recommended to increase the pH to 5.5 of the top 30 cm of the soil. The figure of 3 ton/ha is the average lime requirement of soil at 0 – 15 cm and 15 – 30 cm depth, which can be estimated from the buffer curve (*Fig. 2).*

Liming and fertilizing the soil results in the accumulation of some nutrients (Table 1) which can create nutrient imbalance. Excess of base may also increase electrical conductivity, which is equally bad for plant growth. In this soil, electrical conductivity is less than 1 m mho/cm, thus the soil is not saline (Table 2). Electrical conductivity of the water in the drain around the sampling area is 0.50 m mho/cm or less. It is difficult to leach the excess salt as the soil is in the depression.

It is suggested that crops be grown on specially constructed bunds. In this way, excess salts are leached to the lower horizons. It seems logical, therefore, to have bunds or to pump out some of the water containing salt during dry season. This eventually will remove part of the excess salt.

## CONCLUSION

The studied organic soil has a bulk density of 0.97 $g/cm^3$ and a pH of about 5 at the top 15 cm depth. However, at depth, the pH is low because of the presence of high amounts of Al. At 45 – 60 cm depth, buffering capacity is very high. Strong buffering takes place at pH 4 – 5. Liming and fertilizing the soil result in the accumulation of bases, especially Ca and Na. These bases are not leached because of the high water table and the presence of soil in the depression. $pH_0$ is around 3 and CEC is more than 50 meq/100 g soil. This is a reflection of high amounts of organic matter and mica-vermiculite-smectite mineralogy.

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