SHORT NOTE

MOISTURE RETENTION CURVE OF TROPICAL SAPRIC AND HEMIC PEAT

Ayob Katimon[1,*], Lulie Melling[2]

[1]*Department of Hydraulics and Hydrology, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia*

[2]*Soil Science Branch, Department of Agriculture, Jalan Badruddin, 93400, Kuching, Sarawak, Malaysia*

*Corresponding Author: *ayob57@gmail.com*

Abstract: This paper presents the preliminary result from a laboratory study to establish the moisture retention curve of undisturbed tropical peat samples classified as Sapric and Hemic. The results obtained were compared with those of the temperate peat. Under the same suction head, tropical peat seems to hold more water. The soil moisture at permanent wilting point (-15000 cm or -150 kPa) was still relatively high at 50-60 % volumetric indicating that the soil was still visually wet, but may not be available for plant use. The possible implication could be, water table in the field should be maintained optimally high to facilitate irrigation water supply from capillary rise.

Keywords: *Peat; moisture retention curve; capillary rise*

Abstrak: Kertas kerja ini melaporkan keputusan awal mengenai kajian makmal untuk menerbitkan lengkung penahanan lembapan tanah gambut tropika jenis sparik dan hemik. Hasil kajian dibandingkan dengan tanah gambut yang didapati di negara beriklim temprat. Pada tekanan negatif yang sama, tanah gambut tropika didapati mampu memegang kandungan air yang lebih tinggi. Lembapan tanah pada tahap layu kekal (-1500cm atau -150 kPa) didapati masih tinggi pada tahap 50-60% isipadu, suatu petanda bahawa tanah jenis ini kelihatan basah, tetapi munkin lembapan tersebut tidak tersedia kepada tumbuhan. Implikasinya ialah, paras air tanah di lapangan perlu dikekalkan tinggi bagi mempermudah mendapatkan pengairan melalui kenaikan air rerambut.

Katakunci: *Tanah gambut; lengkung penahanan lembapan; kenaikan rerambut*

1.0 Introduction

Soil moisture retention curve is a curve representing the relationship between moisture content and pressure head or matric suction of soil (Brady and Weil, 1996). In irrigation and drainage practice, moisture retention curve contained very useful information especially that is related to irrigation water supply. From the retention curve, the field capacity (FC) and permanent wilting point (PWP) can be determined and water holding capacity or available water (WHC) of the soil can be estimated.

The common practice of evaluating the available water or the water held by a soil that can be used by plants, is defined as,

$$\text{Available water} = MC_v\,(\psi = -330\ \text{cm}) - MC_v\,(\psi = -15000\ \text{cm}) \tag{1}$$

where MC_v is the volumetric moisture contents and ψ is the matric potential head. It is noted that -330 cm matric suction is equivalent to -33 kPa or -0.33 bar. Knowing FC, PWP and WHC, the amount of irrigation requirement by plant under a certain field condition can be estimated. Subsequently, irrigation design specification for specific soil textural classes (type) can be proposed to meet the plant need.

Soil moisture retention curve is also an important input in the determination of hydraulic conductivity *(K)* of unsaturated soil condition (Campbell, 1974). For instant, Gardner's model (Gardner, 1958) stated that the relationship between unsaturated hydraulic conductivity (K_{unsat}) and soil suction head is as follow,

$$K_{unsat} = K_{sat}\exp(-\alpha h) \tag{2}$$

where K_{sat} is the saturated hydraulic conductivity, h is the suction head and α is the parameter representing the rate of decrease in hydraulic conductivity with decreasing suction head and can be interpreted from the soil retention curve.

Another usage of a retention curve of soil is to estimate the capillary rise potential following Darcy's law, which can be expressed as follow (Lu and Likos, 2004),

$$q = K_{sat} i = n\frac{dz}{dt} \tag{3}$$

$$i = \frac{h_c - z}{z} \tag{4}$$

where, q is discharge velocity, n is soil porosity, h_c is the ultimate height of capillary rise and z is the distance from water table.

Solving eq. (2) and (3), the capillary height, *z* as an implicit function of time,

$$t = \frac{nh_c}{K_{sat}}\left(\ln \frac{h_c}{h_c - z} - \frac{z}{h_c} \right) \qquad (5)$$

Unlike in other soil textural classes, peat soil has been given less emphasis by researchers due to several reasons. First, being a ‘problematic soil’, the physical characteristic of peat varies tremendously according to locations as well as land management practices. Second, most of the established scientific equipment and experimental procedures were developed based on mineral soil requirement. For example, in determining soil moisture retention curve, scientists always use disturbed soil sample (air dried, crushed and crumbled) in order to establish the standard moisture curve. For peat, such procedures are not quite practical as peat would shrink significantly upon air drying that would definitely change its volume and hydraulic properties. As such, the main objective of the current study is to use undisturbed peat sample to produce soil moisture retention curve. The second objective is to make a general comparison with peat materials found from other parts of the world especially from the temperate areas.

2.0 Material and methods

2.1 Peat samples

Undisturbed peat samples taken using standard soil sample ring holder were obtained from sites at Mukah, Sarawak, representing two different layers of peat profile. i.e. sapric (Plate 1) and hemic (Plate 2). In soil classification system, peat profile of the tropics can be categorized into three distinguish degrees of decomposition, i.e. sapric, hemic and fibric. In general, sapric layer is located at the upper soil layer underlain by hemic and fibric. Sapric contained a more decomposed peat material compared to hemic and fibric (Mutalib et al, 1992; Melling, 2000). To obtain undisturbed samples, soil sample ring holder containing a numbers of core samplers were pushed to a desired depth, then pulled out carefully, cut into individual core and brought to the laboratory for soil moisture-pressure head relationship determination.

2.2 Moisture Curves test

Core samples size of 50 mm diameter and 50mm high were covered with nylon cloth at the bottom aperture before it was soaked overnight for saturation process**.** The saturated core samples were then transferred into sand/kaolin box (Plate 3) to determine the soil moisture retention at low range suction pressure from -10 cm (-1 kPa) to -500 cm (-50 kPa). Upon completion of -10 to -500 cm suction range, the same samples were

Plate 1: Sapric peat sample

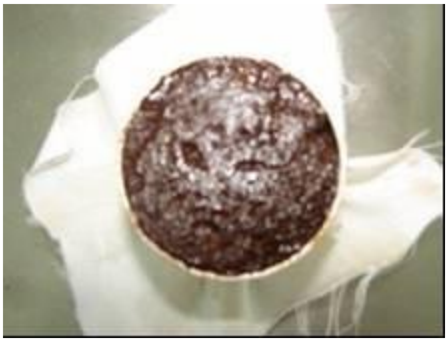


Plate 2: Hemic peat sample

transferred into moisture pressure plate chambers (Plate 4) for soil moisture determination at higher soil pressure -500 cm (-50 kPa) up to -15000 cm (-1500 kPa). A total of seven different suction head (-1, -100, -330, -500, -1000, -3000, -5000, -10000 and -15000 cm of water) were applied to the same samples in order to obtain a complete curve of the soil moisture-pressure head relationship. The treated core samples were weighed in order to quantify the moisture reduction due to the respective suction head. Eventually, at the end -15000 cm suction head, the samples were oven dried for soil moisture determination. Two different drying temperatures were applied. First, 60^{o}C, according to Lambert and Vanderdeelen (1996) and second at 105 ^{o}C (ASTM, 1999). The soil moisture data were plotted against matric suction head to produce moisture retention curve of the sample.

2.3 Bulk density

The bulk density of the samples were obtained using the same samples used in the previous moisture retention curve analysis. The dry bulk density was computed by dividing the dry weight to the volume of the core (the volume is 98.1875 cm^3, based on 5cm diameter and 5cm height). The bulk density of the sample was then used as the multiplying factor to convert the gravimetric moisture into volumetric basis.

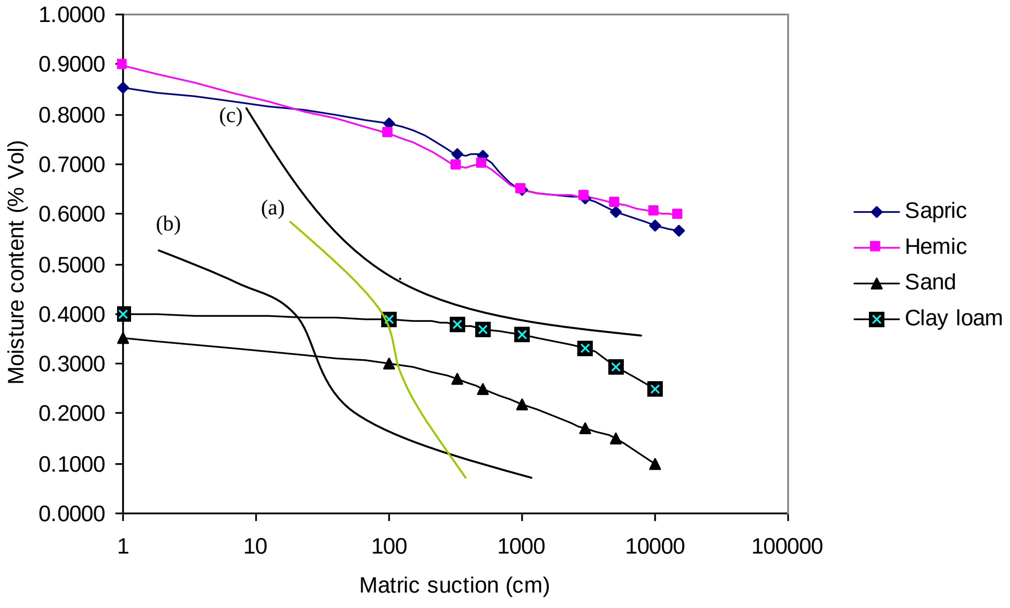
3.0 Results and Discussion

Table 1 shows the soil moisture characteristics of the peat samples tested in the study. According the Von Post Scale (Soil Classification Working Group, 1998), using squeezing test, it is found that the sapric sample used in the present study belong to H_5 (more decomposed), whereas hemic belongs to H_3 (less decomposed). This can be visualized from Plate 1 and 2 and further supported by its bulk densities.

As shown in Table 1, Sapric sample having bulk density of 0.2365 g/cm^3, higher that Hemic of 0.1621 g/cm^3. Compared to temperate peat, they are much lower than the Canadian peat of 0.5-0.8 g/cm^3 (Price, 1997), Finland peat of 0.6-1.6 g/cm^3 (Hesikanen and Makitato, 2002) and Israel peat of 0.69 g/cm^3 (Dasberg and Neuman, 1977). A full range comparison in moisture retention curves between the peat sample of the present study and temperate peat is not possible to make because most of the study done from the temperate covered only up to -1000 cm suction head (-10 kPa).

Table 1: Moisture Retention Characteristics of the Tested Sapric and Hemic

Type of peat	Von Post Scale	Bulk density (g/cm^3)	Moisture Content (% vol) Matric Suction (cm)			Water Holding Capacity	
			Saturation	Field Capacity (-33cm)	Permanent Wilting Point (-15000cm)	(% vol)	cm/m rootzone depth
Sapric	H5	0.2365	1.0315	0.8769	0.6986	0.1786	17.86
Fine Hemic	H3	0.1621	1.0444	0.8144	0.7014	0.1130	11.30



(a): Price (1997)
(b): Heiskanen and Makitalo (2002)
(c): Dasberg and Neuman (1977)

Figure 1. Soil moisture retention curve of Sapric and Hemic peat in relation to temperate peat sand and clay loam

Figure 1 shows the moisture retention curves of the tested peat sample in comparison to temperate peat, sand and clay loam. As can be seen, at low matric suctions range, between -10 to -1000 cm, temperate peat of similar degree of decomposition hold more water (indicated by the soil moisture different between these two suction head) compared to the tropical Sapric and Hemic.

At a higher suction head range (-10000 cm and above) Sapric and Hemic were still apparently wet with their volumetric moisture contents of above 60%. However, the moisture may not available to plant due to low capillary height. On the other hand, temperate peat seems to behave similar to sand and clay loam in which their moisture contents are approaching zero under the higher suction pressure. Another possible strong reason is that Sapric and Hemic are still considerably fibrous and having large percentage in macro porosity. As such, a Darcian flow would not occur in the sense that such hydraulic connectivity within the peat sample were not in hydraulic contact. As such, a laminar flow, a type of flow assumed in Darcy law would not occurred. Peat material especially from the temperate is found to have dual porosities (Hemond and Fifield, 1982), multiple type of flows, i.e. micro and macro flow (Holden and Burt, 2002) and thus the flow within the soil profile is deviated from the Darcy's law (Hemond and Goldman, 1985).

4.0 Conclusions

These short studies suggest that, the hydrologic properties of Sapric and Hemic peat of the tropics are deviated slightly from that found in the temperate. Quantitatively, Sapric samples appear to hold less water than Hemic. They also appear to hold less water than temperate peat but quite similar to sand and clay loam soil. The volumetric moisture content still appeared high even under a high suction head. This could imply that, under the force of gravity pressure (atmospheric) alone, the internal drainage is difficult to perform and irrigation water supply from capillary rise would need water table depth shallow. Nevertheless, a more thorough study should be carried out to find a greater detailed on the concept of hydraulic disconnectivity that would occur within peat profile in relation to its anisotropic condition and multiple porosity of the peat material.

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