THE EFFECTS OF RICE HUSK ON THE SHEAR STRENGTH OF PEAT SOIL

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A Final Year Project report submitted in partial fulfillments of the requirements
for the award of the Degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

ABSTRACT

Peat is in the type of soft soil and consider as a problematic soil by engineers which should be avoided if possible. This is due to the low shear strength and high compressibility which are not suitable for construction. With rapidly growth of development infrastructures facilities in Malaysia, the price of lands are very expensive and very limited and, it may impossible to avoid any construction on the soft soil especially peat soil. Soil improvement needed to do to in order overcome this related problem. This paper presents the effects of rice husk on the shear strength of peat soil. The effects of rice husk by proportion have been investigated in this study. The properties and shear strength of peat soil taken from Kampung Tanah Puteh, Pekan, Pahang were determined by experimentally investigation. The direct shear test was performed to determine the parameters of shear strength which are cohesion and angle of shear resistance and also to determination the optimum mix of rice husk with peat soil mix which gives the maximum shear strength. The test was done on 18 samples with different mixed proportion of 0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5% of rice husk subjected to normal stress of 136.2kPa, 272.5kPa and 408.8kPa for each of the proportion. The study revealed that adding rice husk at exact value can give the maximum value of shear strength. The shear strength parameter which is cohesion is inversely proportional to the angle of shear resistance. The optimum mix was 1.5% rice husk with peat proportion.

ABSTRAK

Tanah Gambut adalah dalam jenis tanah yang lembut dan dianggap sebagai tanah yang bermasalah oleh jurutera yang harus dielakkan jika boleh. Ini adalah kerana kekuatan ricih yang rendah dan kebolehmampatan yang tinggi yang tidak sesuai untuk pembinaan. Dengan pertumbuhan pesat kemudahan infrastruktur di Malaysia, harga tanah adalah sangat tinggi dan sangat terhad dan, ia mungkin mustahil untuk mengelakkan sebarang pembinaan di atas tanah yang lembut terutamanya tanah gambut. Pembaikan tanah perlu dilakukan dalam usaha mengatasi masalah ini. Kertas kerja ini membentangkan kesan sekam padi kepada kekuatan ricih tanah gambut. Kesan sekam padi mengikut bahagian telah disiasat dalam kajian ini. Sifat-sifat dan kekuatan ricih tanah gambut yang diambil dari Kampung Tanah Puteh, Pekan, Pahang telah ditentukan melalui penyiasatan eksperimen. Ujian ricih telah dijalankan untuk menentukan parameter kekuatan ricih iaitu kejelekitan dan sudut rintangan ricih dan penentuan campuran optimum sekam padi dengan campuran tanah gambut yang memberi kekuatan ricih maksima. Ujian ini telah dijalankan ke atas 18 sampel dengan nisbah campuran yang berbeza iaitu 0%, 0.5%, 1.5%, 2.0% dan 2.5% daripada sekam padi tertakluk kepada tekanan biasa 136.2kPa, 272.5kPa dan 408.8kPa di setiap bahagian campuran. Kajian menunjukkan bahawa menambah sekam padi pada nilai yang tepat boleh memberikan nilai maksima kepada kekuatan ricih tanah. Kekuatan parameter ricih yang merupakan kejelekitan adalah berkadar songsang dengan sudut rintangan ricih. Campuran optimum adalah 1.5% sekam padi dengan kadar tanah gambut.

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LIST OF SYMBOLS

W_w	mass of wet soil
W_d	mass of dry soil
ω	moisture content
ρ_w	dry density of water
ρ_d	dry density
γ_d	dry unit weight
v_a	air voids
Gs	specific gravity
¢	Cohesion
Ø	Angle of shear resistance

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British Standard
LL	Liquid Limit
MDD	Maximum dry density
OMC	Optimum moisture content
PI	Plasticity Index
PL	Plastic Limit
RH	Rice husk
RHA	Rice husk ash
STP	Standard proctor test
UNDP	United Nations Development Programmed
ZAV	Zero-air voids

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Malaysia has known as one of developing country in this era. With rapidly growth of development infrastructures facilities in Malaysia, it may impossible to avoid any construction on the soft soil especially peat soil .Wetlands International Malaysia (2010) reported that tropical peat lands cover about 23 million hectares in South-East Asia. Malaysia has about 3 million hectares of peat and organic soil which representing about 8% total land area of country. Sarawak leads the major area of peat soils in Malaysia which is about 80% and 13% of the state area or 1.66 million hectares (Said and Taib, 2009). Pahang has a total of 197768 hectares of peatlands which comprising Pahang River North peatlands and the Pekan, Nenasi, Kedondong and Resak Forest Reserves, including small areas west of Pahang (Wetlands International Malaysia, 2010). Peat is a type of soft soil with high content of fibrous organic matters. The high organic content which is more than 75% present in the peat remains partially decomposed and disintegrated plant and takes place in conditions where the rate of accumulation is more than the rate of decays. The rate of decay is slower than the rate of addition (Bell, 2000). It accumulates when the conditions are suitable which means that in areas where there is an excess of rainfall and the ground is fully undrained, irrespective of latitude or attitude. Peat can also be defined as the accumulation of 100%

pure organic material which contains at least 65% organic matter or less than 35% mineral content (Muhamad et al., 2010). There are varies definitions of peat between soil science and engineering, as well as between countries. Peat is a type of soft soil which composes of high contents of fibrous organic matters and produced by the partial decomposition and disintegration of mosses, sedges, tress and others plant that grow in the wet place condition with lack of oxygen (Sina Kazemian, Bujang B.K.Huat, Arun Prased and Maassoumeh Barghchi, 2011). Since the main component of the peat soil is organic matter, it is very spongy, highly compressible and combustible in characteristic (Roy, 2004). According to Craig (1992) peat soil is a type of soil which dark brown and have distinctive odour. This made the peat soil pose its own distinctive geotechnical properties compared with other inorganic soils like the clay and sandy soils which are made up by the soil particle only (Deboucha et al., 2008).

Because of its low shear strength and large compressibility, peat soil can cause the major problem in construction. The high in water content and low dry density gives exceptionally low shear strength. The shear strength of peat soil is depending on moisture content, mineral content and degree of decomposition. Munro (2005) studied that when the peat soil has higher moisture content and decomposition, the shear strength becomes lower. Since peat soil is in decomposition stage, the stability of any structure that will build on that particular peat soil would be affected by the overall change of peat soil with time. It is also may experience bearing capacity failure and excessive settlement. Construction over peats and organic soils include expectations of very large settlements over and extended time period and possibility of stability problems gives challenges to engineer in faced that problem. On such types of soil, the high compressibility, low shear strength and high ground water level causes specific problems for designing and constructing structures. Because of the low shear strength and contributes to low bearing capacity, an improvement of peat soil need to do before any engineering works can commence. Mixing peat with waste material, rice husk is implemented as a method to improve the shear strength of peat soil. Rice husk is a by product of milling paddy grain which can easily found in Malaysia. Rice husk was use to stabilize and improve the structure of peat soil. Due to the environment concern and the need to conserve energy, various research efforts have been directed toward the utilization of waste materials. In Thailand, rice husk is one of the major agricultural wastes. When rice husks are burned under controlled conditions, the ash is produced in

the form of non crystalline or amorphous silica with cellular structure. This can be done by open field burning of small heap of rice husk ash (Chindaprasirt et al. 2007). The rice husk ash is a pozzolanic material containing a large amount of silica (Chindaprasirt et al. 2007; Metha 1979; Gjorv et al. 1998).

In determined the effect of waste material, rice husk mix with peat soil, an experimental investigation is the general test to determined the shear strength of soil. The common test that use in determined the shear strength is direct shear test and triaxial test. In this research, direct shear test is choosing to use in determining the drained shear strength of fibrous peat. Direct shear test is quick and inexpensive. The shortcoming is that it fails the soil on a designated plane which may not be the weakest one. On the other hand, triaxial test is frequently use for evaluation of shear strength of peat in the laboratory under consolidated-un drained (CU) conditions due to the fact that the results of triaxial test on fibrous peats are difficult to interpret. This is because fiber often acts as horizontal reinforcement, so failure is seldom obtained in a drained test. The reason being the triaxial test for peat with low permeability, if performed under a drained condition, may take several days to complete.

1.2 PROBLEM STATEMENTS

In construction, there are so many problem arise when it come to soft soil especially peat soil. The problem could be in any construction which is construction of building and road. Peat soil is consider as extremely form of soft soil and problematic by engineers. Peat is a mixture of fragmented organic materials formed in wetlands under appropriate climatic and topographic conditions and it is derived from vegetation that has been chemically changed and fossilized (Ediland Dhowian, 1980). In natural state, peat consists of water and decomposed plant fragment with virtually no measurable strength (Munro, 2005). Problem related to soft soil such as peat soil have low shear strength, high compressibility and high water content. Engineers defined peat soil as a problematic soil which should be avoided if possible. Construction on peat soil should be avoided because of the low shear strength. Peat soil may gives problem in bearing capacity of soil which can affect the foundation construct such as sliding,

overturn, excessive settlement and failure due to low bearing capacity. With the development rapidly occurred nowadays, limitation of lands caused problem. Nowadays, lands are very expensive and very limited and due to this, construction on this type of soil cannot be avoided. This gives challenges to engineer in finding the possible solution to solve this problem. Besides avoiding construction on the problematic soil such as peat soil, method of removing or replacing the peat soil with more stabile soil is commonly use. Unfortunately the replacement method is uneconomical. This research is done to evaluate the results of the effect of rice husk on the shear strength of peat soil.

1.3 AIM & OBJECTIVE

The general aim of this research is to investigate the effect of rice husk on the shear strength of peat soil. The objectives of this research are as the following:

i. To determine the angle of shearing resistance of the soil and waste various mixes.

ii. To determine the cohesion of the soil and waste for various mixes.

iii. To determine the optimum mix for the soil and waste which is gives the maximum shear strength.

1.4 SCOPE OF STUDY

This research was focused on the improvement of peat soil by using waste material; rice husk. Peat soil samples were taken at Kampung Tanah Puteh, Pekan, Pahang and the sample of rice husk was collected from factory of Padiberas Nasional Berhad (BERNAS) located at Peringat, Kota Bharu, Kelantan. Rice husk is an industrial waste material from paddy grains. This research was done based on experimental

investigation in laboratory by focusing on the effect of rice husk on the shear strength of peat soil. Some laboratory test was carried out to complete this research. In determined the properties of soil, natural moisture content was performed according to BS 1377: Part 2:1990:3 and Atterberg limit test which include plastic limit and liquid limit test was performed based on BS 1377: Part 2: 1990: 4.3 (Standard test Method for Liquid Limit) and ASTM D4318 Plastic Limit and Plasticity Index of Soils. The property of soil also was determined by specific gravity test. The specific gravity test was conducted according to BS1377: Part 2: 1990: 8.3 (Standard test of Specific Gravity for grained soil using density bottle). In determine the optimum moisture content of peat soil; standard proctor test was conducted according to ASTM 698. Besides that, in determines the angle of shearing resistance and cohesion of peat soil mix with rice husk, direct shear test was performed. The direct shear test was conducted accordance with ASTM Standard D3080 (Standard Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions and BS 1377: Part 7: 1990: 4. Peat soil was mix with rice husk at the various mixes proportions. The mixes were varying from 0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. The result of shear strength is compare and the optimum mix of peat soil and rice husk is determined.

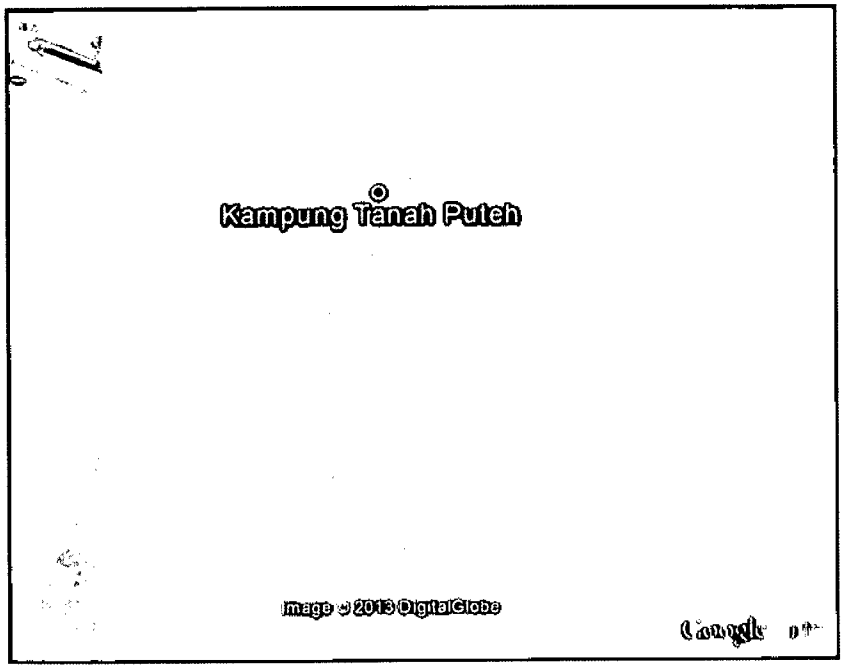

Figure 1.4: Location of Peat Soil Taken Kg.Tanah Puteh,Pekan,Pahang,Malaysia(Google Earth Map)

CHAPTER 2

LITERATURE REVIEW

2.1 PEAT SOIL

Peat is brownish-black in colour with distinctive odour (Craig,1992) and is formed by decomposed of organic matter that have accumulated over thousands of years, with lack of oxygen and under waterlogged conditions. These promote its formation. Edil and Dhowian (1980) reported peat is a mixture of fragmented organic materials formed in wetlands under appropriate climatic and topographic conditions and it is derived from vegetation that has been chemically changed and fossilized. According to Huat (2004), the content of peat soil is differs at different location and the factors responsible for this origin fibre, temperature, climate and humidity. In natural state, peat soil consists of water and decomposed plant fragment with virtually no measurable strength (Munro, 2005). Peat soil is a type of soft soil with containing high content of fibrous organic matter. Peat soil can be defined as soil which containing 65% organic matter or less than 35% mineral content (Muhammad et.al., 2010). Peat is a type of soft soil which composes of high contents of fibrous organic matters and produced by the partial decomposition and disintegration of mosses, sedges, tress and others plant that grow in the wet place condition with lack of

oxygen (Sina Kazemian, Bujang B.K.Huat, Arun Prased and Maassoumeh Barghchi, 2011). Since the main component of the peat soil is organic matter, it is very spongy, highly compressible and combustible in characteristic (Roy, 2004). According to Hobbs(1986) and Edil(1997), as referred in Huat (2004), there are seven characteristic should be included in a full description of a peat. There are colour of peat, degree of humidification, water content through oven drying method at 105°C, principal plant components, namely course fibre, fine fibre, and amorphous, organic content as a percentage of dry weight, determined from loss of ignition at 450-550°C as a percentage of oven dried mass at 105°C , liquid limit and plastic limit and the last characteristic addressed is fibre content determined from dry weight of fibre retained on #100 sieve (>0.15mm) as a percentage of oven dried mass. Deboucha (2008) stated that peat soil does show its unique characteristic, such as:

a) High natural moisture content (up to 800%)

b) High compressibility including significant secondary and tertiary compression.

c) Have low shear strength (typically 5-20kPa)

d) High degree of spatial variability

e) Potential for further decomposition as a result of changing conditions.

Tropical peat lands can be found throughout the world and usually found in river valleys and estuaries. Peat swamps occurs in a few areas in Africa and parts of Central America, but more than 60 percent of world's tropical peat lands are found in South-East Asia. Most notable of these are large peat swamp forest on the islands of Borneo (belonging to Indonesia, Malaysia and Brunei Darussalam) as shown in **Figure 2.1(a)**. Based on the global chart of total peat deposit around the world, Malaysia is the 9th country with the highest total area of peat soil as shown in **Table 1**. The total area of peat soil in Malaysia is about 2.6 million hectare which representing 8% of total land area of the country. Sarawak possesses the 80% of Malaysia peat soil area and 13% in Peninsular Malaysia (Mesri, et,al., 2007)

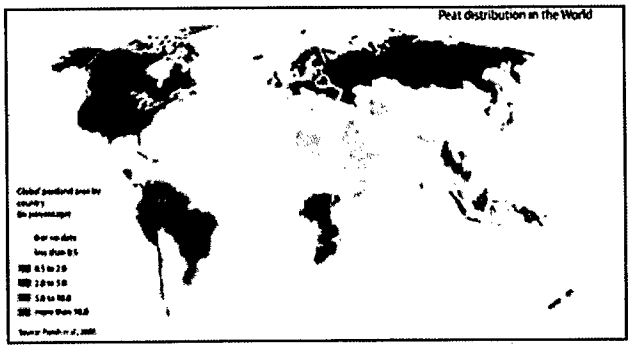

Figure 2.1(a): Peat soil distribution in the World. (R.Adon,et al,2012)

Table 1: Division of peat area distribute by countries. (Mesri, et,al.,2007)

Country	Area(km^2)	Country	Area(km^2)
Canada	1 500 000	Germany	16 000
U.S.S.R(the former)	1 500 000	Brazil	15 000
United States	600 000	Ireland	14 000
Indonesia	170 000	Uganda	14 000
Finland	100 000	Poland	13 000
Sweden	70 000	Falklands	12 000
China	42 000	Chile	11 000
Norway	30 000	Zambia	11 000
Malaysia	25 000	26 other Countries	220 to 10 000

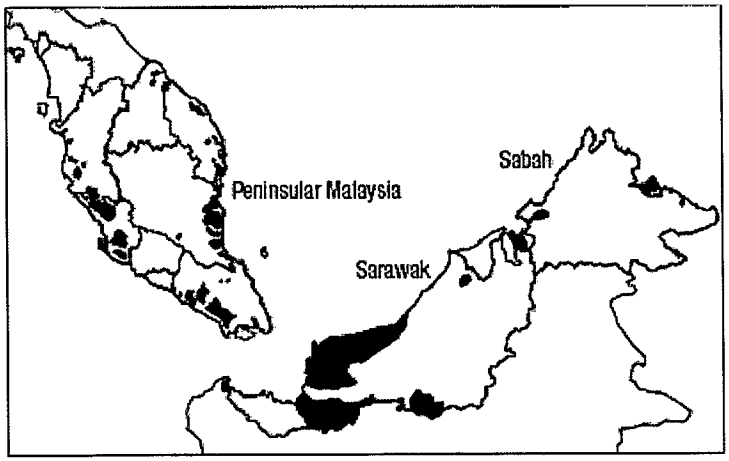

Figure 2.1 (b): Distribution of peat soil in Malaysia (Leete.R ,2006)

2.1.1 Formation of Peat Soil

About 23 million hectares in South- East Asia cover by tropical lowland peatlands, which the natural vegetation is predominantly peat swamp forest. A major characteristic of peat swamp forest is that they are permanently waterlogged which is leading to reduced decomposition of organic matter from plant litter, then accumulates as peat. Most of the lowlands peatlands in Malaysia have develop along the coast, behind accreting mangrove coastlines, where sulphides in mangrove mud and water restrict bacterial activity, leading to the accumulation of organic matter as peat. The peatland formed along the coast do not form an unbroken area, rather, they develop as individual units on the alluvial plains rivers flowing to the sea. A typical situation is that a peat dome develops between two rivers. The rivers possess natural levees in their floodplain stages, and as the levees fall away from the river, a thin strip of alluvium is left which has been deposited by the river flooding. Because of the mineral soils, freshwater swamps forest develops. Peat can develop over both sand and clay. Generally, peat are considered to be partly decomposed biomass(vegetation).Kurbatov (1968) summarize 35 years research as

the formation of peat is relatively short biochemical process carried on under influence of aerobic micro-organisms in the surface layers of the deposits during periods of low subsoil water. Peat is formed in the peat-producing layer becomes subjected to anaerobic conditions in the deeper layers of the deposit; it is preserved and shows comparatively little change with time.

The natural vegetation of peatlands in Malaysia is generally peat swamp forest. Peat swamp forests are waterlogged forests growing on a layer of dead leaves and plant materials up to 20m thick. They comprise an ancient and unique ecosystem characterized by water logging, with low nutrients and dissolved oxygen levels in acidic water regimes. Their continued survival depends on a naturally high water level that prevents the soil from drying out to expose combustible peat matter. The evolution of many species of flora uniquely adapted to the harsh waterlogged environment.

Peat forms when plant materials, usually in marshy areas, are inhibited from decaying fully by the acidic conditions and an absence of microbial activity. For example, peat formation can occur along the inland edge of mangroves where fine sediments and organic materials become trapped in the mangrove roots. Peat is mostly soil with more than 65 percent organic matter which largely composed of vegetation including trees, grasses, mosses, fungi and various organic remains including insects and animal. Peat formation occurs when the rate of accumulation of organic materials exceeds the rate of decomposition (Leete.R, UNDP, 2006).

The build-up layers of peat and degree of decomposition depend principally on the local composition of the peat and the degree of water logging. Peat formed accumulates considerably faster in very wet conditions compared to peat accumulating in drier places which is less decomposition. The peat acts as natural sponge, retaining moisture at times low rainfall but because it is normally waterlogged with a very limited capacity to absorb additional heavy rainfall during periods such as a tropical monsoon. Peat swamp forest develops on these sites where dead vegetation has become waterlogged and is accumulating as peat. Water in peat swamps is generally high in humid substances that give a typically dark brown to black colour to the water. These conditions influence the types of vegetation that thrive in the covering forests and that, in turn, contribute to the

character of the peat (Leete.R, 2006). **Figure 2.1.1** illustrates the formation of peat swamps peat.

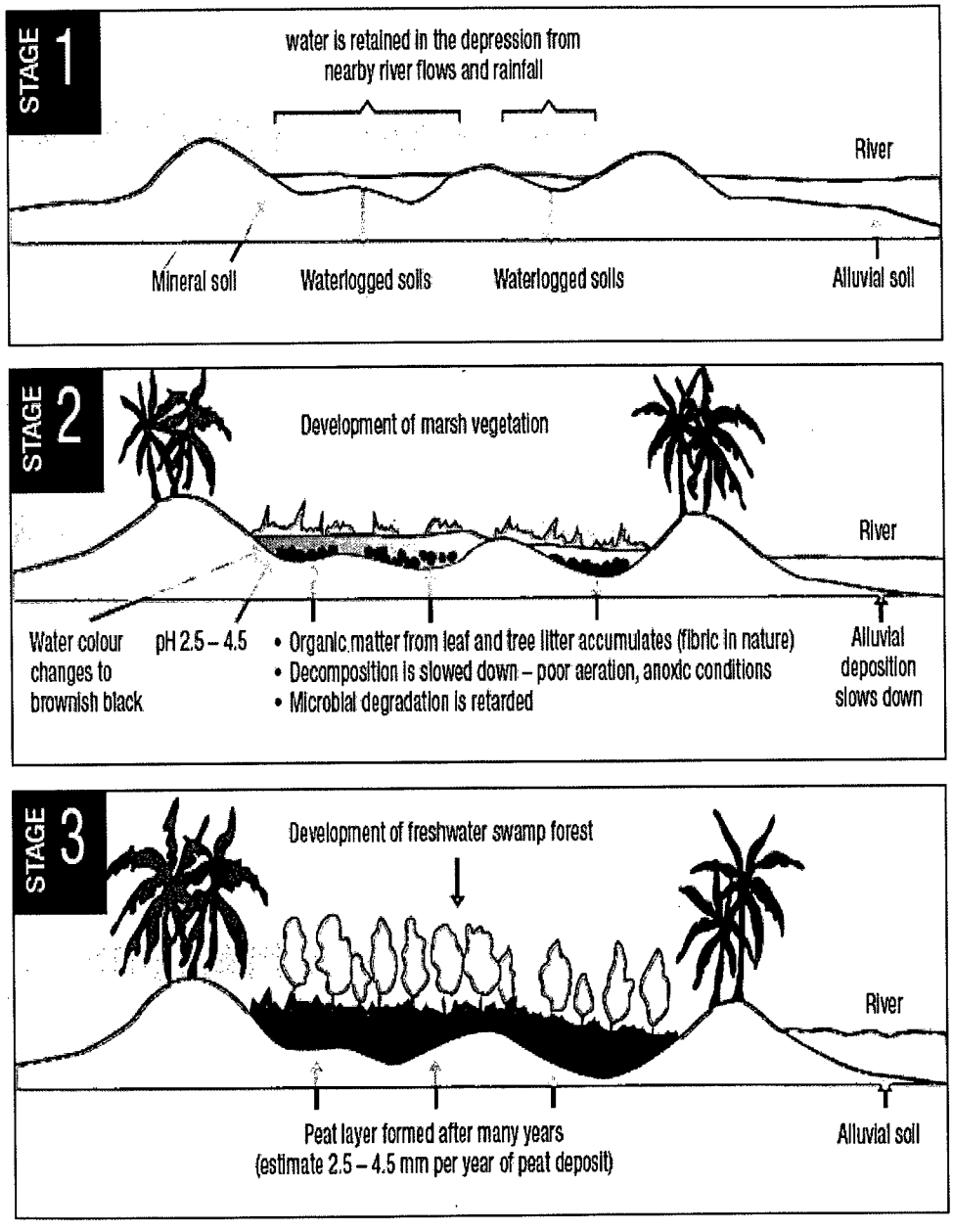

Figure 2.1.1: The formation of peat swamp. (Leete.R, 2006)

2.1.2 Importance of Peat lands

Most of the country use peat for energy use comes from peat briquettes. According to Schilstra (2011), if peat is milled and compressed at high temperatures it can be pressed into briquettes with user friendly and predictable burning properties along with a smokeless combustion. Peat soil is use as a soil improvement material in agricultural and gardening purposes. By adding milled peat to the soil it is possible to make it better since the peat adds nutrient and retains moisture, thus making the soil optimal for growing plants. The healthy peatlands of Malaysia provides an environmental benefit table 2 below lists some of the benefits from peatlands (Milne,et,al,. 2010)

Table 2: Benefit of peat lands (Milne,et,al.,2010)

Grouping	Benefit
Direct uses(goods)	Forestry, agriculture, plant gathering, wildlife capture, fish capture, tourism or recreation, water supply
Functions(services)	Water storage or retention, carbon storage, flood mitigation, nutrient, and toxicant removal
Attributes	Biological diversity, cultural or spiritual value, historical value, aesthetic value.