Characterization of Soil Organic Matter in Peat Soil with Different Humification Levels using FTIR

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Abstract: Peat soil is defined as an accumulation of the debris and vegetative under the water logging condition. Soil organic matter of peat soil was affected by the environmental, weather, types of vegetative. Peat soil was normally classified based on its level of humification. Humification can be defined as the transformation of numerous group of substances (proteins, carbohydrates, lipids, etc.) and individual molecules present in living organic matter into group of substances with similar properties (humic substances). During the peat transformation process, content of soil organic matter also will change. Hence, that is important to determine out the types of the organic compound. FTIR (Fourier Transform Infrared) is a machine which is used to differential soil organic matter by using infrared. Infrared is a types of low energy which can determine the organic minerals. Hence, FTIR can be suitable as an indicator on its level of humification. The main objective of this study is to identify an optimized method to characterization of the soil organic content in different level of humification. The case study areas which had been chosen for this study are Parit Sulong, Batu Pahat and UCTS, Sibu. Peat soil samples were taken by every 0.5 m depth until it reached the clay layer. However, the soil organic matter in different humification levels is not significant. FTIR is an indicator which is used to determine the types of soil, but it is unable to differentiate the soil organic matter in peat soil FTIR can determine different types of the soil based on different wave length. Generally, soil organic matter was found that it is not significant to the level of humification.

Keywords: Soft soil, peat soil, soil organic, ftir, humification.

1. Introduction
In geotechnical field, peat soil is defined as a problematic soil due to its physical properties. Peat soil which has very high moisture content, high fiber content, low permeability and low shear strength cause the soil cannot support high loading and not suitable for construction.

Research such as that conducted by [1,2,3] have shown that peat is an accumulation of the debris of plant, trunk and roots in water logging condition. Besides that, in research [4] stated that peat soil is an organic matter which is usually in light brown or dark colour. It has high organic matter
and therefore it can be classified into different types of peat soil based on different level of humification of peat.

According to [5,6], humification can be defined as the transformation of numerous groups substances (proteins, carbohydrates, lipids, etc.) and individual molecules present in living organic matter into groups of substances with similar properties (humic substances). After that, the humic substances are changed into carbon deposits. In the carbon biogeochemical cycle, transformation from living organic to the carbon substances, in terms of humification is affected by the high variability of environmental conditions and affected by degradation and synthetic reaction.

Based on [7,8] in their research stated that the organic matter inside peat soil will have some differences in its physical properties during the living organic matter transformation. During peat transformation process, the degree of decomposition, peat’s specific gravity and compaction are increased while the peat’s moisture content is decreased. In addition, the colour of peat will also change. According to [9], the colour of peat will change into dark brown and black colour due to calorific value. Other than that, [10,11] also mentioned that the behavior and types of organic matter of peat soil will be affected by the environmental condition. There are several factors which will lead to the affection such as the types of forest, vegetative, temperature and weather as well as bog hydrological conditions. Hence, different level of humification will have different quantity and different types of soil organic matter during the transformation process.

To characterize the peat soil, level of humification is one of the indexes link that rate the transformation of organic matter. Von Post classification are widely used by the most of the researchers to determine the level of humification on site [12]. This is because this method can directly obtain result of the level of humification on site based on the squeezing of peat soil sample.

Nowadays, Fourier Transform Infrared (FTIR) is a popular and simple equipment that can be used to determine and characterize the soil organic matter. This is because FTIR spectroscopy can show the direct information of functional groups in the soil organic matter fraction analyzed [13,14]. Based on [15], used the FTIR spectroscopy to determine organic surface layers of forest while [16,17] use it to determine or evaluate the humic extracts. Based on [23], there are different types of mineral in different wave length. For range less than 1500 cm\(^{-1}\) is fingerprint area (mineral) while the soil organic matter is in the range of 1500 cm\(^{-1}\) to 3500 cm\(^{-1}\). For the clay mineral, it is more than 3500 cm\(^{-1}\). Based on the differences in wavelength, the type of the mineral content can be determined.

2. Method and Methodology
In this study, there are 2 investigated peat soil sites. The first investigated site is located at UCTS Sibu, Sarawak. Sibu is a place which has largest peat soil land in Malaysia. Some of the geo properties have been partly described by [7]. For another site, it is located at Peninsular Malaysia. Peat soil lands in Peninsular Malaysia are mostly located at west coastal and east coastal. The site that has been chosen for the research is located at UCTS, Sibu as shown in figure 1 (a) and Parit Sulong Batu Pahat Johor as shown in Figure 1(b).

![Figure 1.](image1.png) (a) shows the location at Sibu and figure 1 (b) show the location at Parit Sulong.
There are 2 different types of land activity on site. In Parit Sulong, the peat soil land is mainly used for palm oil plantation while in Sibu, there is no any land activity. According to the map, it is shown that the depth of the peat soil in Sibu is around 4-6m while for Parit Sulong, it shows that the location is at the boundary between peat soil and other types of soil. This means that peat soil in Parit Sulong is shallow and most probably has been mixed with other types of soil such as clay.

The peat soil was taken from every site until reached the clay layers, this is because peat soil is types of soil which affected and classify by the humification level. For the clay soil which have own mineral to separate out the different types of clay and clay soil would not happen any humification process. Peat soil was taken by every 0.5m depth. The depth for the peat soil in Sibu was recorded at 5.5m. For Parit Sulong site, the peat soil depth was recorded at 3m. There are several tests used to determine the level of decomposition of the peat soil. In this study, Von Post classification is chosen to determine the level of humification on site [12]. This is because it can directly obtained the result on site. Degree of humification of peat is identified based on the color of water escape from fingers when squeezing the fresh peat soil by hand and quantity that left inside hand after squeezing. The range of scale for the humification of peat is from 1 to 10. H1 represents the least humification and the H10 is the most humification.

In this paper, peat soil samples were tested. This is because peat soil properties was affected by the environmental and the different level of humification. Although there are different depth of two different points, but in this paper, the main focus was soil organic matters in different level of humification.

| Table 1. Classification types of peat according to the humification level. |
|------------------|------------------|
| Level of Humification | Types of Peat   |
| H1 to H3          | Fibric peat      |
| H4 to H6          | Hemic peat       |
| H7 to H10         | Sapric peat      |

Based on the [18,22], there are 3 types of peat was classified due to different level of humification and it is general and common standard to classify types of peat. During sample preparation for FTIR, the sample must be dried in advance at the temperature of 50°C. This is because higher temperature or temperature of 105°C will destroy the fiber. After that, the sample is grinded into powder form. Fourier Transform Infrared (FTIR) is carried out by using the low energy, infrared to identify the structures of molecule of soil.[19,20] In this study, FTIR spectroscopy that is used is Mid FTIR which has wave length of range from 4000 to 200 cm$^{-1}$. The spectroscopy must be ensured to be under the low temperatures to reduce the moistin order to prevent it from affecting the result of FTIR. Furthermore, the stage must be cleaned and there must not have any samples on it. This is because different types of samples will have different composition that may affect the result.

3. Result and analysis

The result of the laboratory Mid FTIR and in-situ testing (Von Post classification) are summarized in different types of format. The Mid FTIR result is shown in Figure 2 and Figure 3 while the result of level of humification is summarized in Table 2 and Table 3. Data that have been summarized is subdivided based on its location, namely Parit Sulong, Batu Pahat and UCTS, Sibu.

According to Table 2, the result showed the humification level of the site at the Parit Sulong. From the data obtained, 0-0.5m which has a record of H3 is the lowest humification on this site. For the second layer, it is recorded H6 while the rest are maintain at the same level of the humification. According to the researcher [21], H1 to the H4 is the fibrous peat, H5-H7 is pseudo- fibrous peat and H8-H10 is amorphous peat. Based on table 1, peat on the depth 0-0.5m was fibrous peat, 0.5-1m was pseudo- fibrous peat and 1-2.5m was amorphous peat.

Data in Table 3 shows that humification of peat soil is almost the same. However, there is a slightly different result at the depth of 2m to 3 m. For the depth of 2-2.5m, it was H7 while for the depth of 2.5-3m, it has a record of H6. Other layers of peat soil are recorded H8.
Table 2. Von post classification of peat soil (Parit Sulong, Batu Pahat).

| Depth (m) | Degree Of Humification |
|-----------|------------------------|
| Top Soil  | N/A                    |
| 0 - 0.5   | H3                     |
| 0.5 - 1.0 | H6                     |
| 1.0 - 1.5 | H8                     |
| 1.5 - 2.0 | H8                     |
| 2.0 - 2.5 | H8                     |
| 2.5 - 3.0 | N/A                    |

Table 3. Von post classification of peat soil (UCTS, Sibu).

| Depth (m) | Degree Of Humification |
|-----------|------------------------|
| 0-0.5     | H8                     |
| 0.5-1.0   | H8                     |
| 1.0-1.5   | H8                     |
| 1.5-2.0   | H8                     |
| 2.0-2.5   | H7                     |
| 2.5-3.0   | H6                     |
| 3.0-3.5   | H8                     |
| 3.5-4.0   | H8                     |
| 4.0-4.5   | H8                     |

3.1 FTIR result

FTIR result of Parit Sulong is shown in Figure 2. According to FTIR machine software, it shows that the peat soil of Parit Sulong is Slvent Impurities, group methanol. According to [13], 500–1500 cm\(^{-1}\) is fingerprint region for FTIR. It usually contains a very complicated series of absorptions. This is mainly due to all manner of bending vibrations within the molecule.

The higher point is recorded at 1606cm\(^{-1}\). The second higher peak which is dwi peak is at 2850.24cm\(^{-1}\) and 2919.66 cm\(^{-1}\). While, the last peak is recorderd at the 3351 cm\(^{-1}\). From the result, there are some slightly differences between various layers. At the peak of 1600 cm\(^{-1}\), layers 2-2.5m and layer 2.5-3m is lower than others layers, layer 2.5-3m is obviously has very low intensity. Furthermore, the layer of 2.5-3m also has the lowest intensity at the peak 2800-3000 cm\(^{-1}\). It does not have any peak at the range of 3000-3500 cm\(^{-1}\), but have a peak after 3500 cm\(^{-1}\). Based on the table of charactreristic of IR absorptions, functional group at different peak can be determined. For the peak which is range of 1600-1585 cm\(^{-1}\), it is aromatics. For the range 1760–1665 cm\(^{-1}\) is carbonyls (general). For 3000–2850 cm\(^{-1}\) is alkanes. 3500–3200 cm\(^{-1}\) is alcohol and for more than 3500cm-1 is categorized as clay mineral.

Based on the Parit Sulong humification result, samples of the depth 0-0.5m and 0.5-1m were different with the others layers samples. But from the FTIR result, there are no different of the peak or any change with the other layers. This show that organic compound of the samples still in the same group of the mineral. There are slightly different for the layer 2.5-3m, because this layer is clay layer. From the FTIR, result, it have a peak after 3500cm\(^{-1}\) which is categorized as a clay mineral.
For the UCTS Sibu FTIR result, there is a total of 5 peak point which is located at 1508 cm\(^{-1}\), 1606 cm\(^{-1}\), 1702 cm\(^{-1}\), dwi peat at 2850 cm\(^{-1}\), 2919 cm\(^{-1}\) and last at 3351 cm\(^{-1}\). According to the humification result, peat soil samples in Sibu get the almost same result which is H8. While based on FTIR result, although the humification of all samples are same, it still have some differences. For the peak before 3500 cm\(^{-1}\), all the samples are basically do not have any changes. However after 3500 cm\(^{-1}\), there are 3 layers of soil are consisting of peaks which have the depth of 3-3.5m, 3.5-4m and 4-4.5m respectively.

According to this FTIR result, although Parit Sulong peat samples have different level of humification, the result of FTIR for organic matter is still shown in same pattern and do not have changes. For Sibu FTIR result, all the samples are almost in same humification level, H8. The range before 3500 cm\(^{-1}\) is still the same pattern but there is slightly different after 3500 cm\(^{-1}\). From this, the level of humification of peak soil could not be directly observed from FTIR spectroscopy. The group of soil organic matter does not change much and it could be affected by the quantity of mineral.

4. Conclusion

In general, soil organic matter in different types of soil is different. This is because of the soil organic matter and the minerals in soil are different. Peat soil which is affected by environmental and the humification level. For the clay soil, there are different types of minerals which is giving different properties in physical and chemical. In different level of humification, the quantity and types of the
organic compound will also be different. In this study, FTIR can only classify the types of organic matter and determine the mineral content inside peat soil. From the research result of Parit Sulong, FTIR can directly identify that the layer of 2.5-3m is clay layer. For the UCTS, Sibu result, FTIR has showed that some of the layers have mixture of clay. This is because they have peat more than 3500cm\(^{-1}\). According to the result, FTIR can used for separated peat soil and clay soil. Besides that, FTIR has several limitations. It cannot directly classify the level of humification of peat soil. The range for humic acid is very wide and the level of humification could be affected by the quantity of organic matter. From this, another conclusion can made is FTIR cannot used for separated out the humification of peat soil. Furthermore, von post classification procedures also has some limitations. The samples that are used to carry out the test through squeezing them by hand are taken from a certain part of 0.5m undisturbed soil samples. Therefore, the result cannot represent the rest of the soil since there is a large range of soil and that may contain other composition which leads to different result. As a conclusion, FTIR is not suitable for classify level of humification for the peat soil.

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