Early study of magnetic permeability and magnetic susceptibility of peat in Ogan Komering Ilir, South Sumatera, Indonesia

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Abstract. Increasing peat fire in Indonesia have encouraged government or research institutes to develop an early warning system. This system needs various parameters in order to have an accurate result. Magnetic permeability and susceptibility are the physical properties of peat which expected to support this system. Field and laboratory measurements were conducted to determine the relationship between the peat temperature rise and the physical properties of the peat. A total of 30 samples was collected from Ogan Komering Ilir (OKI) Regency, South Sumatera, Indonesia. Each sample was tested with a temperature rise of 20°C until reach the convergent temperature. Statistical analysis were then performed. The results show that the magnetic permeability correlate with the peat temperature but the coefficient of the linear regression model is very small, with the constanta of 1.0022 from the linear regression model. In addition, magnetic susceptibility have a small correlation and a small determination coefficient with temperature. Therefore, it indicates that magnetic susceptibility can’t support this system.

1. Introduction

Regionally, Indonesia is a tropical country that has the widest area of peat among Southeast Asian countries and has global second largest tropical peatland [1] [2]. The widest peat distribution, which is around 14.9 million hectares is found in three large islands, namely Sumatera, Kalimantan and Papua, excluding peatlands in the other islands [3]. Peat in Indonesia is a tropical peat which is the result of a transformation and translocation process. Transformation process is biomass formation process with dissolved nutrients, water, air and solar radiation supports. Translocation process is material transfer by water movement from a higher place to a lower place and wind (air) movement caused by a difference in pressure [4].

In 2015 peat in Indonesia have a fire that was severe enough to make the government form an agency which specifically dealing with peat namely Peat Restoration Agency (BRG). Beside BRG, many institutions in Indonesia also created various early warning system instruments or fire danger rating systems that are expected to minimize the risk of peatland fire. These systems are also supported by various physical parameters according to their purpose and benefits. Magnetic permeability and magnetic susceptibility are physical properties of peat that are expected to support one of these systems. Magnetic permeability is the magnetic properties of a material (peat). While magnetic susceptibility is the material (peat) response to magnet. These two physical properties became our concern in this study. As we known that magnetic susceptibility is widely used to indicate contaminated areas because human activities influence (e.g.[5] [6])

Similarly, magnetic permeability is also widely used to predict soil moisture content (e.g.[7]) Saepuloh stated that the increasing temperature leads to decrease magnetic susceptibility and permeability in general [8]. Therefore, this early study is expected to be able to determine how far the relation between
magnetic permeability and magnetic susceptibility with the peat temperature rise and the importance of using magnetic properties as indicators for the creation of an early warning system for peatland fire.

2. Material and Methods

2.1. Field Data
In this study, there are 30 peat samples from Ogan Komering Ilir, South Sumatera, precisely in Penyabungan Subdistrict and Kayu Agung Subdistrict. Each sample is given a sample code according to the location of the sampling point. There are 6 sampling points and at each point, a sample is taken every 10 centimeters to 50 centimeters, so there are 5 sample in each sample point namely a sample of 0-10 centimeters, 11-20 centimeters, 21-30 centimeters, 31-40 centimeters and 41-50 centimeters. The following sample data is used:

| Sample Code | Date of sampling | Longitude | Latitude | Land cover |
|-------------|------------------|-----------|----------|------------|
| KYG 17B     | 26, 27 May 2018  | 104° 56' 57.7" | 3° 28' 5.8" | Oil Palm  |
| KYG 17C     | 27 May 2018      | 104° 56' 58" | 3° 28' 6" | Oil Palm  |
| KYG 19A     | 26, 28 May 2018  | 104° 55' 10.4" | 3° 27' 21.8" | Oil Palm  |
| PYB 29A     | 1 June 2018      | 105° 21' 44.2" | 3° 3' 0.4" | Acacia    |
| PYB 29B     | 1 June 2018      | 105° 23' 12.3" | 3° 3' 44.3" | Acacia    |
| PYB 29C     | 1 June 2018      | 105° 23' 15.6" | 3° 3' 11.8" | Acacia    |

The KYG sample code is a sample from Kayu Agung Subdistrict which is dominated by oil palm while the PYB sample code is a sample from Penyabungan Subdistrict which is dominated by acacia. Here the sample data and study area:

Figure 1. Sample data (a), Study area (b).
2.2. Laboratory Method
The peat samples that have been obtained are then tested for peat combustion in the laboratory. The purpose of this test is to determine how the effect of temperature rise on the physical properties namely magnetic permeability and magnetic susceptibility. This test was carried out in two stages, first was a drying process under the sun for 3-4 days. This drying process reduces the composition of water in peat sample. Furthermore, the second stage was heating the peat samples to reach extreme temperature. During this test, the measurement of the value of physical properties was carried out in stages as well. The first measurement was done before it enters the first stage for obtaining initial data. The second measurement was carried out after the peat sample was dried before heating. Subsequent measurements were made for each temperature increase of 20°C to reach a convergent temperature of 96,6°C. Convergent temperature is achieved when the peat sample stop to rise even though it is heated to 180°C.

2.3. Statistical Method
Next step is analyzing the sample data from the peat combustion test. Simple statistical analysis were then performed namely correlation analysis dan linear regression.

2.3.1. Correlation analysis
Correlation analysis aims to measure linear relationships between two random variables. If the correlation is close to 1, the relationship between the two random variables is “very close” and in the same direction, whereas if the correlation value approaches -1, the relationship between the two random variables is “very close” and in the opposite direction. Meanwhile if the correlation value is zero, there is no linear relationship between the two random variables. Correlation can be measured by the sample correlation coefficient [9]:

\[ r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}(\sum_{i=1}^{n}(y_i - \bar{y})^2)} \]

2.3.2. Linear Regression
Linear regression analysis aims to determine or estimate the parameters involved in a linear mathematical model and to predict a variable based on other variables. A simple linear regression model is expressed as [9]:

\[ y_i = \beta_0 + \beta_1 x_i + e_i \]

where \( \beta_0 \) and \( \beta_1 \) are model parameters to be estimated, \( e_i \) is error in the \( i \)th observation. Furthermore, one of the instruments to see whether the regression model is adequate or not is the coefficient of determination as follows [9]:

\[ R^2 = \frac{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \]

with \( 0 \leq R^2 \leq 1 \). Both of they were carried out based on peat depth, location of sample, and based on both depth and location at once. The separation of the analysis needs to be done to get a simple but detailed analysis.

3. Result and Discuss
Linear relationship between temperature and magnetic permeability for each depth in all of the samples showed strong enough and in the opposite direction. Determination coefficient of the regression model is good enough, but the coefficient of the model is very small. It shows that the effect of temperature rise does not significantly affect the value of magnetic permeability. While the constant is quite large with the average 1.0022 and standard deviation 0.000447. So the significant parameter in OKI Regency is the constant of the linear regression model. On the contrary, the linear relationship between temperature and magnetic susceptibility based on depth showed very weak and in the opposite direction.
So, the depth of peat is not significantly affected the physical properties namely magnetic permeability and magnetic susceptibility. This results support the statement that magnetic minerals are only limited to the top 10 centimeters of peat near the surface [10]. The profile below shows the sample of magnetic permeability and magnetic susceptibility based on the depth.

Figure 2. Profile based on depth (a). temperature and magnetic permeability, (b). temperature and magnetic susceptibility.

According to Rothwell, spatial maps of magnetic susceptibility revealed that peat soil adjacent to the edge of the ditch at Alport Moor has the highest concentration of magnetic minerals [11]. The rate of peat formation is very slow and differs from one place to another which is influenced by many factors, especially the local environment including water resources and water balance, mineral content in water, climate (rainfall, temperature, humidity), vegetation cover and management after drainage [12]. This result indicate that the location give greatly influences to the value of both magnetic permeability and magnetic susceptibility. But in our result show that the linear relationship between temperature and magnetic permeability both in PYB sample and KYG sample have the same result, whereas KYG sample is taken in wet area and PYB sample is taken in dry area. They are quite strong and in the opposite direction. On the contrary, the determination coefficient of the model is small. So the model is not good enough to explain the effect of temperature rise related to magnetic permeability. Even though it is small but it can be seen that the constant with average 1.0025 and standard deviation 0.000707 have greater effect of magnetic permeability value than the coefficient of the model. Here the profile of the sample between magnetic permeability and temperature based on the location.

Figure 3. Profile of temperature and magnetic permeability rise based on location.
Furthermore, analysis between temperature rise and magnetic susceptibility showed the opposite result with magnetic permeability. Based on the location shows that linear relationship in PYB is quite good than in KYG but the value is very small and in the opposite direction as well as determination coefficient. So, there is no significant change in both PYB and KYG sample. Here the profile of the sample between temperature and magnetic susceptibility based on the location.

![Figure 4. Profile of temperature and magnetic susceptibility rise based on location.](image)

The last analysis is based on depth and location at once. Both magnetic permeability and magnetic susceptibility have the similar result with analysis based on depth. The average of constants in linear model of temperature and magnetic permeability in PYB sample is 1.0026 with standard deviation 0.000548 and in KYG sample is 1.002 with standard deviation 0.000707. Because the temperature have no significant effect related to magnetic susceptibility, so the profile below just show the temperature and magnetic permeability of the sample based on depth and location at once.

![Figure 5. Profile of the sample based on depth and location at once (a). magnetic permeability in KYG depth, (b). magnetic permeability in PYB depth.](image)

4. Conclusions
Based on the result, it can be concluded that temperature and magnetic permeability have quite strong linear relationship and in the opposite direction in terms of depth, location and depth and location at once. However the coefficient of the linear regression model is very small which mean that the effect of temperature rise does not significantly affect the value of magnetic permeability. Therefore it is better to use a constanta of the model which have a small standard deviation among them as an input for early warning system in OKI Regency. So it can be choose for a constanta of 1.0022 based on the depth analysis. For temperature and magnetic susceptibility, there is no quite strong linear relationship in terms
of depth, location and depth and location at once. So do the determination coefficient. Therefore magnetic susceptibility is not recommended as an input for early warning system.

5. Acknowledgements
The authors would like to thank the Agency for the Assessment and Application of Technology (BPPT) for funding. We would also like to thank all colleague of Center for Regional Resources Development of Technology (PTPSW) for collecting field data and helpful discussions.

6. References
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