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Determination of soil moisture reduction rate on peatlands in South Sumatera due to the 2019 extreme dry season

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Determination of soil moisture reduction rate on peatlands in South Sumatera due to the 2019 extreme dry season

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Abstract. The positive phenomenon of Indian Ocean Dipole (IOD +) in 2019 caused an extreme dry season in parts of Indonesia, including in the province of South Sumatera. This caused massive fires on peatlands in South Sumatera. The Government of Indonesia through the Agency for Peat Restoration (BRG) has deployed an integrated equipment system to measure in situ several fire control parameters on several peatlands, including in South Sumatera. The aim is to predict and mitigate fire incidents on peatlands. One of the measured parameters is soil moisture. This study has examined the impact of the extreme dry season on the rate of decline in soil moisture at four BRG measurement stations, namely: Cinta jaya-1, Cinta Jaya-2, Padang Sugihan-3, and Karang Agung. The rate of decrease in soil moisture (% per day) obtained were: 0.06, 0.31, 0.38, 0.47 respectively for the stations Cinta jaya-1, Cinta Jaya-2, Padang Sugihan-3, and Karang Agung.

1. Introduction

Peatlands are water saturated soils and consist of organic material with a thickness of more than 50 cm. Indonesia has peatlands around 50% of the total peatlands in the world. The total area of peatlands in the world is around 40 million hectares. Peatlands in Indonesia are spread across almost all islands, especially on the islands of Sumatera, Kalimantan, Sulawesi and Papua. South Sumatera Province has peatlands of around 8.7 million hectares [1-7].

Peatlands in Indonesia are highly flammable, especially in the dry season [8,9]. Peatland fires especially in Sumatera and Kalimantan have a great influence on environmental damage and public health [8, 10-12]. In 2019 there was a fire on peatlands due to the phenomenon of IOD +. The total area of land burned in South Sumatera in 2019 was 361,857 hectares, of which 220,483 hectares were in peat areas, while 131,374 others were in non-peat areas [13].

The Government of Indonesia has deployed several hydrological and climatological parameters measurement stations to predict and mitigate fires on peatlands. This station is managed by an institution called the Agency for Peat Restoration (BRG). In peatlands in South Sumatera province, several stations have been established that can measure parameters, namely: rainfall, groundwater level, soil moisture, and temperature [14,15].

Parameters that are closely related to fire events in peatlands are groundwater level and soil moisture [16-22]. The lower the groundwater level and the lower the soil moisture the peat land will be more flammable [17,23]. This study has analyzed the characteristics of soil moisture especially the speed of decline in the value of soil moisture due to the minimal amount of rainfall during the extreme dry season on peatlands in South Sumatera. Previous studies have found a strong correlation between the amount of rainfall and soil moisture [24], but have not calculated how fast the rate of decline in soil moisture is due to the reduced amount of rainfall.

2. Data

This study has used daily soil moisture data for the period of 1 July 2019 to 31 July 2019 at four BRG stations. The name of stations location and its coordinates is shown in Table 1.

Table 1. Stations name and coordinates.

Name of Stations	Coordinates
Cinta Jaya-1 (CJ-1)	-3.492, 104.978
Cinta Jaya-2 (CJ-2)	-3.472, 104.965
Padang Sugihan-3 (PS-3)	-3.020, 105.232
Karang Agung (KA)	-2.582, 104.511

3. Methodology

This study began by making a time series graph of soil moisture for the period of July 2019. This graph is needed to see the dynamics of soil moisture in the extreme dry season of 2019. The data period was chosen in July 2019 because July 2019 was included in the extreme dry season in South Sumatera. Based on the time series graph, the period of time series whose time series graph is almost linear is chosen, which occurs on July 1, 2019 until July 20, 2019. Then the linear regression equation and the correlation coefficient are calculated using equation (1) - (4). The linear regression equation that has been obtained is processed to get the rate of decreasing soil moisture.

3.1. Linier regression

The general form of linier regression is [25]-[27]:

$$y = a + bx, \tag{1}$$

$$a = \frac{(\sum y \sum x^2) - (\sum x \sum xy)}{N(\sum x^2)\,(\sum x)^2}, \tag{2}$$

$$b = \frac{N(\sum xy) - (\sum x \sum y)}{N(\sum x^2)(\sum x)^2}, \tag{3}$$

where *y* is a dependent variable, *x* is an independent variable, *a* is intercept and *b* is slope.

3.2. Linier correlation

The mathematical formula for calculating the value of the correlation coefficient (r) is:

$$r_{xy} = \frac{1}{N-1}\sum_{i=1}^{N}\frac{(xi-x)-(yi-y)}{s_x s_y}, \tag{4}$$

where s_x and s_y are standard deviation for each variables (*x*, *y*).

4. Result and discussion

Figure 1 displays a time series graph of soil moisture during July 2019. In the figure it appears there is a decrease in soil moisture in all locations with different slope levels. These different slope levels indicate that the rate of soil moisture degradation varies at each study location. Extreme dry season causes very little amount of rainfall so that the discharge of water stored on peatlands is reduced. Reduced water discharge in peatlands causes soil moisture to decrease.

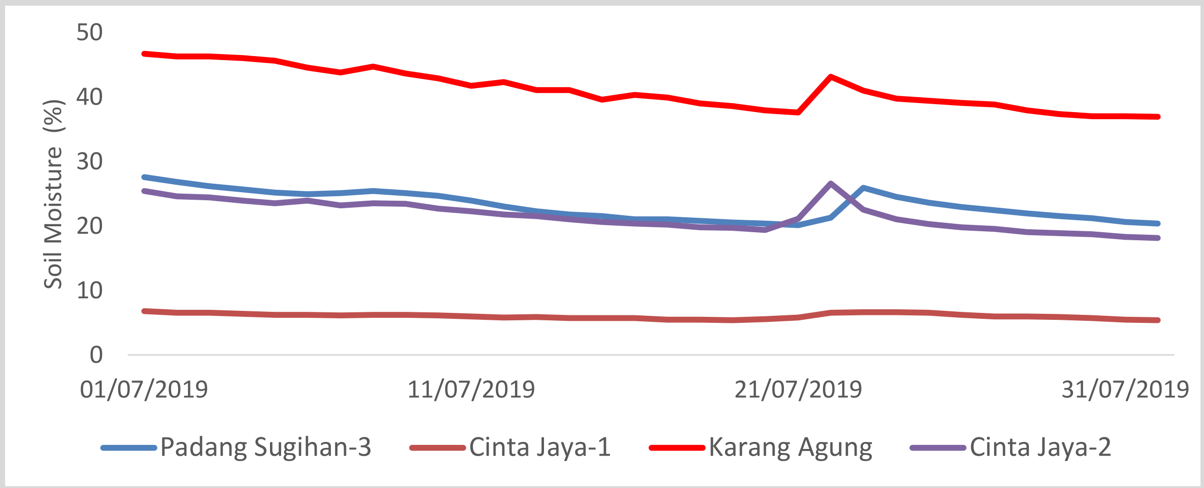

Figure 1. Soil moisture time series graph.

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Figure 2 shows a graph, linear regression equation, and the coefficient of linear correlation. The linear line in the figure is the time series graph of soil moisture in the period 1 July 2019 to 20 July 2019 which has been processed using a linear regression formula. Linear regression equations and linear correlation coefficients are calculated using the regression formula and linear correlation formula. The linear regression equation that has been obtained is processed to calculate the rate of reduction of soil moisture. The calculation process is shown in Table 2.

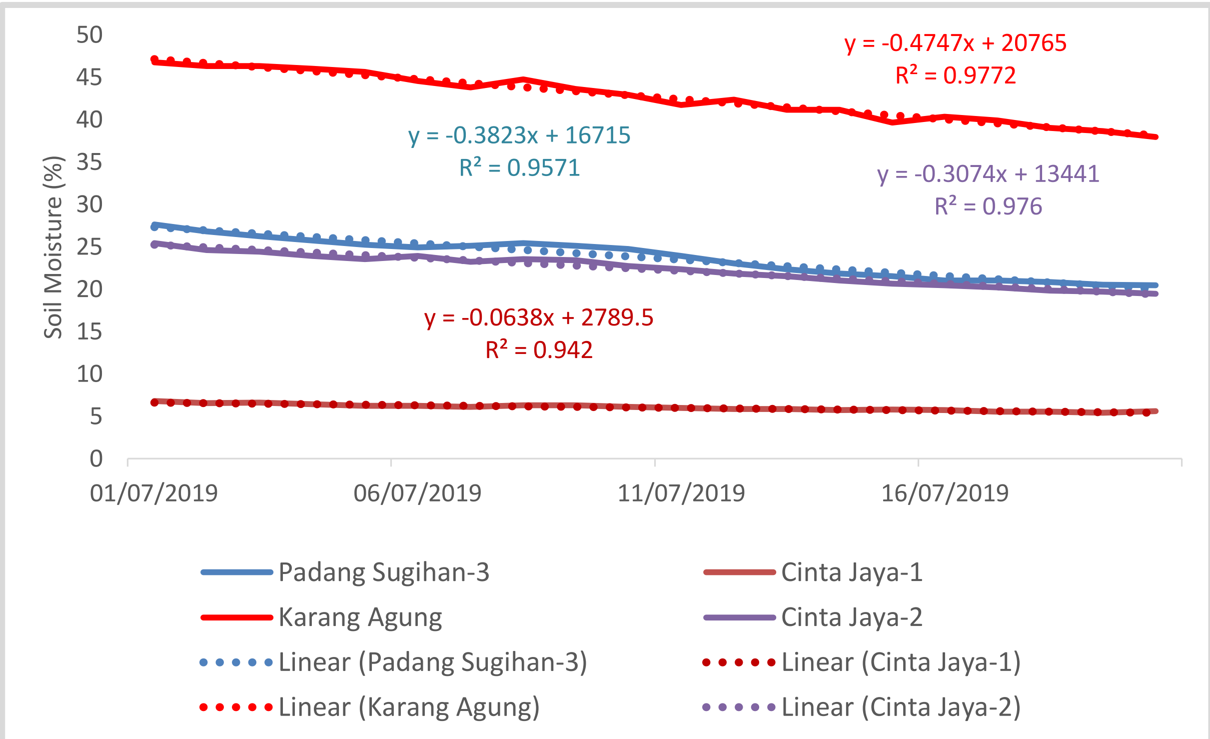

Figure 2. Graph, linear regression equation, and the coefficient of linear correlation.

In Table 2, the value of Y_1 is the value of soil moisture on July 1, 2019 obtained from the linear regression equation at the location concerned by entering the value X = 1. While the Y_{20} value is the soil moisture value on July 20, 2019 obtained from the regression equation at the relevant location by entering the value X = 20. In Table 2 it appears that the location of Karang Agung (KA) has the fastest rate of soil moisture reduction compared to other locations, namely V = 0.47 % /day. This shows that the peat soil layer at Karang Agung location has the highest ability to release water.

Table 2. Statistical data calculation of the rate of decline in soil moisture values.

Station Name	Linier Equation	Y_1 (%)	Y_{20} (%)	$\Delta Y=Y_1-Y_{20}$ (%)	ΔX (day)	$V=\Delta Y/\Delta X$ (%/day)
KA	Y=-0.474X+20765	20764.5260	20755.520	9.0060	19	0.47
PS-3	Y=-0.3823X+16715	16714,.177	16707.354	7.2637	19	0.38
CJ-2	Y=-0.3074X+13441	13440.6926	13434.852	5.8406	19	0.31
CJ-1	Y=-0.0638X+2789.5	2789.4362	2788.224	1.2122	19	0.06

5. Conclusion

The extreme dry season of 2019 has resulted in a decrease in soil moisture in peatlands in South Sumatera. The rate of soil moisture reduction can be calculated by utilizing daily soil moisture data from BRG station measurements. The rate of reduction of soil moisture in each peatland in South Sumatera is different.

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