What is the rate of groundwater level decline on peatlands in South Sumatera during the 2019 extreme dry season?

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What is the rate of groundwater level decline on peatlands in South Sumatera during the 2019 extreme dry season?

M Irfan[1,2], O C Satya[1], Arsali[1], M Ariani[1], A Sulaiman[3] and I Iskandar[1,2]

[1]Department of Physics, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia
[2]Graduate School of Sciences, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia
[3]Agency for Assessment and Application of Technology, Jakarta, Indonesia

E-mail: irfplg@yahoo.com

Abstract. Groundwater level is a parameter that is closely related to fire events in peatlands. The lowering of the groundwater level causes a decrease in soil moisture so that the peatlands become dry and flammable. This study looked for the rate of decline in groundwater levels at 6 locations on peatlands in South Sumatera. The data used are in-situ data from 6 measuring stations belonging to the Peat Restoration Agency on peatlands in South Sumatera. The purpose of this study was to determine the characteristics of the groundwater level which is one of the fire control parameters as an effort to mitigate fire disasters on peatlands. The groundwater level decline rate obtained was (cm/day): 1.68, 1.45, 1.41, 0.85, 0.75, and 0.39 respectively for Sungai Saleh-1, Padang Sugihan-2, Karang Agung, Padang Sugihan-3, Cinta Jaya-1, and Cinta Jaya-2.

1. Introduction

Indonesia is a country that has the largest peatlands in the world. More than 50% of the total peatland in the world is located in Indonesia. The total area of peatland in Indonesia is around 40 million hectares, the majority of which are spread across the islands of Sumatera, Kalimantan and Papua. The majority of peatlands on the island of Sumatera are in the provinces of South Sumatera, Jambi and Riau. The area of peatland in South Sumatera province is around 8.7 million hectares, the majority of which are scattered in Ogan Komering Ilir, Banyu Asin, and Musi Banyu Asin Districts [1, 2, 3, 4, 5, 6, 7].

In the extreme dry season peatlands in Indonesia often burn massively because peatlands in Indonesia are flammable. In the extreme dry season, the rainfall is minimal so that soil moisture decreases. Decreased soil moisture causes peat soils to become very dry, so they burn easily. Extreme dry seasons can occur due to natural phenomena such as El Nino, positive Indian Ocean Dipole (IOD+), or a combination of these two phenomena. In 2019 there was an extreme dry season due to the IOD+ phenomenon. In 2019 peatlands in South Sumatera burned massively covering an area of approximately 220,483 hectares [8, 9, 10, 11, 12, 13].

Various efforts have been made to mitigate fire disasters on peatlands by both the government and the private sector. The Indonesian government, through the Peatland Restoration Agency (BRG), has established several stations to measure parameters related to fires on peatlands. The aim is to control these parameters so that the number of hotspots that appear is minimal. In South Sumatera the measurement station has been established since July 2017 [14, 15].

Several parameters which are estimated to be related to fire events in peatlands are rainfall, groundwater level, temperature, wind rate, and soil moisture [16, 17, 18, 19, 20, 21, 22]. This study examines the dynamics of one of these parameters, namely the groundwater level (GWL) by calculating the rate of decline of the groundwater level at several locations on peatlands in South Sumatera. By knowing the rate of groundwater level decline, it can be used as an input to formulate strategies to maintain the groundwater level in its normal position. Drastically decreasing groundwater levels can cause soil moisture to decrease so that peatlands become dry and flammable [23, 24].

2. Method

2.1. Data

The data used in this study were groundwater level and rainfall measured by BRG stations in the period 1 August 2019 to 31 October 2019. Groundwater level and rainfall data are the average daily BRG data for the period July-October 2019. This period was chosen because in that period the amount of rainfall was very minimal. Groundwater level data were taken from 6 stations, namely Sungai Saleh-1, Cinta Jaya-1, Cinta Jaya-2, Padang Sugihan-2, Padang. Sugihan-3, and Karang Agung. Rainfall data is only available at 4 stations, namely Sungai Saleh-1, Cinta Jaya-2, Padang Sugihan-2, and Karang Agung. The coordinates of the 6 stations are shown in Table 1.

Table 1. Stations name and coordinates

Name of Stations	Coordinates
Sungai Saleh-1 (SS1)	-2.911, 105.082
Cinta Jaya-1 (CJ1)	-3.492, 104.978
Cinta Jaya-2 (CJ2)	-3.472, 104.965
Padang Sugihan-2 (PS2)	-3.091, 105.217
Padang Sugihan-3 (PS3)	-3.020, 105.232
Karang Agung (KA)	-2.582, 104.511

2.2. Data Analysis

The relationship between rainfall and groundwater level data is searched through time series graphs. The time series graphs obtained are analyzed to find periods that have a graph approaching a linear line. After obtaining the period, a time series groundwater level graph is made for that period which is linear. Then look for the linear regression equation using linear regression equation assisted by Excel software. The linear regression equation obtained was analyzed to obtain the rate of decline in the groundwater level at each station.

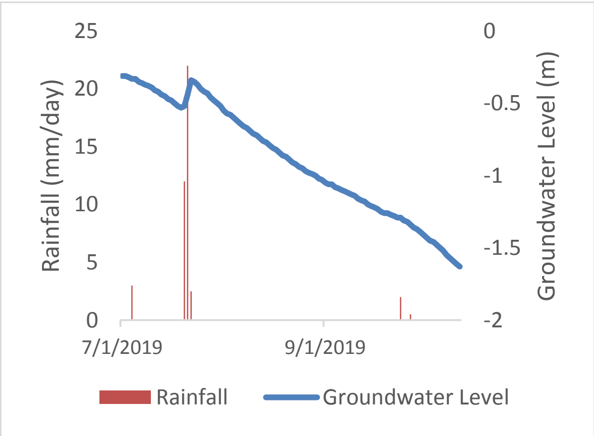
3. Result and Discussion

The time series graph of the relationship between groundwater level and rainfall at 4 stations is shown in Figure 1. From this figure, it is evident that the groundwater level is greatly influenced by rainfall, and in August 2019 there was almost no rain in the four locations so that the graph tends to be linear.

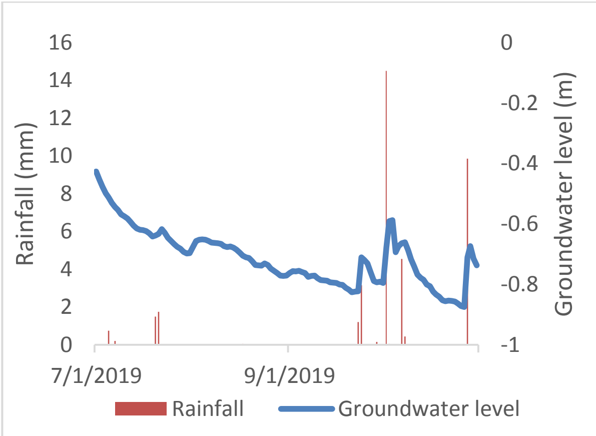
To calculate the rate of groundwater level decline, a groundwater level time series graph is taken during the period 1-25 August 2019, in which the rainfall is close to zero. Groundwater level data were taken from 6 study locations, namely: Cinta Jaya-1, Cinta Jaya-2, Sungai Saleh-1, Padang Sugihan-2, Padang Sugihan-3, and Karang Agung. The graph obtained is almost in the form of a straight line as shown in Figure 2.

In Figure 2, it can be seen that the slope of the line is different for each station, which shows the difference in the rate of groundwater level decline at each study location. Based on the statistical data related to this linear line, it can be calculated the rate of groundwater level decline at each location as shown in Table 2.

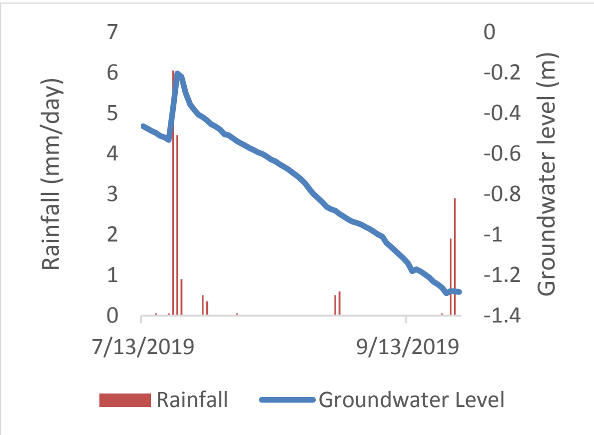
In Table 2, the Y1 value is the groundwater level value on August 1, 2019 which is obtained from the empirical equation at the location concerned by entering the value X=1. Whereas the Y25 value is the groundwater level value on August 25, 2019 which is obtained from the empirical equation at the location concerned by entering the value X=25. From Table 2, it appears that the SS1 location has the fastest groundwater decline rate compared to other locations, namely v = 1.68 cm/day. This is related to the position of the BRG measurement station on SS1 which is very close to the canal as shown in Figure 3. It is proven that the presence of canals can accelerate the decline of groundwater level, especially in the extreme dry season.



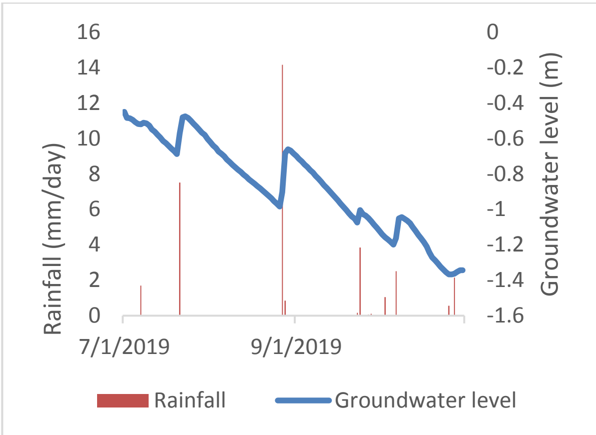
(a)



(b)



(c)



(d)

Figure 1. Time series graph of groundwater level and rainfall relationship in (a) Sungai Saleh-1, (b) Cinta Jaya-2, (c) Padang Sugihan-2, (d) Karang Agung

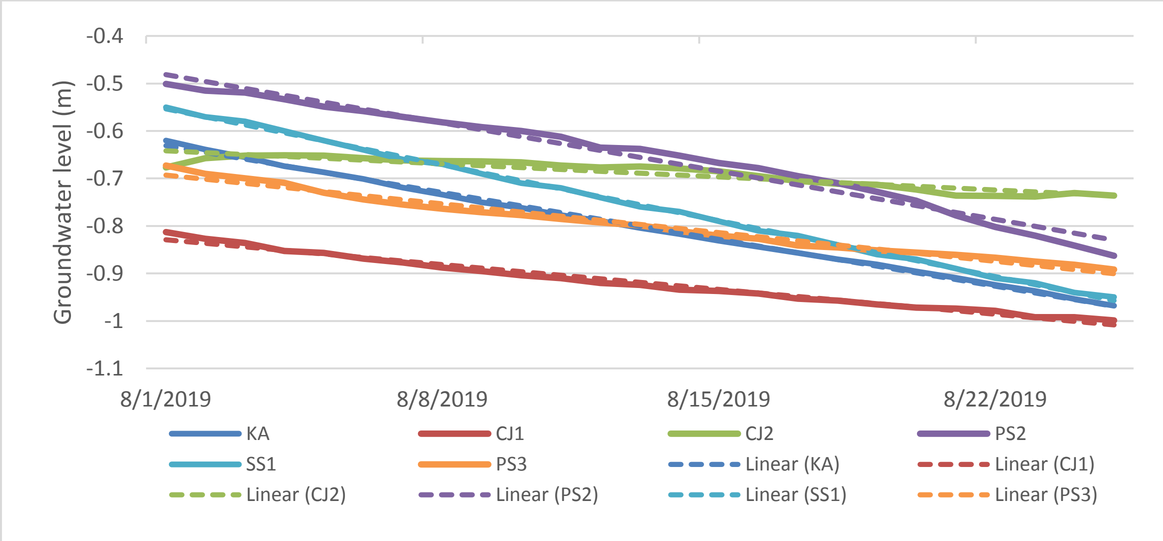


Figure 2. Time series graph of groundwater decline

Canalization can be one of the factors causing peatlands to dry up, so that peatlands can burn easily. Peatlands can be imagined as flammable sponges but if they are saturated with water they are very difficult to burn. In the extreme dry season where the amount of rainfall is very little, the water deposits in the peatlands will flow into the canals due to the lower position of the canals so that the peatlands become dry and become flammable.

The function of peatlands must be returned to its original state so that it is not flammable, namely by returning groundwater on peatlands to its original state. This can be done by closing the canals in the peatlands so that the water content remains even in the extreme dry season. If this is difficult to do, simple reservoirs can be built on peatland where water can be filled from rivers so that the groundwater level can be maintained during extreme dry seasons.

Table 2. Statistical data for determining the rate of decline in groundwater level

Station	Linier regression of GWL decline	Y_1 (m)	Y_{25} (m)	$\Delta Y=Y_1-Y_{25}$ (m)	ΔX (day)	$v=\Delta Y/\Delta X$ (cm/day)
SS1	Y=-0.0168X+734.25	734.2332	733.8300	0.4032	24	1.68
PS2	Y=-0.0145X+633.76	633.7455	633.3975	0.3480	24	1.45
KA	Y=-0.0141X+614.69	614.6579	614.3375	0.3384	24	1.41
PS3	Y=-0.0086X+377.05	377.0414	376.8350	0.2064	24	0.85
CJ1	Y=-0.0075X+324.57	324.5625	324.3825	0.1800	24	0.75
CJ2	Y=-0.0039X+171.15	171.1461	171.0525	0.0936	24	0.39

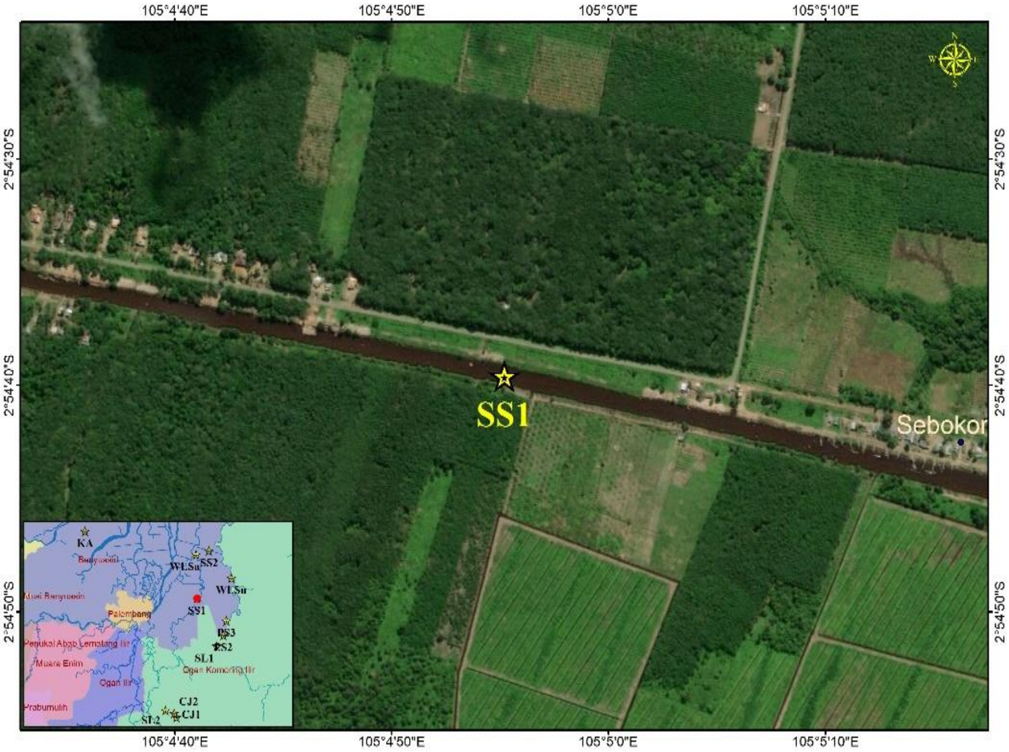


Figure 3. Map of SS1 station

4. Conclusion

This research has succeeded in calculating the rate of groundwater levels decline at several measurement locations on peatlands in South Sumatera. The rate of the groundwater level decline at each location is different. The highest rate was found at the location closest to the canal, namely the Saleh 1 River. This shows that the presence of canals on peatlands can accelerate the decline of groundwater levels in the peatlands during the extreme dry season.

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