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Effect of Water Content and Soil Improvement (Hydrogel) on Peat Fire Suppression

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Abstract

Forest and land fires are Indonesia's biggest problem which has continued from 2014 to the present. The number of activities to find the best solution in fire is something that has been done until now. Various methods, both preventive and repressive, have been implemented to prevent forest and land fires from occurring. This research aims to be a sureextinguishing gel, namely hydrogel, which can be used in efforts to extinguish forest and land fires. Extinguishing forest and land fires using hydrogel is a new method that is expected to prevent forest and land fire zones from spreading. This research shows that the tendency of decreasing the average water content of peat due to the drying process based on different intervals of oven time, namely the lowest yield ranged from 61.25% to the highest with a water content of 109.57%.

.Keywords: Air Sugihan, Water Content, Hydogel

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1. Introduction

South Sumatra has an administrative area of 91,806.36 km2, which is located between 1037'27" - 4055'17" South Latitude and between 10203'54" - 106013'26" East Longitude. South Sumatra has 1.42 million ha of peatlands or around 15.46% of the area of South Sumatra. South Sumatra's peatlands are included as the second largest province on the island of Sumatra after Riau Province [1].

Extensive peatland fires occurred in 2006 - 2008, destroying around 1.2 million ha of peatlands in South Sumatra, which are scattered in Ogan Komering Ilir (OKI), Banyuasin, and Musi Banyuasin Districts. In addition, the provinces of Jambi, Riau, West Kalimantan, Central Kalimantan, and South Kalimantan experienced severe peat fires from 1997 to 1998, and 2015 was the peak of peat fires[2] The occurrence of peat fires can be caused by several factors such as El Nino, forest encroachment activities, cultivation, the resilience of vulnerable ecosystems, the degradation of peat forests into industrial plantations and oil palm plantations[2].

One of the impacts of forest fires is the loss of vegetation which causes the land to open, making it easily eroded and unable to withstand flooding [3] Currently, the process of extinguishing forest and land fires in Indonesia only uses water, where water that is dropped from above at a hot temperature will evaporate into the air so that it does not reach the point of fire [4]. The process of reducing the temperature of the fuel does not occur because water that is lowered through rain can be evaporated back into the air at high fire temperatures. This makes extinguishing using these methods ineffective and inefficient so that a more effective and efficient method of extinguishing forest and land fires is needed in the social, economic, and ecological aspects [4].

This study aims to ensure extinguishing gel, namely, the hydrogel can be used in efforts to extinguish forest and peatland fires. Extinguishing forest and land fires using hydrogel is a new method that is expected to prevent forest and land fire zones from spreading.

2. Materials and Methods

The study was conducted at the Laboratory of Soil Science Physics, Faculty of Agriculture, Sriwijaya University. The location of the peat soil sampling in the rice fields of the Air Sugihan sub-district 2˚ 44' 40,38˚ South, 105˚ 20',734˚ E and 341˚ N (Figure 1). In general, the vegetation in the area is in the form of shrubs and smallholder plantations.

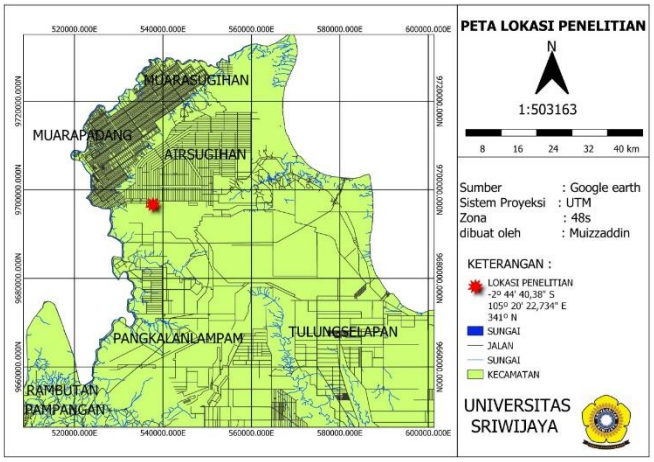

Figure 1. Location of Sampling

Peat soil samples were taken using a peat drill with a fibric peat soil type depth of ± 60 cm and a hymic soil type of ± 30-60 cm. Then the samples are classified according to the type of peat soil (fibric and himic) and then the process is dried or aerated in a greenhouse. Measurement of the water content of the peat was carried out after the oven process with a temperature of 105º C. Then the process of burning the peat soil was carried out as much as 7 kg with a water content of 60%, 70%, 80%, and 100%. After 50% of the combustion process, the peat soil is extinguished using a hydrogel at a dose of 0%, 0.25% and, 50%. The time recorded for each peatland burned is until a blackout occurs.

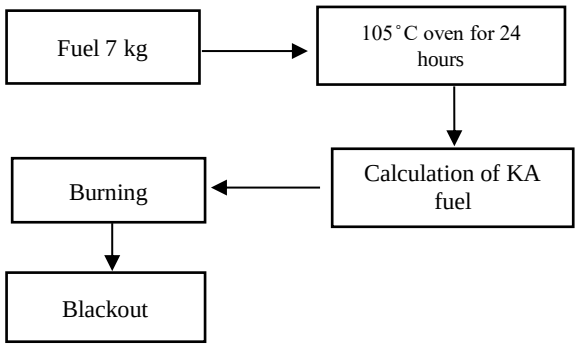

Figure 2. Research Flow Diagram

2.1 Analysis of variance

Extinguishing duration testing was carried out using a completely randomized design analysis (CRD). The analysis used is two factors, namely the type of fuel and water content. The treatment was carried out in three repetitions so that there were 24 experimental units. The linear model used in the RAL analysis is as follows:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Information:

Y_{ij} = result of observation of treatment I and repetition of j

μ = general average value

α_i = the effect of the old blackout factor at level i

ε_{ij} = error test treatment I-test j-repeat

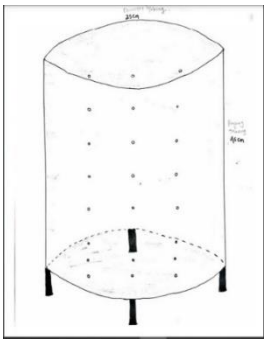

Figure 3. The combustion process tube

3. Results and Discussion

3.1 Initial Combustion Conditions

Climate and weather are natural factors that can affect forest and land fires [5]. 87% of forest and land fires started at 10 a.m. to 5 p.m., generally, the peak of fires occurred at 2 p.m. with 109 out of 110 fire occurrences [6]. This is because the water content is quite low <30% occurs during the day with temperatures ranging from 30-35˚C so that it can cause the process of forest and land fires quickly[6].

Table 1. Initial conditions before combustion

Burning Time (WIB)	Room Temperature (ºC)	RH (%)
12.00	28	65

In this study, the initial conditions for the combustion process before combustion are presented in Table 1. At 12.00 WIB, the initial temperature before combustion is 28Cand the low wind speed prevents the fire from developing so that it is concentrated at one point. During the day, the average temperature ranges from 30-34º C with the water content of the fuel is low enough (< 30%) which can make the combustion process take place quickly.

3.2 Peat land Moisture Content

The water content of peat soil greatly affects the

vulnerability of land to fire, the lower the water content, the heavier the peat fire rate [7] The difference in the thickness of the peat soil follows the wet weight used, and the dry weight of the peat soil will affect fire behavior because the availability of water content as fuel decreases. [4]. This research generally uses the second and third soil layers. So that the depth of the soil layer determines the storage volume of groundwater, the deeper a layer of soil, the higher the soil water content. This is because the deeper the soil layer, the lower the maturity of the peat so that the soil can hold more water. The ability to absorb (absorbing) and holding (retaining) water from peat depends on the level of maturity [8] Groundwater availability is not only based on maturity, but is also influenced by rainfall or irrigation water, the ability of the soil to hold water, evapotranspiration, and groundwater level[9].

The higher the water content of the peat, the more heat energy is needed to evaporate the water to reach the burn point phase, therefore peat that has a lower water content will burn more easily and the fire from the combustion process will spread faster, and the results showed that there was a tendency to decrease the water content of the peat due to the drying process based on different oven time intervals[4]. Stated that the water content of peat due to the combustion process tends to be low compared to that of the peat due to the drying process [10]

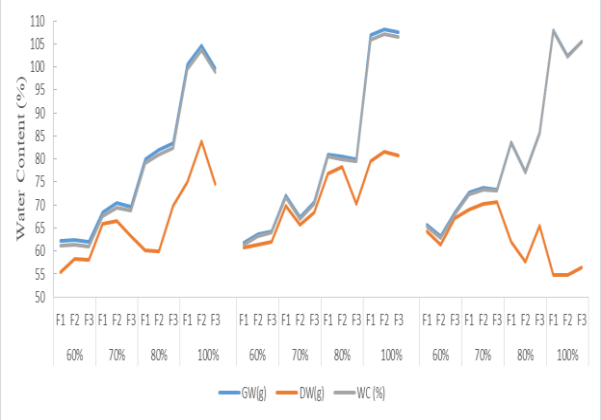

Figure 4. Water Content of Fibric Peat Soils

Figure 4 shows the difference in the percentage of water content in fibric peat soils, where the lowest water content is 61.25% at DW of 55.50 g and GW for 62.25 g for 0% treatment (without hydrogel). While the highest percentage of water content was 107.81% with BK 54.75 g and BW 107.93 g for treatment using 0.50% hydrogel. In addition to the difference in percentage also occurred in the type of hemic peat (Figure 5), the type of peat for treatment 0% had the lowest water content of 60.79% with DW 51.44 g and GW 61.79 g. For the highest water content is 0.25% treatment at 109.57% with BK 83.48 g and BW 110, 57 g.

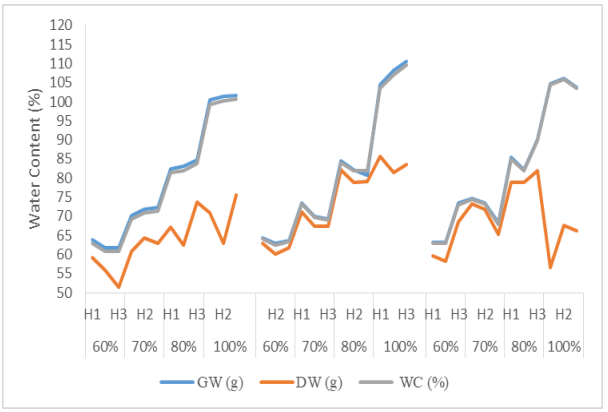

Figure 5. Hemic Peat Soil Content

3.3 Testing Moisture Content and Combustion Time

Water content testing is conducted to determine how much water is still stored and the amount of water lost in the peat soil based on the length of heating time. The results of the analysis of field observations and laboratory tests are presented in Table 2.

Table 2. Duration of burning peat soil at 0%

Sample Code	Burning Time (Hours)			
	KA 60%	KA 70%	KA 80%	KA 100%
F1	10.52	13.01	28.28	32.22
F2	10.32	12.17	27.27	32.14
F3	9.34	12.30	27.08	31.04
Average	10.06	12.49	27.54	31.80
H1	10.49	14.04	27.20	32.27
H2	10.14	13.52	29.30	33.39
H3	10.19	13.31	29.27	34.36
Average	10.36	13.62	28.59	33.34
F1	9.17	14.37	28.92	30.09
F2	9.35	14.14	29.53	33.19
F3	9.32	14.03	28.81	32.01
Average	9.28	14.18	29.09	32.03
H1	10.14	16.04	30.92	32.87
H2	10.07	17.52	31.73	34.99
H3	10.26	18.29	32.04	33.96
Average	10.16	17.28	31.59	33.24
F1	9.44	12.45	28.16	33.27
F2	9.36	14.22	28.01	32.45
F3	9.32	12.25	28.12	33.33
Average	9.37	12.97	28.10	32.02
H1	10.19	14.27	30.01	36.99
H2	10.27	14.13	30.30	35.24
H3	10.02	14.22	30.16	36.23
Average	10.16	14.20	30.16	36.15

The effect of water content on burning peat soil without using hydrogel with the treatment carried out is burning until the end or until the fire goes out by itself without the help of hydrogel. In Table 2 the minimum average time for the

burning process is 9 hours 28 minutes and the time at 60% moisture content and the maximum is 32 hours 55 minutes at 100% moisture content for fibric peat (F3). Meanwhile, the minimum average time for the burning process on hemic peat is 10 hours 16 minutes with a moisture content of 60% and the maximum time is 36 hours 15 minutes at a moisture content of 100% (H3).

Table 3. F (ANOVA) Duration of Burning Peat Soil with Water Content of 60%, 70%, 80%, 100%.

Test Type	Sig	F_{count}	F_{table}	Conclusion
Homogeneity	0.013			Homogeneous
F ANOVA	0.000	1.095.08	2.74	H_1 is accepted. H_0 rejected.

Based on the results of the analysis of the F ANOVA test, the significance value obtained for the homogeneity test was 0.013 so it was less than 0.05, meaning that the data tested had unequal or heterogeneous variances. In the F ANOVA test, a significance value of 0.000 was obtained, and the value of the count of 1.095. Thus, it can be concluded that the F ANOVA hypothesis test H_1 is accepted, and H_0 is rejected because the significance value obtained is 0.00 <0.05 and the F value obtained is 1.095 (F_{count}) > 2.74 (F_{table}). This means that there is an influence between water content on peat burning.

Table 4. Post- hoc test

Water Content	Comparison of Moisture Content	Sig	Conclusion
60%	70%	0.00	Significant Influence
	80%	0.00	Significant Influence
	100%	0.00	Significant Influence
70%	60%	0.00	Significant Influence
	80%	0.00	Significant Influence
	100%	0.00	Significant Influence
80%	60%	0.00	Significant Influence
	70%	0.00	Significant Influence
	100%	0.00	Significant Influence
100%	60%	0.00	Significant Influence
	70%	0.00	Significant Influence
	80%	0.00	Significant Influence

In this hypothesis, further testing was carried out using post-hoc tests because the results showed that there was an influence between water content on peat burning (hypothesis H1 be accepted). The *post-hoc* test was carried out using the *Games-Howell* test because the data used had unequal variances. The significance value obtained is 0.00 < 0.05. Thus it can be concluded that there is a significant effect between each moisture content (60%, 70%, 80%, and 100%) on peat burning time.

3.4 Effect of Hydrogel on Extinguishing.

Extinguishing the peat is carried out when 50% burning occurs using water mixed with 0.25% and 0.5% hydrogel, then the time is calculated until the fire goes out, there are no embers, and smoke remains. Tests were carried out to determine how much influence the water content mixed with hydrogel had on the blackout time. The results of the laboratory test analysis are presented in Table 5 and the test results on the second hypothesis can be seen in Table 6 below:

In Table 5, extinguishing treatment was carried out with water content of 60%, 70%, 80%, and 100% for fibric and hemic peat soil types using 0%, 0.25%, and 0.5% hydrogels. The average maximum extinguishing time is 2 minutes 39 seconds using 0.25% hydrogel, 70% water content and the minimum time is 1 minute 9 seconds using 0.5% hydrogel, 100% water content for fibric peat types. Meanwhile, for hemic peat, the minimum average burning time is 1 minute 9 seconds using 0.5% hydrogel, 100% moisture content and the maximum average time is 2 minutes 39 seconds with 0.25% hydrogel content 70% water content.

Based on the results of the F ANOVA test analysis, it can be seen that the significance value obtained for the homogeneity test is 0.111 so that it is greater than 0.05, meaning that the data being tested has the same variance or is homogeneous. In the F ANOVA test, a significance value of 0.000 was obtained and the value of included to 165.993. Thus, it can be concluded that the F ANOVA hypothesis test H1 is accepted, and H_0 is rejected because the significance value obtained is 0.00 <0.05 and the F value obtained is 165.993 (F_{count}) > 2.74 (F_{table}). This means that there is a significant effect of hydrogel on fighting peat fires.

Table 6. Analysis of the F ANOVA Test the Effect of Hydrogel on Extinguishing.

Test Type	Sig	F_{count}	F_{tabel}	Conclusion
Homogeneity	0,111			Homogeneous
F ANOVA	0,000	165,99	2,74	H1 is accepted, H0 rejected

Table 5. The duration of peat soil extinguishing on hydrogel 0%, 0.25%, and 0.5%

WC %	Hydrogel (%)	Burn Time (minutes)			Average
		F1	F2	F3	
60%	0	2.16	2.05	2.18	2.13
	0.25	2.45	2.23	2.56	2.41
	0.5	1.09	1.02	1.31	1.14
		H1	H2	H3	
	0	2.41	2.09	2.21	2.23
	0.25	2.22	2.45	2.05	2.24
	0.5	1.02	1.41	1.04	1.15
70%	0	2.18	2.22	2.18	2.19
	0.25	2.45	2.15	2.56	2.39
	0.5	1.01	1.31	1.56	1.29
		H1	H2	H3	
	0	2.45	2.28	2.31	2.35
	0.25	2.01	2.45	2.05	2.17
	0.5	1.11	1.32	1.46	1.30
80%	0	2.10	2.14	2.02	2.09
	0.25	2.01	2.18	2.33	2.17
	0.5	1.11	1.42	1.21	1.25
		H1	H2	H3	
	0	2.32	2.17	2.41	2.30
	0.25	2.22	2.16	2.24	2.21
	0.5	1.41	1.18	1.08	1.22
100%	0	2.11	2.20	2.18	2.16
	0.25	2.13	2.34	2.56	2.34
	0.5	1.09	1.12	1.05	1.09
		H1	H2	H3	
	0	2.40	2.35	2.40	2.38
	0.25	2.15	2.45	2.05	2.22
	0.5	1.03	1.18	1.05	1.09

In this hypothesis, further testing was carried out using a post-hoc test because the results showed that there was a significant effect between hydrogels on extinguishing peat fires (hypothesis H1 be accepted). The post-hoc test was carried out using the *Bonferroni* test because the data used had the same variance. In the results of the post-hoc test analysis, the significance value obtained for 0% and 0.25% hydrogels was 0.062 and the remaining ratio between the percentages of hydrogels was 0.000. Thus, it can be concluded that there is no significant effect if extinguishing is carried out using 0% and 0.25% hydrogels at the time of extinguishing peat fires. If peat fire suppression uses 0.5% hydrogel, there will be a significant effect on the time needed to extinguish peat fires.

Table 7. Results of the Post-Hoc Test on the Effect of Hydrogel on Extinguishing.

Hydrogel	Hydrogel Comparison	Sig	Conclusion
0%	0,25%	0,062	No Significant Effect
	0,50%	0,000	Significant Influence
0,25%	0%	0,062	No Significant Effect
	0,50%	0,000	Significant Influence
0,50%	0%	0,000	Significant Influence
	0,25%	0,000	Significant Influence

4. Conclusion

1. There is a tendency to decrease the average water content of peat due to the drying process based on different oven time intervals, namely the lowest yield ranging from 61.25% to the highest with a water content of 109.57%.
2. The effect of hydrogel on extinguishing the significance value obtained for 0% and 0.25% hydrogels was 0.062 and the remaining ratio between the percentages of hydrogels was 0.000. Thus, there is no significant effect if extinguishing is carried out using 0% and 0.25% hydrogels at the time of extinguishing peat fires. However, a significant value occurred in the 0.5% hydrogel for fighting peat fires.

5. Conflict of Interest

The author stated that there is no conflict of interest with any institution or any person related with the research and publication.

6. Acknowledgement

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