Impact of forest fire in peat land on land properties in Pelalawan district region

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Abstract. The physical, chemical, and biological properties of peat soil in several levels of fire in Kampar regency. The research was conducted from March to April 2017 in Pelalawan Regency, Riau Province, and Soil Science Laboratory, Faculty of Agriculture, University of Riau. The research was conducted by a survey in the field, determining the sample point using Purposive Sampling Method. The samples were taken from 3 locations i.e. the land with heavy, medium and light fire level and control (non-burning/natural forest) 12 units of the experiment. Soil samples were analyzed by the physical and chemical characteristics soil. The results of the physical and chemical characteristics of soil undergoing changes and categorized as broken.

1. Introduction
Riau Province has the charm of peatlands with a million benefits in the ecosystem structure. At present, the privilege is threatened by land degradation that goes hand in hand with the development of plantations, agriculture, and industry. Peat soil island that can be used as an energy source. Peat soil is one of the most abundant lands in the world by originating from weathering or decay from the remnants of plants that are half-rotten and in the process takes a very long time.

Even though it has a myriad of features, peat soil also has deficiencies, such as a very wide range of fires. Even if peatland is on fire, it has a high degree of difficulty to extinguish it. Fire is a serious problem that can have an impact if viewed from various aspects. One of the impacts of forest fires that can be assessed is the quality of the land including the physical, chemical and biological properties of the soil.

The impact of changes in the physical properties of soil due to combustion is seen by the loss of soil organic matter by the heat of the fire destroys the structure of the soil, increases the weight of the soil, reduces soil porosity. This damage will result in decreasing the speed of infiltration and increasing the speed of runoff water [1]. Where, it appears that the chemical properties of peat soil due to combustion are changes in fuel to ash containing various nutrients such as N, P, S, and C / N will be lost by the evaporation process during the process of forest fires. In addition, combustion increases the pH of peat soil. The chemical properties of soil due to fire will not be able to improve soil fertility in the long term but only temporary.

The impact of changes in the biological properties of peat soil due to combustion is the death of flora, fauna and soil microorganisms. This loss will affect the chemical properties of peat soil. This is caused by the secretion and excretion of fauna and soil microorganisms that can indirectly improve the chemical properties of the soil.
2. Materials and Methods

This research was conducted in 4 locations, which consisted of a non-burning area (K1) in Pangkalan Gondai village, (coordinates 00 05 '31 "N 101 04' 14" E), (K2) slightly burned area in Kerinci Barat village (coordinates 00 23 '39 "N 101 04' 56" E), Pangkalan Kerinci Subdistrict, (K3) Moderately burned area in Langgam Village (coordinates 00 06 '32 "N 101 39' 41" E), Langgam District, and (K4) heavily burned area in Kerinci Timur village (coordinates 00 24 '42 "N 101 52' 40" E), Pelalawan Regency, Riau Province. The location of this study has experienced a fire incident for 1 year; this land is now dominated by peatland with a maturity level between milk and cloth and has a depth of 4-7 meters (Figure 1).

2.1 Analysis of the physical properties of peat soil

The tools used to measure the activity of physical properties of soil are soil samples in the form of rings, hoes, peat drills, ovens, analytical scales, porcelain glasses, measuring cups, plastic, soil. Analysis of soil samples was carried out at the Soil Laboratory of the Faculty of Agriculture, Riau University, Pekanbaru, Riau. This study was conducted for 1 month starting from March to April 2018. In analyzing nutrient levels in a solid sample. Nutrients in the soil were analyzed by the gravimetric method in the form of nutrient deposits in the soil. The constant price of nutrient deposition solubility in soil = 1.8 x 10−10.

The implementation is first weighed 2 grams of sample, then dissolved in a little HCl in a small beaker. Then transferred and diluted in a 250 mL measuring flask. Next, pipette from this solution 25 mL into a 400 mL beaker, add 50 mL aquadest and 10 mL 1: 1 HCl. Add 2 mL HNO 3 concentrated and boil carefully until the solution sample is yellow. Dilute to 200 mL. Heat until boiling. Then, slowly add 1: 1 ammonia to it until all the nutrients (III) are deposited (the steam on it smells of ammonia). Boil for one minute and leave the precipitate down to the bottom of the beaker. After most of the sediment has gone down, the solution is decanted through filter paper that has been prepared in a filter funnel, but it is tried so that most of it remains in the beaker.

Added a 1% hot solution of ammonium nitrate into a beaker, stirred briefly, and left the precipitate down to the bottom of the glass, then repeated this decantation work several times, then transferred most of the sediment to filter paper, cleaned the glass wall with policeman and transferred the remaining sediment to filter paper with hot water spray aid. Wash these deposits several times with a hot solution.

![Figure 1. Map of research location in Pelalawan Regency](image-url)
of ammonium nitrate until the filtrate is practically chloride free. While this work took place, it was spawned with a clean porcelain cup with a lid. After cooling in the desiccator, the weight is determined. Next, it is wrapped in sediment in ash-free filter paper or Whatman 41 filter paper and placed in a cup. Heated on low heat until all the water evaporates, then paperized and scraped the paper insufficient airflow. Finally, the cup is spread and the sediment above the Bunsen burner for 15 minutes, cooled in the air and in the exicator before determining the weight. Repeat this work until the weight is constant.

Determination of Gravimetric Nutrient Levels
1. Carefully weighed 2 grams of a soil sample, dissolved in 100 mL beaker with 25 mL of water. Moved quantitatively into a 100 ml measuring flask and diluted to the boundary mark.
2. Piped 25 mL of this solution into a 400 mL beaker, added a little distilled water, and 5 mL of 1: 1 HCl solution, diluted to 200 mL.
3. Heated to around 70°C, added 25 mL Dimethyl Glioksim solution, stirred evenly.
4. Carefully add Ammonium Hydroxide solution until Ni-DMG red precipitate is formed, a little alkaline solution is added until it smells ammonia.
5. Put the beaker and the contents above the water bath and left for 20 to 30 minutes, checking whether all nutrients have settled completely.
6. The solution is cooled for a while and then filtered through a maser glass cup which has known the weight.
7. Washed with cold water, and then dried at 110°C to 120°C. After being cooled in the exicator, it is weighed until the weight is constant, and done in duplicate.

So, in one liter of a solution, there is 0.48 mg of nutrient deposits in the soil which is not deposited. In accordance with the laws of similar ions, the equilibrium reaction will shift towards the formation of deposits. The impact of changes in the chemical properties of peat soils due to forest combustion is that there is a change in organic material to ash, which contains many nutrients such as N, P, S. Then C or N will disappear along with the evaporation process during the process of forest fires. In addition, forest fires can increase the pH level of peat soils, and warm up by fire. So that all this can destroy the soil structure, increase soil weight, and ultimately reduce soil porosity. Damage to soil structure can result in a decrease in the speed of infiltration and an increase in runoff water speed [1]. Based on the chemical properties of the soil, due to these forest fires, it turns out that it will not be able to increase soil fertility in the long term but is more temporary.

Furthermore, the impact of changing the biological properties of peat soils due to forest fires is the death of flora, fauna and soil microorganisms. The death of flora and fauna will affect the chemical properties of peat soil. This is caused by the results of secretion and excretion of soil fauna and microorganisms, which indirectly can improve the chemical properties of the soil itself.

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2.2 Analysis of the physical characteristics of peat soil
The material used in this study is peat soil on burned land and natural forests. Isolates, GPS, cameras, meters, stationery, and tools used during the analysis in the soil laboratory. This research was conducted using a survey method. Determination of sampling points using the Purposive Sampling Method, which is choosing locations according to the purpose of the research conducted in four locations. The four selected locations are as follows:

Pangkalan Kerinci District includes:
- Point K1, land that does not experience a fire in the village of Pangkalan Gondai, (coordinates 00 05 '31" N 1010 49 '14" E),
- Point K2, the area that burned a little in the village of Kerinci Barat (coordinates 00 23 '39" N 1010 49 '56" E),

Langgam District includes:
- K3 point, a moderate burning area in Desa Langgam (coordinates 00 06 '32" N 1010 39 '41" E),
- Point K4, heavily burned area in Kerinci Timur village (coordinates 00 24 '42" N 1010 52 '40" E),

The 4 points are in the area of Pelalawan Regency, Riau Province. The 3 areas of sampling area under conditions:
- Land with a mild fire level (K1).
- Land with moderate fire (k2).
- Land with a heavy fire level (K3).
- Zero fire level (K4)

The fourth location is the land from the land area where there has never been an event of land burning (natural forest), which in this study was used as a control. Each location is given 3 replications so that all 12 units of observation sample points are obtained.

3. Results and Discussions
3.1 Analysis of soil physical properties
3.1.1 Soil water content (%)
The results of the analysis show that the more severe the level of land fires, the lower the moisture content at the point of observation. The level of soil water in various levels of peatland fires is presented in Figure 2. Figure 2 shows that there has been a decrease in peat water content after peat soil has burned with different levels of fire. The heavier the level of peat fires, the lower the water content in peat soil. The highest water content value occurs in non-combustible peat soils which are used as control treatments.
Based on the results of observations, it can be seen that the water content with the highest percentage is found in unburned soil samples 296, 61%. While with increasing soil temperature the peat evaporation process is faster so that the soil water content decreases. This is consistent with the statement of [2] that fires can increase soil temperature and cause soil water content to decrease.

Fires also produce minerals (ash) which can reduce the moisture content of peat soil, this is due to the ash would fill soil pore spaces are empty, so the pore space for storage of groundwater is reduced. This is consistent with the statement of [2] that ash from burning organic matter due to burning peatland causes clogged soil pores and impacts on disturbing the storage process of groundwater, resulting in reduced peat water content.

3.1.2 Water binding power (%)
The results of the analysis show that the heavier the level of land fires, the lower the value of the binding power of water at the point of observation. Power to bind groundwater at various levels peatland fires are shown in Figure 3.
Figure 3 shows that there has been a decrease in the binding power of peat water after burning with different levels of fire. The value of the binding power of water at the level of fire is lower than 164, 76 %, compared with the value of the binding power of water at the moderate fire level of 177.13%, lightly 187.34%, and those that did not burn higher with a value of 208.65%. The presence of fires shows that a clear impact on the physical properties of the soil will affect soil temperature, soil structure, and the ability of the soil to absorb water. Large fires will cause the bulk density to increase, which in turn will reduce the porosity and rate of soil infiltration which in turn has an impact on the ability to bind water. As a result, the surface flow will increase so that the soil becomes sensitive to factors that increase erosion and flooding [3].

In addition to the low power after a fire, because the water-binding fires on peatland produces ash, the ash will move to the bottom layer so that it fills the peat pores [2]. Proof of movement Fire ash, seen by increasing BD and pH (Table 3) at different fire levels. The low ability of peat to bind water after burning with various levels of fires is increasingly heavy due to the destruction of functional groups of water-binding peat material (hydrophilic) that is carboxylic and OH-phenolics because the temperature is too high. This is in line with the statement of [4] that the decreasing ability of peat to absorb water after drying is closely related to the reduced availability of carboxylic and OH-phenolics. Both the organic component is a hydrophilic compound that helps the absorption of water availability, but if the peat is in a dry state, then both the organic compound to be not working [5].

3.1.3 Load weight (bulk density)

The results of the analysis show that the heavier the level of fires in peatlands, the bulk density increases at the point of observation. The weight of the soil in various levels of peatland fires is shown in Figure 4. The graph in Figure 4 shows that there has been an increase in BD (Cultivation) peat after burning with different levels of fire. The BD value at the level of heavy fires was higher at 0.23 g / cm³ compared to the BD value at the moderate fire level of 0.22 g / cm³, the light at 0.21 g / cm³ and those that did not burn as a control treatment 0.2 g / cm³. In addition, there was an increase in BD from control to after a fire from a mild to severe fire.

![Figure 4. Histogram of bulk density in various levels of peat fires](image)

Based on the results of observations it can be seen that the sample of land with a heavy fire level has an average content weight highest land, that is 0.23 g / cm³. Think this is due to precipitation from the occurrence of ignition due to land fires. Fires will cause a process of ignition on the surface of the burning ground, the ash produced from combustion will enter into the pores of the soil with an
intermediary of rainfall, so that the soil becomes dense and BD increases. BD enhancement in the peat layer is accompanied by increasing pH, ash content, and base saturation. Increases in pH, ash content and base saturation at a depth of 10-20 cm indicate the presence of combustion ash, fires provide input of minerals (ash and charcoal) in the soil so as to increase soil pH.

The burning peatland causes loss of organic matter in the top layer of peat and the soil becomes dense. Compaction occurs because of the addition of soil mass in the form of ash. Ash comes from the burning of peat organic matter. The ash fills the pores of the peat so that the peat becomes dense and has increased BD. This is in accordance with the statement of [2] that fires cause peat to become dense, caused by an increase in the weight of contents by the ash produced by combustion. In addition, Wasis (2003) explained that burned land will experience the destruction of soil particles that cause compaction.

3.1.4 Particle density
The results of the analysis show that the heavier the level of land fires, the particle density increases at the point of observation. The density of soil particles in various levels of peatland fires is shown in Figure 5.

![Figure 5. Particle density histories in various levels of peatland fires](image)

Figure 5 shows that there has been an increase in peat PD after burning with different levels of fire. The PD value at the fire level is higher than the PD value at the moderate, mild and non-combustible fire levels as a control treatment. In addition, there was an increase in PD from control until after a fire from a mild to severe fire. Based on the observations obtained data that the particle density in the control treatment (non-combustible soil) has the highest value (1.52 cm³). Based on PD observations, the results showed that the highest BD was found on land with a heavy fire level. The increase in PD that occurs in burned land is affected by the ash from combustion that fills the pore space peat. PD is strongly influenced by the presence of combustion ash because ash is a mineral material that will mix with peat material so that it can increase the density of solids.
3.1.5 Permeability
The results of the analysis show that the heavier the level of land fires, the permeability value decreases at the point of observation. Soil permeability in various levels of peatland fires can be seen in Table 1.

Increasing bulk density and decreasing the total value of the soil pore space, especially the macropore space will be able to pass large amounts of water per unit time. However, other research found that soil is micropores [6]. Table 2 indicates the value which varies from observing permeability. The highest value of permeability is control (not burning) with a value of 19.43. Furthermore, followed by permeability in mildly burned land (8.13), moderate (4.1) and heavy (2.4). This shows a decrease in permeability ability of each soil sample due to fire.

| No | Fire Level | Permeability (cm/hour) |
|----|------------|------------------------|
| 1  | Weight     | 2.4                    |
| 2  | Is being   | 4.1                    |
| 3  | Light      | 8.13                   |
| 4  | Not burnt  | 19.43                  |

The highest value from the control sample (non-combustible land) makes the land classified as a good category with the highest permeability. This is because the control still has a good soil structure and pore so that it can pass water well when compared to burning land which is much lower in value.

3.1.6 The permeability value of burned land is caused by several factors.
Factors that influence permeability include texture, porosity, soil pore size distribution, aggregate stability, structure, and soil organic matter content. Heating produced by fires will reduce soil pores so that the soil becomes dense and the ability of the soil to hold groundwater that decreases bulk density and increases total soil pore space resulting in increased soil permeability rates.

3.1.7 Total pore space (TRP)
The results of the analysis show that the more severe the level of land fires the more the total pore space (TRP) decreases at the point of observation. The total soil pore space in various levels of peatland fires is presented in Figure 6.
Figure 5 shows that there has been a decrease in peat TRP after burning with different levels of fire. The TRP value at the fire level is lower than the TRP value at the moderate, mild and non-combustible fire levels as a control treatment. In addition, there was a decrease in TRP from control until after a fire from a mild to severe fire.

The highest value of total pore space (TRP) is in the control sample with a value of 85.82. Furthermore, the highest value followed by the value of mild fire land (85.80) and moderate fire land (84.24) and light indicates that the increase in temperature due to fire causes damage to the structure on the ground surface with reduced soil pore space which affects the increase in weight (83.07). This shows that the total pore space value (TRP) is classified as not significantly different and shows the result that the total pore space value (TRP), however, decreases.

The total soil pore space and bulk density are important in the assessment of soil density or density. The soils with increased bulk density mean that their porous space is getting lower and the soil is getting denser [7]. Soil that has a large bulk density, the denser the soil, which means it is difficult to pass water or penetrate the roots of plants.

The results of [8] in the burning of Acacia mangium in Parungkuda, Sukabumi showed that the increase in temperature due to fires caused structural damage to the soil surface with reduced soil pore space which had an effect on increasing soil weight (Figure 6). Fires make the soil open with loss of litter, understorey, and canopy which increases the temperature and rate of evaporation while causing loss of organic matter which decreases the available water content.

3.2 Analysis of Chemical Properties of Soil

3.2.1 Degree of acidity

The results of the analysis show that the heavier the level of land fires, the higher the soil pH value but not significant at the point of observation. Soil pH in various levels of peatland fires can be seen in Table 2. The number of pH in various levels of peat fires Table 2 shows the results that observing soil pH from each soil sample showed results that were not significantly different. It can be seen that the highest pH is in samples with heavy fires with a value of 4.37 and the lowest pH that is in the control (no fire) with a value of 4.11. This shows that the level of fire that has occurred both mild, moderate and severe and control (non-combustible forest) does not significantly affect changes and differences in forest soil pH.
Table 2. Fire level and soil pH

| No | Fire Level | Soil pH |
|----|------------|---------|
| 1  | Weight     | 4.37    |
| 2  | Is being   | 4.34    |
| 3  | Light      | 4.23    |
| 4  | Not burnt  | 4.11    |

However, thus, occurrence forest fires can slightly increase the value of forest soil pH when viewed from the value of control and observation of treatment. This shows that with the incidence of forest fires, soil pH will be increased so that the availability of certain nutrients needed for plants becomes available.

3.2.2 Redox

The results of the analysis show that the more severe the level of land fires, the lower the soil redox value at the point of observation. Redox soil in various levels of peatland fires can be seen in Table 3. Table 3 shows the results that observations of soil redox from each soil sample show results different from each treatment. It can be seen that the highest redox is in the sample with control (no fire) with the lowest value of 195.6 and redox, which is in the soil sample with heavy fires with a value of 165. The existence of redox changes due to changes in elements and chemical reactions due to fire. This can also be seen from the explanation of changes in the chemical properties of peat soil. The impact of fires on soil chemistry is explained by [9] that fire will change the chemical properties of the soil in three ways, namely minerals released from the combustion process that is left behind by ash, changes in microclimates after a fire, and decomposition of minerals to see the simplification of organic structures into inorganic materials. The contribution of soil nutrients due to fire does not last long and is limited. If fires occur repeatedly, land degradation will increase and the nutrient impoverishment process will take place.

Table 3. Redox in various levels of peatland fires

| No | Fire Level | Redox |
|----|------------|-------|
| 1  | Weight     | 165   |
| 2  | Is being   | 167   |
| 3  | Light      | 175.6 |
| 4  | Not burnt  | 195.6 |

3.2.3 Electrical Conductivity

The results of the analysis show that the heavier the level of fires in peatland, the higher the conductivity of soil electricity at the point of observation. Redox soil in various levels of peatland fires can be seen in Table 4. Table 4 shows that there are differences in the value of the electrical conductivity of each soil sample. The greatest value of electrical conductivity is in heavy fires with a value of 118.6 and followed by a moderate fire level sample (109.6), mild fire (106.1) and non-burning peatland or control (86.9). The greatest value from soil samples of heavy fires is possible to change the physical properties of the soil so that electricity is easier to deliver.

Table 4. Electrical conductivity in various levels of peat fires

| No | Fire Level | Electrical Conductivity |
|----|------------|-------------------------|
| 1  | Weight     | 118.6                   |
| 2  | Is being   | 109.6                   |
| 3  | Light      | 106.1                   |
| 4  | Not burnt  | 86.9                    |
However, moderate and light fires do not differ significantly. This is possible due to changes in the nature of the soil from heavy fires that facilitate the transmission of electricity so that the value is quite large. Whereas there is no fire in the soil due to the natural state of the soil so that the electrical conductivity remains the same size. However, land the electrical conductivity of fires that are not included in the criteria for chemical properties is damaged (except mild fire land) based on the general criteria for damage to peat soil PP No. 4 of 2001 relating to forest fires and/or land. This is because PP No. 4 of 2001 states that electrical conductivity is included in chemical properties and is classified as damaged if it has a rising value compared to non-combustible soil.

Analysis Of The Biological Properties Of Soil

- Total Soil Microbes (CFU / ml)

The results of the analysis show that the more severe the level of peat fires, the lower the total value of soil microbes at the observation point. The total soil microbes in various levels of peatland fires can be seen in Table 5.

| No | Fire Level  | Total Microbes (CFE / ml) |
|----|-------------|----------------------------|
| 1  | Weight      | $1.86 \times 10^8$        |
| 2  | Is being    | $3.63 \times 10^8$        |
| 3  | Light       | $8.53 \times 10^8$        |
| 4  | Not burnt   | $12.64 \times 10^8$       |

Table 5 shows that there are differences in the total microbial values of each soil sample. The largest total microbial value was in non-combustible soils $12.64 \times 10^8$ and followed by samples after mild, moderate and severe fires. The greatest value of non-combustible soil samples is caused by no change in the physical properties of the soil and the availability of organic matter in peat soil.

Physically or visually, the most striking difference in non-burning peat soils is that they become more compact or harden the soil by accumulating organic matter (plant litter), and the appearance of white on peat soil which indicates the presence of microorganisms that grow in it. This is because microorganisms that function as decomposition agents or cellulase decomposers and fibers contained in peat soil. In this study used control variables and the comparison of the number of microorganisms contained in the soil before the fire and after the fire. The table shows that the total microbial amount in unburnt peat soil causes more changes in the amount. Increasingly increasing TPC.

4. Conclusion

Based on the results of the research and discussion described in the previous section it can be concluded that at various levels peatland fires can increase the value of fill weight, particle density, water binding power, soil pH in various levels of peatland fires, total pore space, permeability, expected to increase the activity of decomposition or decomposition of organic matter from peat soil. Where, soil chemistry such as pH is also one of the factors that support microbial life in the soil, as well as macrofauna and soil mesofauna that the soil pH supports the life of microbes in the soil. Usually, soil microbes commonly grow at a soil pH of about 7, but soil microbes can grow at pH 2 - 10 if available organic material in total soil microbes does not increase compared to peat not burn out, water content, redox, electrical conductivity, and total soil microbes do not experience an increase compared to peat not burning.
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