THE EFFECT OF MAIN CANALS ON CO₂ EMISSIONS IN PALM OIL PLANTATIONS AT PEATLAND, CENTRAL KALIMANTAN OF INDONESIA

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ABSTRACT

The making of main canals in oil palm plantation areas, especially on peatlands, will affect changes in the physical, chemical and biological properties of peatlands, will affect the process of oxidation and reduction of peatland which affects the regulation of changes in gas emissions, especially the concentration of gases such as: carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄). The research objective was to determine the effect of the making of main canals on the rate of CO₂ emissions from peat soil surface for each difference in the measurement distance from the drainage channel (25, 50 and 100) m in the block of oil palm plant age (3, 4, 5 and 6) years after planting. The average rate of emissions in Palm Oil Plants Age 3 Years after Planting at a distance of 25 m equal to 147.87 mg C m² Hour¹, the distance of 50 m is 156.17 mg C m² Hour¹ and a distance of 100 m amounted to 148.01 mg C m² Hour¹, Palm Oil Plants Age 4 Years after Planting at a distance of 25 m equal to 247.10 mg C m² Hour¹, the distance of 50 m is 248.90 mg C m² Hour¹ and a distance of 100 m amounted to 257.10 mg C m² Hour¹, Palm Oil Plants Age 5 Years after Planting at a distance of 25 m equal to 147, 87 mg C m² Hour¹, the distance of 50 m is 156, 17 mg C m² Hour¹ and a distance of 100 m amounted to 148, 01mg C m² Hour¹. Palm Oil Plants Age 6 Years after Planting at a distance of 25 m equal to 329, 95 mg C m² Hour¹, the distance of 50 m is 335, 08 mg C m² Hour¹ and a distance of 100 m amounted to 347, 22 mg C m² Hour¹. The effect of distance from canal main on CO₂ emissions does not significantly affect changes in CO₂ emissions in the block of oil palm plant age (3, 4, 5 and 6) years after planting, but the farther away from main canals, CO₂ emissions are increasing.

KEY WORDS

Peatlands, canals, CO₂ emissions, palm oil.

The current environmental problem that becomes the concern to the international community is the phenomenon of climate change, namely the changing physical conditions of the Earth's atmosphere among other temperature and rainfall distribution, which have a wide impact on various sectors of human life. Global climate change occurs because of an increase in gas concentration such as: carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and hydrocarbons such as (CFCs) in the atmosphere of the earth, which is called the greenhouse effect or greenhouse gases (Batjes and Bridges, 1992).

Along with the issue of global climate change on earth caused by increasing concentrations of greenhouse gases, one of which occurs due to unwise use of forests and peatlands, causing organic matter in peat to decompose aerobically or anaerobically, so the three gases above potentially release into the atmosphere (Jauhiainen *et al*, 2005). Hooijer *et al*, (2010) say decomposition on damaged peatlands in Indonesia is estimated to emit CO₂ emissions of 632 Mton/year (range 355-874 Mton/year) and are likely to increase every year, unless peatland use practices change.

According to Page *et al*, (2008), tropical peat swamp forest ecosystem is the most efficient place to capture and store carbon (C) reserves, because in this ecosystem carbon is stored in the body of plants that are still alive (biomass) and on dead body parts of plants, whether they are still standing or fallen, including fallen branches and leaves.

The ecological function of tropical peatlands is as a storehouse of carbon, carbon balance, *sediment retention*, *nutrient detention*, and micro-climate stability (Maltby, 1997; Rieley *et al*, 2008). Peatlands are a place for carbon accumulation (*carbon reservoir* or *carbon storage*). The release of CO₂ into the air from reclaimed natural peatlands for agricultural activities is a process of oxidation and reduction of organic matter. In a reductive environment, the rate of decomposition of peat is very slow and many toxic organic acids and methane (CH₄) are produced, whereas in the oxidative state the release of C is increased more especially in the form of CO₂. The type of land use affects the ability of soil to store CO₂. This type of land use plays a very important role in controlling CO₂ flux in the atmosphere (Jauhiainen *et al*, 2005).

The opening of peat swamp land for agriculture and plantations is always followed by the making of deep and wide main (canals), which will cause damage to the hydrological system due to oxidation of organic matter and subsidence of the peat surface (Wosten *et al*, 1997, Furukawa *et al*, 2005), further in the area where the tropical peat area has been drained it will cause sudden and permanent changes to the carbon ecosystem balance (Page *et al*. 2002, Canadell *et al*, 2007, Hirano *et al*, 2007).

The making of main canals in oil palm plantation areas, especially on peatlands, will affect the high-low level of the groundwater. The high and low of groundwater level will affect the oxidation and reduction process on peat so it affects the regulation of CO₂ gas emissions.

The aim of the study was to determine the effect of the making of main canals on the rate of CO₂ emissions from peat soil surface for each difference in measurement distance from the drainage channel (25, 50 and 100) m.

MATERIALS AND METHOD OF RESEARCH

This research was carried out in oil palm plantation companies on peat land, Kota Besi sub-district, East Kotawaringin Regency, Central Kalimantan Province, Indonesia, which was held from November 2016 to October 2017. Field surveys at company sites on the plots of oil palm plants with 3 years of planting age (S:02° 26' 20.45", E:112° 54' 03.70") , oil palm plants 4 years planting age (S:02° 24' 07.76" , E:112° 59' 43.47"), oil palm plants with 5 years planting age (S:02° 26' 14.76" , E:112° 54' 08.72"), and oil palm plants with 6 years planting age (S:02° 26' 22.11" , E:112° 54' 05.23"). Measurement of CO₂ emissions for each oil palm plot from the main canals edge (25, 50 and 100) m, (Figure 1).

Figure 1 – Outline of CO₂ emission monitoring location at average distance in the block of oil palm plant age (3, 4, 5 and 6) years after planting

Measurement of CO₂ emissions using the open closed chamber method for each research plot. Open closed chamber method with three replications. Gas fluxes were measured monthly from January 2017 to December 2017. Methods of sample retrieval and analysis of CO₂ gas using the method by Takakai et al, (2006), Nakano et al, (2004), Toma and Hatano(2007), and Toma et al, (2011). Method of Chamber oven and close measurement of CO₂ gas emissions. The laboratory using CO₂ emission measuring devices (infrared CO₂ analyzer Fuji type ZFP9GC11).

Figure 2 – Method of Chamber oven and close (Toma and Hatano, 2007)

Statistical analysis using a randomized block design with 3 replications, and 4 treatments namely the use of conservation forest land, grass land and oil palm plants with planting age (3, 4, 5 and 6 years). Analysis data was conducted using Genstat 18 Statistic program and Microsoft Office Excel program 2010.

RESULTS OF STUDY

The results of the effect of differences in the distance of measurement from the edge of the drainage channel to the average CO₂ emissions in the block of oil palm plant age (3, 4.5 and 6) years after planting, are shown in Figures below.

Figure 3 shows the average emission rate at a distance of 25 m equal to 147.87 mg C m² Hour¹, the distance of 50 m is 156.17 mg C m² Hour¹ and a distance of 100 m amounted to 148.01 mg C m² Hour¹ in Plots Location of Palm Oil Plant Age 3 Years after Planting.

Figure 3 – The pattern of CO₂ emissions at a distance of 25, 50 and 100 m in the Plots Location of Palm Oil Plant Age 3 years after planting

Figure 4 – The pattern of CO₂ emissions at a distance of 25, 50 and 100 m in the Plots Location of Palm Oil Plant Age 4 years after planting

Figure 4 shows the average emission rate at a distance of 25 m at 247.10 mg C m² Hour¹, the distance of 50 m is 248.90 mg C m² Hour¹ and a distance of 100 m amounted to 257.10 mg C m² Hour¹ in Plots Location of Palm Oil Plant Age 4 Years after Planting.

Figure 5 – The pattern of CO₂ emissions at a distance of 25, 50 and 100 m in the Plots Location of Palm Oil Plant Age 5 years after planting

Figure 5, Shows the average emission rate at a distance of 25 m equal to 147, 87 mg C m² Hour¹, the distance of 50 m is 156, 17 mg C m² Hour¹ and a distance of 100 m amounted to 148, 01mg C m² Hour¹ in Plots Location of Palm Oil Plant Age 5 Years after Planting.

Figure 6 – The pattern of CO₂ emissions at a distance of 25, 50 and 100 m in the Plots Location of Palm Oil Plant Age 6 years after planting

Figure 6 shows the average emission rate at a distance of 25 m equal to 329, 95 mg C m² Hour¹, the distance of 50 m is 335, 08 mg C m² Hour¹ and a distance of 100 m amounted to 347, 22 mg C m² Hour¹ in Plots Location of Palm Oil Plant Age 6 Years after Planting.

The results of the variance analysis showed that there was no interaction of treatment on the CO₂ emissions at the error level of 5% ($P > 0.05$), but there is a major influence, namely, the age of oil palm plants is significantly different on the CO₂ emissions, but the effect of the distance of measurement from the drainage channel is not significantly different on the CO₂ emissions shown in Appendix Table 8. Effect of Palm Oil Plant Age and Distance on the Average of CO₂ Emissions can be seen in Table 1.

Table 1 – Effect of Palm Oil Plant Age and Distance on the Average of CO₂ Emissions

Treatment	CO ₂ (mg C m ² Hour ¹)
3 years palm oil plant	150.7 a
4 years palm oil plant	251.0 b
5 years palm oil plant	307.8 c
6 years palm oil plant	337.4 d
Distance from canal main	
25 meter	259.7 a
50 meter	260.9 a
100 meter	264.7 a

Note: Numbers accompanied by the same letter on the same row and column are not significantly different from Duncan's test 5%.

Table 1, shows that the average of CO₂ emissions according to the age of oil palm plants and the distance of measurement from the edge of the drainage canal on the 6 years oil palm plants is higher and significantly different from the age of other oil palm plants with an average of CO₂ emission equal to 337.4 mg C m² Hour¹ while the lowest average of CO₂ was found in the age of 3 years of oil palm plants amounted to 150.7 mg C m² Hour¹.

The average of CO₂ emissions based on distance indicate a distance of 100 m with the higher average of CO₂ namely 264, 7 150, 7 mg C m² Hour¹ but not significantly different from the distance of 25 m and 50 m. Variations in the value of CO₂ emissions according to distance indicate that the farther away from the canal channel, the CO₂ increases.

DISCUSSION OF RESULTS

The difference in the average pattern of CO₂ emissions in the area of oil palm plantations is thought to be influenced by changes in environmental factors due to the conversion of peatlands into oil palm plantations. Some researchers say that the factors that affect the high and low average of CO₂ emissions that released to the atmosphere are environmental factors, especially groundwater, soil temperature and soil moisture, This is in accordance, that the average value of CO₂ emissions released by peatlands is influenced by environmental factors, including groundwater depth, air temperature, soil temperature, peat properties such as peat pH, CEC, C-organic content and microorganisms. Vegetation type (land cover / canopy) will affect the average temperature under the canopy which will automatically affect CO₂ emissions in different vegetation types.

Darung et al. (2018), Changing of the land use conversion of tropical peat land for oil palm plantation activities plays a very important role in the pattern of changes in the rate of emissions from the surface of peatlands, controlling the rate of CO₂ emissions in the atmosphere, means controlling global warming. Changes in peat land use in oil palm plantations, the findings obtained the rate of CO₂ emissions vary widely depending on changes in vegetation types.

Based on the results of the analysis of variance, there is a major influence, namely, the age of oil palm plants is significantly different on the CO₂ emissions, but the influence of the

measurement distance from the drainage channel is not significantly different on the CO₂ emissions. The average of CO₂ emissions according to the age of oil palm plants and the measurement distance from the edge of the drainage canal in 6 years oil palm plants is higher and significantly different from the age of other oil palm plants. The average of CO₂ emission in 6 years palm oil plants is 337.4 mg C m⁻² Hour⁻¹ then a 5 years oil palm plant equal to 307.8 mg C m⁻² Hour⁻¹, 4 years oil palm plantations amounting to 251.0 mg C m⁻² Hour⁻¹, The lowest oil palm plants found at the age of 3 years for oil palm plants equal to 150, 7 mg C m⁻² Hour⁻¹, while the average of CO₂ emissions based on distance show a distance of 100 m with the higher average CO₂ namely 264, 7 150, 7 mg C m⁻² Hour⁻¹ but not significantly different from the distance of 25 m and 50 m. Variation in the value of CO₂ emissions according to the distance measurement of CO₂ emissions shows that the farther away from the canal channel then CO₂ increases to a distance of 100 m from the drainage channel.

The results of measurements on CO₂ emissions released in the area of oil palm plantations on peatlands show that there are differences where the older the plant ages, the greater the CO₂ emissions released into the atmosphere. According to Melling *et al.* (2005), that the differences in the age of oil palm plants have an important role in the value of CO₂ emissions on peatlands. Mature oil palm plants have more plant roots (rhizosphere) compared to young plants and simultaneously that the microbial community of the rhizosphere region is higher than non rhizosphere so that in addition to plant root respiration, microbial activity is possible to contribute a number of emissions around plant roots so that the CO₂ emissions produced are also higher.

The part of the plant that has the most role in the respiration of plant roots is the root area. The root area as the rhizosphere is a place where concentrated root hairs which play a role in plant root respiration. In oil palm plants with the age of 6 years have more rhizosphere compared to the age of 3 years. The process of root respiration of oil palm plants is the second largest emitter after the process of decomposition by microbes on peatlands (Melling *et al.* 2005).

This is in line with the opinion from Ekberg *et al.* (2007), that the process of respiration produced by plants is one of the contributors to carbon emissions in oil palm agroecosystem land. Soil respiration is a joint process between autotrophic respiration (root respiration) and heterotrophic respiration (peat decomposition), root respiration activity; is one component that plays an important role in determining the value of CO₂ emissions released into the atmosphere (Tian *et al.* 2010).

Main canals in oil palm agroecosystems are one of the important factors in the process of carbon emissions. The research results showed variations in the value of CO₂ emissions according to the distance of measurements from the drainage channel. At a distance of 25 m from the drainage channel the CO₂ emissions equal to 259.7 mg C m⁻² Hour⁻¹ at groundwater level of 33.24 cm, measurement distance of 50 m from the drainage channel the CO₂ emissions equal to 260.9 mg C m⁻² Hour⁻¹ at groundwater level of 34.58 cm, and the measurement distance of 100 m from drainage channel the CO₂ emission equal to 264.7 mg C m⁻² Hour⁻¹ at groundwater level of 35.42 cm, this shows that the farther away from the canal channel, then the average of CO₂ emission increases, as well as the groundwater level, gets deeper to 100 m distance.

This is thought that the further away from the drainage channel there is a decrease in groundwater level causing changes in anaerobic conditions to be aerobic in the layer above the groundwater level thereby increasing O₂ availability and can accelerate the process of reforming organic matter further, it will further spur C-organic mineralization to produce CO₂ gas, so that CO₂ emissions increase the further from the edge of the drainage channel.

According to Hooijer *et al.* (2009 and 2012), fluctuations in the depth of peat soil water have a positive relationship to changes in the value of CO₂ emissions in the rhizosphere and non rhizosphere, in line with the findings of Hirano *et al.* (2014) that there is a significant relationship between groundwater level and soil CO₂ emissions on tropical peatland in Palangkaraya, Central Kalimantan.

Jauhiainen *et al.* (2012) said that if groundwater is close to the surface for a long time then heterotrophic carbon emissions will occur so rapidly along with changes in groundwater

depth, at this time there will also be a non-linear relationship between groundwater and humidity. Hirano et al, (2012) also said that the increase in carbon flow or decomposition of oxidative peat in low groundwater conditions was due to thickening of the unsaturated soil zone and the result of increased aeration.

Research by Hirano et al. (2012) suggests that the relationship of groundwater and carbon flow is a linear relationship. Jauhiainen, *et al*, (2012) also said, when measuring the relationship between CO₂ emissions and the depth of groundwater, it must be remembered that the depth of groundwater does not control the oxidation of peat. Conversely, it is used to measure moisture from peatland above groundwater, which has a direct effect on peat oxidation by affecting the availability of oxygen in porous space. Also added that on peatlands which have high groundwater depth and no good drainage control, had a strong relationship with soil moisture.

CONCLUSION

Effect of distance from canal main on CO₂ emissions does not significantly affect changes in CO₂ emissions in the blocks of oil palm plant age (3, 4, 5 and 6) years after planting, but the farther away from canal main CO₂ emissions are increasing

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