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The Estimation of Peatlands Reserve on Carbon in the Forest and Shrubs That Has Been Drained

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Abstract

Global warming and greenhouse gas emissions (GHGs) became a hot issue in the world today. An increased concentration of carbon in the atmosphere becomes one of the serious problems that can affect life on Earth. Peatlands pointed out as one of the sources of GHG emissions. Drainage of peatlands cause decreased water level so that the decomposition process is faster on a layer above the groundwater table, thus affecting the chemical characteristics of peat. In addition to affecting the ground water level, drainage also leads to a decrease in surface height peat soil (subsidence). Given the magnitude of the role of drainage and land use types in affecting carbon stocks and emissions of CO2 on peat soil, this study is to measure carbon stocks and emissions of CO2 on peat soil in forests and shrubs that have been drained. CO2 emissions increase with the closer spacing of the drainage channel that is at a distance of 50 m to 500 m of drainage channels. Meanwhile, at a distance of 5 m and 10 m of the drainage channel can not be concluded because of the condition of ground water that is stagnant at the time of sampling gas, so be very low CO2 emissions. CO2 emissions on the use of forest land are higher than the shrub land.

Keywords: carbon, peat land drainage

A. Introduction

Demands the fulfillment of the food and the industry in order to improve people's welfare encourages the use of peatlands for agriculture and industry with the opening of the peatland. The utilization is much related to government policies in forest conversion, timber industry, transmigration and settlement as well as the expansion of agricultural land. Practice is usually done by deforestation, followed by the construction of canals or drainage channel to drain the water stored in peatlands (Murdiyarso et al. 2004). Activity logging and timber transport and land clearing cause deterioration of ground water and marsh ecosystem change, resulting in changes. characteristics of peat. Action drainage and cultivation techniques in oil palm plantations resulted in disruption of the stability of the peat that the subsidence due to compaction, increased organic matter decomposition, so that the CO2 emissions will increase (Klemedtssons *et al*. 1997).

Drainage of peatlands cause decreased water level so that the decomposition process is faster on a layer above the groundwater table, thus affecting the chemical characteristics of peat. In addition to affecting the ground water level, drainage also leads to a decrease in surface height peat soil (subsidence). Research Silins and Rothwell (1998) suggest that the drainage effect on the increase in bulk density and occurrence of subsidence, and a decrease in soil water retention. Agus and Wahdini study (2008) showed that the bulk density of the peat that has been converted into oil palm acreage reached a value of 0.3 g / cm3 at a depth of 0-50 cm. Decreased water level, followed by a more rapid decomposition process, will affect carbon stocks in peat.

Loss of C-organic through oxidation will produce CO2. Factors that influence the loss of C-organic, among others, namely temperature, O2, pH, and Eh peat. Peat is the main temperature controller on the rate of decomposition of peat, and will be very dominant role when interacting with O2 (Chapman et al. 1996). Temperature and humidity both air and peat soils in the tropics are strongly influenced by the type and density of vegetation cover. In the closed state forests, peat temperatures ranging from 27.5 ° C - 29.0 ° C and if the open state ranges from 40.0 ° C - 42.5 ° C. The high temperature in an open state will stimulate the activity of microorganisms so that an overhaul of peat faster (Noor, 2001).

Given the magnitude of the role of drainage and land use types in affecting carbon stocks and emissions of CO2 on peat soil, this study is to measure carbon stocks and emissions of CO2 on peat soil in forests and shrubs that have been drained.

B. Methodology

Observations and measurements in the field include:

1. Measurement of the depth of the water table peat in each of the drill hole depth of the ground water level is measured using a meter from peat soil surface to the water table soils.
2. Measurement of surface height peat

High measurement surface peat soil carried on a balance of water which is conducted every distance of one meter up to a distance of ten meters from drainage channels, and every five meters from a distance of ten meters to 25 meters from drainage channel, then measured every 25 meters up to a distance of 500 m from the drainage channel.

1. Sampling CO_2

Gas samples were taken from the forest transects and transects scrub with a sample point position similar to the position that is drilling 5m, 10m, 50m, 250m, and 500m from the drainage channel.

Laboratory analysis covering:

1) Determination of Levels of ash and organic C levels

Determination of ash content do menggukan tools furnace. Peat soil samples placed in a porcelain container then put into the furnace. The temperature in the furnace is set at 550º C. Combustion performed for 4-6 hours until all of the carbon in the peat disappear until all that remains is a mineral material contained in peat.

2) Measurement of fiber content

Measurement of fiber content in the laboratory was done by comparison of the amount of fiber in injections (siringe), that is by determining the number of soil samples in particular an injection volume as V1, then the soil samples were rinsed with water using a 100 mesh sieve and then be re-defined as the volume V2. Peat has fibric maturity when V2 / V1> 66%, hemik if V2 / V1 between 33% - 66%, and sapric if V2 / V1 <33%. But in this study were modified fiber content to determine ripeness degree to maturity fibric peat that is has a fiber content of> 40%, the level of maturity hemik have a fiber content of 20% - 40%, and the maturity level sapric have a fiber content of <20%. Determination of the percentage of fiber content is due to the fiber content results obtained by the method of injection are lower than the determination in the field.

3) Measurement of CO2 emissions is done in two transects are forests and shrubs. Capturing CO2 from soil using a mask (closed chamber) which in turn is measured using a gas chromatograph.

2. Data analysis

Analysis of data using regression analysis for carbon stocks and a comparative analysis of average with the T test for CO2 emissions. Data analyzed using SPSS Ver.13. Regression model used is:

$Y = a + bx + cx^2$

Y = dependent variable a =
Constanta regression

b, c = coefficient of regression
x = independent variable

C. Result and Discussion

1. The Dept of the Ground Water Level and Hingh Ground

The depth of peat soil water level from the ground surface ranging from -40 cm contained on old rubber land at a distance of 500 m from the drainage channel to -120 cm contained in the shrub land at a distance of 5 m from drainage channels. The depth of the peat water level from the soil surface is presented in Table 2.

From the observation depth of the ground water level is known that the ground water level is getting in with the closer of the drainage channel. Forest on peat soil, groundwater level decline looks quite significantly on transect II is at a distance of 5, 10, and 50 m of drainage channels. And on peat soil scrub decreased water level was significant transects III, and IV, at a distance of 5, 10, and 50 m of drainage channels. It shows that the transect II, III, and IV high hydraulic conductivity so that the manufacture of drainage channels greatly affects the depth of the ground water level. From the observation of high ground, it is known that the land subsidence occurred at a distance of 5 m, 10 m, and 50 m of drainage channels. Meanwhile, at a distance of 250 m and 500 m of drainage channels drainage effect is very small or even non-existent. Connected with land use, decreased water level appear higher on peat soils in shrub than peat forest where the deepest ground water level in the peat forest is -87 cm at a distance of 5 meters from the drainage channel, while on peat soil scrub advance the deepest ground water reaches -120 cm.

2. Maturity of Peat

From the observation can be seen that the level of maturity of peat based on the fiber content measurement and scrub forest transect (Transect I, II, III, IV, and V) have a maturity level fibric, hemik and sapric. Fibric maturity level has a fiber content of> 40%, the level of maturity hemik have a fiber content of 20-40%, and the maturity level sapric have a fiber content of <20%. Fiber content in peat forests and shrubs is ranging from 10% to 90%.

3. Ash Content (%)

The ash content ranged from 0.45% to 51.57%. The ash content indicates the influence of peat and mineral materials related to levels of C-organic peat. The greater the ash content, the organic-C levels would be lower.

4. Levels of C Organic (%)

Levels of C-organic ranged between 25.48% - 57.86%. The highest levels of organic C 57.86% contained in the transect V at a distance of 250 m from the channel at a depth of 100-150 cm, the lowest 25.48% contained in the transect II at a distance of 500 m from the channel at a depth of 800-850 cm. At these depths are 31 cm deep layer of clay is starting depth of 819-850 cm.

5. Peat Carbon Stock

The range of carbon stocks is 386 Mg / ha to 3240 Mg / ha. On peat soils to forest land use (transects I and II), the thickness of the peat> 900 cm, while on peat soil with the use of shrub land, peat thickness of the lowest land use old rubber thickness of 98 cm, and the highest in the land use shrubs + pineapple + rubber 8 months of age, 793 cm thickness. On the use of shrub land is seen that the thickness of the peat and carbon stocks lower with the closer spacing from drainage channels. This indicates that the decomposition process is faster at a distance closer to the drainage channel. The thickness of the peat and carbon stocks in each land use is presented in Table 1.

Table 1 Thickness of peat and carbon stocks in each of the sampling points in each land use

Land Use	Distance from the channel drainage (m)	Peat thickness (cm)	carbon stocks (Mg / ha)
Forest (Transect I)	5	> 900	> 2770
	10	> 900	> 2853
	50	> 900	> 2451
	250	> 900	> 2391
	500	> 900	> 2437
Forest (Transect II)	5	> 900	> 2683
	10	> 900	> 2769
	50	> 900	> 2687
	250	> 900	> 2389
	500	> 900	> 2244
Scrub + pineapple + rubber age 8 month (Transects III)	5	663	2672
	10	612	2471
	50	600	2457
	250	650	3240
	500	793	2275
Shrubs (Transect IV)	5	284	879
	10	300	1019
	50	369	1456
	250	379	993
	500	518	1158
old rubber (Transect V)	5	98	386
	10	139	491
	50	170	513
	250	262	1081
	500	168	485

Stocks with the Reference Thickness of 200 cm From the Ground

Distance from the drainage channel affects the depth of the ground water level. It is generally known that the drainage affects the rate of decomposition of the peat. The decomposition process is faster on a layer above the groundwater table, while the peat layers below the groundwater level is relatively more stable. For the count of stocks with reference to 200 cm from the ground. Reference thickness of 200 cm was taken from the highest ground level on a transect. Stocks with reference to 200 cm thickness ranging between 144.42 Mg / ha to 408.94 Mg / ha. The thickness of the peat and carbon stocks with the reference thickness of 200 cm from the soil surface highs on a transect is presented in Table 2.

Stocks with the reference thickness of 200 cm from the ground indicate that the reduction in carbon stocks in peat land use shrubs (transect III, and IV) is relatively higher than the carbon stocks in forest land use (transects I and II) with a pattern of curves which showed an increase in carbon stocks that the greater the distance from the drainage channel, while the visible decline of forest land use and enhancement of carbon stocks, but the decline and the increase is very small, look at the pattern of relatively flat curve. This suggests that the process of decomposition of the peat with the shrub land use faster than peatland forest land use.

Table 2. The thickness of the peat and carbon stocks with the reference thickness of 200 cm from the ground level to the top of each land use

Land Use	Distance from the channel drainage (m)	Peat thickness (cm)	carbon stocks (Mg / ha)
Forest	5	183	285.68
(Transect I)	10	200	317.63
	50	197	326.72
	250	168	263.47
	500	183	279.85
Forest	5	159	363.02
(Transect II)	10	159	315.48
	50	161	304.46
	250	178	370.24
	500	200	361.16
Scrub +	5	65	146.87
pineapple + rubber	10	71	144.42
age 8 months	50	108	267.99
(Transects III)	250	170	216.53
	500	200	373.7
thicket	5	132	306.19
(Transect IV)	10	142	310.18
	50	176	294.7
	250	200	408.94

6. Emission CO_2

CO2 emissions on forest land ranged from 28.17 mg / m2 / hour - 2146.06 mg / m2 / hour. CO2 emissions in shrub land ranged from 83.99 mg / m2 / hour - 1513.71 mg / m2 / hour. T test results on the amount of emissions in forests and shrub land showed that the average amount of emissions on forest land is higher than shrubs, but not statistically different from the value of 0.366 t <t table (4; 0,025) is 2,776. Total emissions at any point on their respective land use are presented in Table 3.

Table 3 Total CO2 emissions on peat soil with the use of forest land and shrubs

Use	distance from land	code channel	Emission	Mean CO_2	F	t	
		(m)		(mg / m^2 / h)			
	Forest	5	H11	28.17	924.28	0.269	.366
		10	H12	562.68			
		50	H13	2146.06			
		250	H14	1212.88			
		500	H15	671.63			
	Bush	5	S11	1013.09	760.63		.366
		10	S12	977.26			
		50	S13	1513.71			
		250	S14	215.12			
		500	S15	83.99			

From the observation depth of the ground water level, it is known that the ground water level is getting in the closer spacing of drainage channels. On peat soils of forests, decreased water level was significant transect II is at a distance of 5 m, 10 m, and 50 m of drainage channels, and on peat soil scrub, decreased water level was significant transect III, and IV a distance of 5 m, 10 m, and 50 m of drainage channels. These results suggest that transect II, III, and IV hydraulic conductivity thus making the high peat drainage channels greatly affects water peat soil subsidence. Reduced levels of ground water due to drying peat cause reduced soil water retention power. It is caused by a decrease in the concentration of COOH functional groups and phenolic OH hydrophilic and polar (Azri, 1999). Regarding the effect of drainage on soil water retention, research Silins and Rothwell (1998) in the peat soil Albarta Canada showed that after 7 years of drainage, soil water retention down from -5 to -15 000 cm or decline 66% larger than the area that is not drained peat.

In general, the level of decomposition of the peat layer above the groundwater level is higher / more than a layer of peat below the groundwater table. But the result of the determination of the level of maturity of peat by volume of fibers with injection method can not explain it. On peat soils of forest seen the phenomenon in which the maturity level of the peat below the ground water level is higher than with a layer of peat above the groundwater level. This is caused by the influence of the peat fires that occurred in the heating process peat. This can be seen from the samples taken showing the layers of peat, burnt black as charcoal. Warming due to the burning of peat resulting in loss of moisture and the resulting properties of resistance to water and dry properties are not behind. As a result of peat forming what is called false sand (pseudo sand). This fake sand has the ability to hold water very low. This causes the peat soil samples are not dissolved by water when it is filtered by the water at the time of the determination by the injection method, so that peat is seen to have high fiber content.

The ash content in peat forests and shrubs is ranging from 0.45% to 51.57%. From the measurement of ash content at any depth of 50 cm is shown that the deeper, higher ash content either on the use of forest land and shrubs. This is because the deeper, the greater the influence of mineral matter because it was close to the bottom of peat. According to Noor (2001), peat ash content varied between 5% - 65%. The higher levels of ash, indicating the higher minerals contained in the peat. Increasingly in the thickness of the peat then the lower the ash content to be. The ash content is also associated with fertility soils. Ash and organic matter content has a relationship with the maturity level of peat. The ash content of more than 5% indicates that the peat has been affected by mineral materials or referred to under (peaty mineral), and peat is more fertile than peat no / very little ash content (true peat) due to higher availability haranya. From the results of measurement of C-organic known that levels of C-organic ranged from 25.48% to 57.86%.

From the results of the calculation of carbon stocks, it is known that carbon stocks ranged between 386 Mg / ha to 3240 Mg / ha. Peat soils are peat forests thickness of more than 900 cm at any point of 5 m to 500 m of drainage channels, but sampling can only be done to a depth of 900 cm because of limitations on the drilling tool peat. On peat soils of forest carbon stocks seen that at a distance of 5 m, 10 m, and 50 m of the drainage channel is higher than the distance of 250 m, and 500 m of drainage channels. This is caused by the decomposition process that takes place more rapidly at a point close to the drainage canal, resulting in higher peat maturity and value of BD increases. The effect of BD, where BD at a distance of 5m, 10m, and 50m from the drainage channel is higher than the distance of 250 m, and 500 m of drainage channels. As previously noted, the effect of drainage on the distance of 250 m, and 500 m is very small or even non-existent. So with the same thickness is 900 cm, but the level of maturity of peat and BD are higher resulting in carbon stocks at a distance of 5 m, 10 m, and 50 m of drainage channels higher.

On peat soils shrubs transect III where there are crops of pineapple and rubber age of 8 months, the total carbon stocks within 5 m of the drainage channel is higher than the distance of 10 m, and 50 m of drainage channels. This is caused by the decomposition process that takes place more quickly so that the maturity of the peat increases and BD also increased. Transect III, the highest carbon stocks are at a distance of 250 m from the drainage channel that is equal to 3240 Mg / ha with peat depth of 650 cm. The high carbon stocks at this point due to the influence of the clay layer that resulted BD value is high. But at a distance of 500 m from the drainage channel carbon stocks is lower than the distance of 250 m due to the low value of BD, although the thickness of the peat higher at 793 cm.

On peat soils shrubs transect IV shown increasing carbon stocks at a distance of 5 m, 10 m, and 50 m of drainage channels. Peat thickness showed an increase from a distance of 5 m, 10 m, 50 m, 250 m, and 500 m of the drainage channel that is 284 cm, 300 cm, 369 cm, 379 cm and 518 cm. it showed a decline in high-surface soil (subsidence) in the area close to the drainage canal due to compaction and decomposition faster. So the closer to the drainage channel, the lower the carbon stocks.

On peat soils transects V, visible enhancement of carbon stocks at a distance of 5 m, 10 m, 50 m, and 250 m of drainage channels. Peat thickness showed an increase from a distance of 5 m, 10 m, 50 m, and 250 m of the drainage channel is 98 cm, 139 cm, 170 cm and 262 cm. At a distance of 500 m from the drainage channel thickness of peat and peat carbon reserves decreased, ie 168 cm thickness, lower than 250 m distance from the drainage channel. This is caused by the presence of a secondary drainage near the 500m point, thus affecting the decomposition process.

It is known that the decomposition process is faster on a layer above the groundwater level. In the calculation of carbon stocks with the reference thickness of 200 cm is known that carbon stocks ranged between 144.42 Mg / ha to 408.94 Mg / ha. On peat soils of forest transect I seen that drainage affecting carbon stocks at a distance of 5 m, 10 m, and 50 m of drainage channels. Likewise on peat soil scrub transect III, and IV that the closer to the drainage channel, the lower the carbon stocks. Stocks with the reference thickness of 200 cm from the ground indicate that the reduction in carbon stocks in peat land with the shrub land use (transect III, and IV) is relatively higher than the carbon stocks in forest land use (I and II). This suggests that the process of decomposition of the peat with the shrub land use faster than peatland forest land use. The decomposition process is faster on peat with shrub land use is also indicated by the value of BD higher than peat soil forest land use. BD value is also related to the maturity of the peat. The more mature peat, the BD will be higher. This means that on peat soil bushes, stocks with reference thickness of 200 cm is affected by the distance from drainage ditches, drainage channels closer to the lower carbon stocks. It shows that emissions at points adjacent to the drainage channel are higher than much of the drainage channel. This is because the points are often in a state of saturation so that the decomposition process runs faster and produced higher emissions.

CO2 emission measurement results on the use of forest land and scrub showed that CO2 emissions on peat soil forest ranged from 28.17 mg / m2 / hour - 2146.06 mg / m2 / hour. CO2 emissions in shrub land ranged from 83.99 mg / m2 / hour - 1513.71 mg / m2 / hour. T test results on the amount of emissions in forests and shrub land showed that the average amount of emissions on forest land is higher than shrubs, but not statistically different from the t value 0.366 <t table (4; 0,025) is 2,776. Forest on peat soil, the amount of emission at a distance of 5 m and 10 m of the drainage channel is smaller than the amount of emissions at distances of 50, 250, and 500 m of drainage channels. It is caused by conditions on the ground at the time of sampling gas which at a distance of 5 m from the drainage channel of peat in a state of stagnant conditions, and at a distance of 10 m from the drainage channel of ground water is very shallow, so the amount of emissions is low. But at a distance of 50 m, 250 m, and 500 m of drainage channels noticeable decrease in the amount of emissions with increasing distance from the drainage channel. Similarly in the shrub land is seen that the amount of emissions at the point of 5 m, and 10 m of the drainage channel is lower because of the influence of ground water that is shallower due to the conditions during the rainy season. At a distance of 50 m, 250 m, and 500 m of the drainage channel is seen that the lower the amount of emissions by getting away from the drainage channel. From the findings, it seemed that CO2 emissions on the use of forest land are higher than the shrub land. This can be caused by the maturity level of peat on the use of forest land is lower than the shrub land so that the CO2 emissions would be higher. The decomposition process that takes place faster in shrub land causes the peat to be higher maturity. The higher the level of maturity of the peat, then CO2 emissions would be lower. CO2 emission is strongly influenced by environmental factors, especially temperature and precipitation, and peatlands are very sensitive to both of them (Adger and Brown, 1995). At the time of low temperature and the condition of the ground water level is saturated or very shallow, the CO2 emissions in the peat will be very low or even no emission occurs.

D. Conclusion

Based on the research results, we can conclude the following:

1. The carbon stocks in peat soil with the use of the lower shrub land with the closer spacing of drainage channels. While the use of forest land within the influence of the drainage channel is relatively small.
2. The carbon stocks in forest land use are higher than the shrub land.
3. CO2 emissions increase with the closer spacing of the drainage channel that is at a distance of 50 m to 500 m of drainage channels. Meanwhile, at a distance of 5 m and 10 m of the drainage channel can not be concluded because the condition of the ground water level is stagnant when gas sampling, so it becomes very low CO2 emissions.
4. CO2 emissions on forest land use are higher than the shrub land.

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