Design of carbon dioxide level measures on peat soil with MG 811 sensor

M H Aziz*, P Saptiani, M Iryanti and A Aminudin

Physics Department, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia

*Corresponding author’s email: haidzar.aziz@gmail.com

Abstract. The world's carbon dioxide pollution is already at alarming levels. Carbon dioxide pollution leads to global warming. One of the cause of carbon dioxide pollution is peatland. Indonesia is one of the countries with largest peatland in Southeast Asia. Therefore there is a need for carbon dioxide concentration detector on peatland. Laboratory scale carbon dioxide concentration detector in peat was made. This detector consist of three main parts, namely, the source of carbon dioxide gas, gas barrier and the sensor system. The sensor system is using MG 811 gas connected to the arduino, in which output voltage from the sensor will be converted to ppm (part per million). Carbon dioxide gas from the source flows towards peatland contained on the barrier, and gas concentration will be measured by gas sensor. The carbon dioxide concentration detector was made with a size of 70 cm in length and width 40 cm. This experiment use peatland with 6 and 7 cm of thickness and carbon dioxide concentration detected are 400 – 1800 ppm.

1. Introduction
Carbon dioxide is the chemical compound composed of two oxygen molecules in a covalent bonding with a carbon molecule. This gas is produced through the decomposition of organic material, respiration and combustion. The average concentration of carbon dioxide on Earth's atmosphere is 387 ppm by volume although this amount may vary depending on location and time. Carbon dioxide is one of the greenhouse gases which able to absorb infra-red and its rate of growth per year is 1.5 parts per million volume (ppmv), which make it very influential to global warming [1]. Aside from the burning of fossil, carbon dioxide gas also come from tropical forests, especially peatland which is rich in carbon.

Peatland has a function to store CO2 from the atmosphere. The CO2 bound by biomass plants during the process of photosynthesis can be stored in peat [1]. Peat store a lot of carbon, because it’s nature of the ecosystem which is buried in soft and watery soil below ground level, resulting in a slight decay of organic material. The soil was buried thousands of years, which caused accumulation of organic material.

Chane of land use can turn peatland into a source of CO2 emissions in the atmosphere [2]. The increase of CO2 emissions because forest combustion and peatland in 1997 is 0.87 to 2.57 Gt C. The increase of CO2 concentration in the atmosphere causes an increase in temperature of 1-3.5 °C, 25% of the total CO2 emissions is from agricultural activity of the anthropogenic sources [3]. Carbon emissions from peatland is very fluctuate and depends on many factors including climate, soil, and hydrology [4]. Environmental factors that greatly affect the magnitude of carbon emissions on peat is
humidity and temperature, as well as the electrical conductivity (EC) [5,6]. For example in the peat at Rasau village of West Kalimantan, electrical conductivity (EC) reaches 0.12 dS/m to 0.03 dS/m [7].

On this research, a prototype for measuring emissions of carbon dioxide in the soil using sensor MG 811 was made. The first step that will be conducted is characterization of MG 811 response to carbon dioxide to find out how the characteristics of the sensor output voltage for higher carbon dioxide concentration. When MG 811 detection material reacts with carbon dioxide, it will produce emf (electromotive force). The next step is to design a chamber to place soil sample, which will be filled with carbon dioxide. Variation of soil thickness will be used to see its influence to MG 811 output voltage. The measured concentration of carbon dioxide which converted from MG 811 output voltage by microcontroller will be displayed on LCD. This research aims to develop a system to find out the concentration of carbon dioxide emissions in ground particularly at peat soils and its relation to the thickness of the soil.

2. Methods
Mechanism of carbon dioxide concentration detector in soil is divided into 3 parts, namely, the gas source, gas barrier and the sensor system. Gas sources flows carbon dioxide gases to barrier, barrier is part of the system to place and set the thickness of peat. While the sensor system using MG-811 gas sensor and Atmega328 microcontroller will measure the concentration of carbon dioxide contained in peat. The result of measurement will be displayed on the computer.

The experiment was conducted by placing peat soil sample on barrier and set its thickness. This barriers will be filled with carbon dioxide gas which flows from the source. Carbon dioxide gas that flows in the soil will be detected by MG-811 sensor. The output voltage from MG-811 will be converted by Atmega328 microcontroller into parts per million (ppm). The system scheme is shown in Figure 1.

![Figure 1. Peat Soil Carbon Dioxide Concentration Detector Scheme.](image)

3. Result and Discussion
The experiment was done on peat soil with 6 cm and 7 cm of thickness. Figure 2 is a photo of peatland’s carbon dioxide concentration detector as a whole.
Before testing on peat soil, MG 811 sensor calibration was carried out to find out which program had been entered as desired. Calibration is done by means of sensors placed in closed boxes and flowed with carbon dioxide for 90 seconds. The output of the MG 811 sensor is a voltage. The more carbon dioxide is detected, the smaller the voltage produced by the MG 811 sensor. Figure 3 is the test result with a curve obtained from the sensor datasheet.

Can be seen from Figure 3 there are similarities in the curves formed from the test results with curves from the sensor datasheet, namely the more carbon dioxide is detected, the smaller voltage produced by the MG 811 sensor.

3.1. Measuring the Peat soil Carbon Dioxide Concentration of 6 cm Thickness
The measured carbon dioxide by MG-811 sensor is 402 to 1833 ppm. As shown in Figure 4, it can be seen that the concentration of carbon dioxide is increasing per 5 seconds. The carbon contained in peat bind carbon dioxide flowed from the source, which resulted in the increase of carbon dioxidde concentration measured by sensor. This value will keep increasing until it reaches a stable value. The time required to achieve a stable value is 260 seconds.
3.2. Measuring the Peat Soil Carbon Dioxide Concentration of 7 cm Thickness

The measured carbon dioxide concentration by MG-811 sensor is 427 to 1571 ppm. As shown in Figure 5, it can be seen that the concentration of carbon dioxide is increasing per 5 seconds. The concentration of carbon dioxide measured by sensor is smaller than the 6 cm of thickness one’s. The decrease of carbon dioxide concentration is due to the distribution of the carbon gas that flows from the source is broader, so that the carbon gas detected by the sensor is smaller. The time required to achieve a stable value is 315 seconds.

3.3. The Influence of Carbon Dioxide Concentration on MG-811 Output Voltage

The higher concentration of carbon dioxide measured by the sensor, will decrease the output voltage of the sensor. As in the data of peat soil with 6 cm in thickness, shown in Figure 6.
Figure 6. Voltage Vs CO2 Concentration For 6 cm-Thick Peatland.

At a thickness of 6 cm the sensor output voltage is decreasing from 1,868 to 1,446 V with carbon dioxide concentration measured is 402 to 1833 ppm. As in the data of peat soil with 7 cm in thickness, shown in Figure 7

Figure 7 Voltage Vs CO2 Concentration For 7 cm-Thick Peatland.

For the thickness of 7 cm the output voltage of the sensor is decreasing from 1,851 to 1,489 with carbon dioxide concentration measured is 427 to 1571 ppm.

4. Conclusion
Peat soil carbon dioxide concentration detector was made with 70 cm in length and width of 40 cm. This system consist of 3 main sections, namely, gas sources, barrier and gas sensor system. Gas sources section flows the carbon dioxide gas towards the barrier. The barrier is used to place and set the thickness of the sample. The sensor is using MG-811 gas sensor which connected to a microcontroller, which will convert sensor output voltage to concentration of carbon dioxide in peat and the results are displayed on the computer.
The experiment is done with peat soil with different thickness of 6 cm and 7 cm. On 6 cm thickness, the concentration of carbon dioxide measured by the sensor is 402 to 1833 ppm and the time required to reach a stable value is 260 seconds. While in 7 cm thickness, the concentration of carbon dioxide measured by the sensor is 427 to 1571 ppm and the time required to reach a stable value is 315 seconds. The output voltage of the sensor is decreasing from 1,851 to 1,489 V with carbon dioxide concentration measured is 427 to 1571 ppm in peat soil with 6 cm thickness. The output voltage of the sensor is decreasing from 1,868 to 1,446 V with carbon dioxide concentration measured is 402 to 1833 ppm in peat soil with 7 cm thickness.

This system is still a prototype, for further research it is necessary to make a peat land’s carbon dioxide concentration detector on the real field.

5. References

[1] Puji H E, Idris K, Sabiham S, Djuniwati S and Van N M 2009 Emisi CO2 Pada Kebun Kelapa Sawit di Lahan Gambut: Evaluasi Flukus CO2 di Daerah Rizosfer dan Non Rizosfer Jurnal Tanah dan Lingkungan 11 8-13.

[2] Vasander H and Jauhiainen J 2008 Uncertainties, Deficiencies and Unknowns in Greenhouse Gas Emissions from Tropical Peatlands Future of Tropical Peatlands in Southeast Asia as Carbon Pools and Sinks

[3] Klemedtsson A K L, Klemedtsson K, Berglund P, Martikainen J, Silvola and Oenema O 1997 Greenhouse gas emissions from farmed organic soils: a review Soil Use and Management 13 245-250.

[4] Chadirin Y, Saptomo S K and Osawa K 2017 Lingkungan Biofisik dan Emisi Gas CO2 Lahan Gambut untuk Produksi Biomassa yang Berkelanjutan Jurnal Ilmu Pertanian Indonesia 146-151.

[5] Setia R, Marschner P, Baldock J, Chittleborough D and Verma V 2011 Relationships Between Carbon Dioxide Emission and Soil Properties in Salt-affected Land. Soil Biology and Biochemistry 43(3) 667-674

[6] Saiz G, Black K, Reidy B, Lopez S and Farrell E P 2007 Assessment of Soil CO2 Efflux and Its Components Using A Process-based Model In A Young Temperatur Forest Site Geoderma 139 (1-2) 79-89

[7] Aminudin A, Hasanah T R and Iryati M 2018 The Characteristics of Electrical and Physical Properties of Peat Soil in Rasau Village, West Kalimantan Journal of Physics: Conference Series 1013 1012178