SPATIAL VARIATION AND CORRELATION BETWEEN ELECTRIC CONDUCTIVITY (EM38), PENETRATION RESISTANCE AND CO_2 EMISSIONS FROM A CULTIVATED PEAT SOIL

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ABSTRACT

An EM38 was used to collect conductivity values (ECa) from a cultivated peat soil in Sweden. These values were compared to CO_2 emission, penetration resistance and water content sampled at 30 points with 10 m spacing. The result showed correlation between penetration resistance and water content, ECa and CO_2 emission. The structure of the spatial variation of ECa was visible as easily identified zones that could be used to design the measurement scheme for soil physical parameters.

Keywords: Spatial variation, EM38, CO_2 emission, Penetration resistance.

INTRODUCTION

Peatlands in their natural state accumulate organic matter and bind large quantities of carbon (5 - 50 g C/m^2/year). The drainage and cultivation of peat soils increase the aeration of the soil, which increase the brake down of the organic matter. The degradation of the organic material release greenhouse gases such as CO_2, N_2O and CH_4. CO_2 emissions dominate when the soil is aerated, while CH_4 mainly is released under anaerobic conditions. The organic soils, about 8% of the arable land in Sweden are the dominant greenhouse gas emitters from arable land in Sweden and these soils contribute to as much as 10% of the total anthropogenic emissions, in which fossil fuels accounts for most, and greatly affect the agricultural sector's contribution of greenhouse gases to the atmosphere (Berglund and Berglund, 2010).

Greenhouse gas measurements from fields are often done on few points per field using chamber measurements (Glenn et al., 1993, Bekku et al., 1995, Smith et al., 1995, Norman et al., 1997). A lysimeter study conducted 2002-2005 showed large variations in CO_2 emissions between different sites, peat type and drainage depth (Berglund and Berglund, 2011). Field trials during the same period showed a very large spatial variation within the same field (Berglund and Berglund, 2010) and large spatial variation is often found on peat soils (van den Pol-van Dasselaar et al., 1998, Campbell et al., 2002, Kandel et al., 2012). This may be due to the fact that organic soils have very large variation in physical and chemical properties, often larger than on mineral soils. One way to obtain information about the spatial variation is to measure the electrical conductivity (EC) of soil with an EM38 (Geonics, 2010), which is, among other properties, sensitive to differences in the amount of organic matter and water holding capacity (Friedman, 2005).

CO_2 emissions from cultivated peat soils show large spatial variation, which gives uncertain estimates of greenhouse gas emissions. To investigate the spatial variation field trials was conducted on two cultivated peat soil just north of Uppsala, Sweden.

The aim of these investigations was to find better methods and models to estimate the greenhouse gas emissions from cultivated peat soils.

Hypotheses:

- CO_2 emission varies with soil properties
- The spatial variability of soil properties in a cultivated peat soil can be identified by measuring the EC or gamma radiation
- By correlating the CO_2 emission with EC and different soil characteristics, a better estimate of gas emissions from cultivated peat soils can be made

MATERIALS AND METHOD

The site is located NW of Uppsala (60°5'0.5"N 17°13'59.0"E) and the soils is a typical cultivated fen peat growing spring wheat. The peat depth is between 15 and 35 cm at the field site (Figure 1).

To estimate the spatial variation we used an EM38. EM38 is an instrument that measures the apparent soil electrical conductivity (ECa) (Söderström, 2004). The instrument is drawn after a 4-wheeler while the position is measured with DGPS and data from the EM38 and GPS recorded continuously. The spacing between the lines and between the points in each line was about 12 m. The EM38 creates an electromagnetic field that gives rise to a secondary magnetic field that is recorded and the relationship between the magnetic field and the EM38 value is a function of conductivity. Depending on whether the instrument is angled horizontally (ECa_h) or vertically (ECa_v), the conductivity is mainly measured on the soil surface, 0-50 cm in the former case or 0-100 cm with a maximum response of about

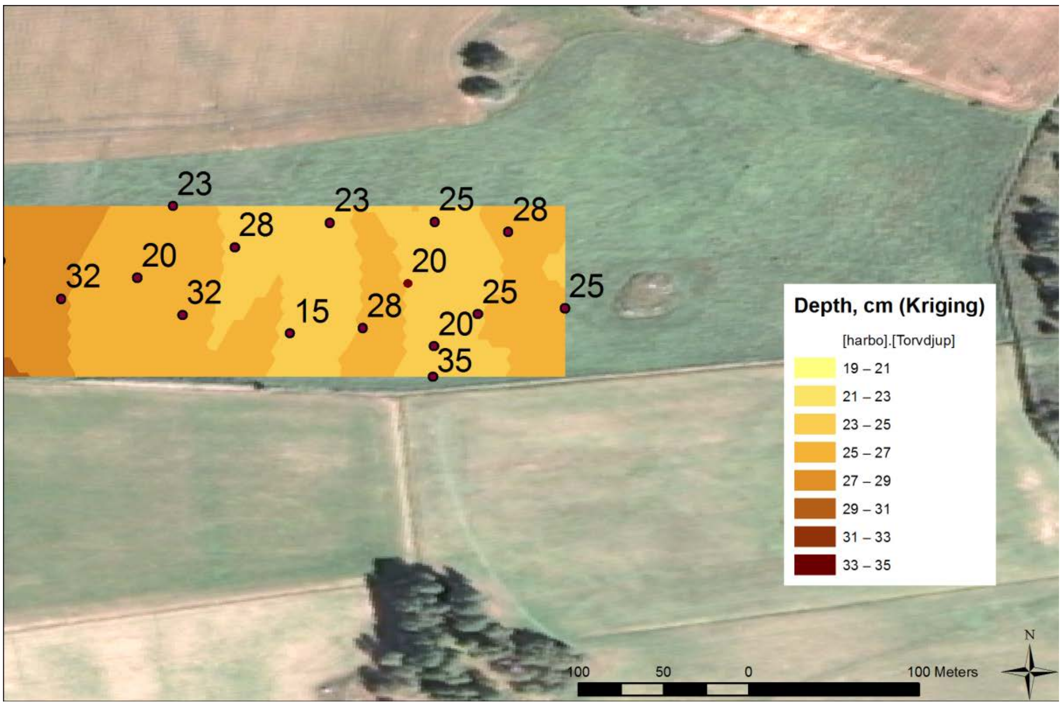

Figure 1. Peat depth (cm) at the field site.

A B

Figure 2. Interpolated map of conductivity values (mS/m) using ordinary kriging from the horizontal (A) and vertical (B) dipole mode and the location of the sampling grid.

40 cm depth (Sudduth et al., 2001) in the latter case. In this experiment we measured the conductivity with both methods. The conductivity is influenced by organic matter content and soil moisture, so variation in the conductivity shows the variations in these properties, which in turn could affect the CO_2 emission.

CO_2 emission, penetration resistance, water content and soil temperature was measured in a grid with 30 points approximately 10 m apart (Figure 2). CO_2 emission was measured by circulating the atmosphere from a 28 cm high dark chamber placed on the ground, through a carbon dioxide analyzer (Vaisala GMP343) for 3-5 minutes to measure the CO_2 concentration increase. Penetration resistance was measured with an Eijkelkamp Penetrologger (www.eijkelkamp.com), cone area 1 cm^2 with a semi-angle of 30°.Ten insertions to 50 cm depth at all points were made. The penetration resistance (the maximum and the average of 5-15 cm, 20-30 cm, 30-50 cm and 0-50 cm soil depth) was calculated for all points. The water content, electric conductivity and soil temperature was measured with a WET-sensor connected to an HH2 Moisture Meter (Delta-T Devices Ltd, Cambridge, UK)

Maps were created from the EM38 conductivity measurements (Figure 2) using ordinary kriging to interpolate the values between the measurement points using ArcMap 10.2 (ESRI, Redlands, CA). The interpolated EM38 values for both the vertical and horizontal dipole modes was extracted for the 30 points in the measurement grid and used for correlation analysis in JMP 9 (SAS Institute Cary, North Carolina).

RESULTS AND DISCUSSION

Table 1. The correlation of different variables to average penetration resistance

Variable	Correlation	Signif. Prob.
CO_2 emission	0.3778	0.0395
Water Content (vol. %)	-0.5559	0.0014
ECa_v	-0.415	0.0226
ECa_h	-0.4345	0.0164

The results show that there are significant correlations between the average penetration resistance and ECa_v, ECa_h, water content and CO_2 emission (Table 1).

The structure of the spatial variation of ECa shows clear zones that can be used to design the measurement scheme for soil properties. The ECa_v values were much higher than the ECa_h values, which is consistent with the fact that the peat layer is quite shallow and that the deeper penetration in the vertical mode reflect another soil type. Even though there were clear patterns in the conductivity values from the EM38 drive, no strong correlation to CO_2 emissions were found and much stronger correlation to soil properties have been found on mineral soils (Domsch and Giebel, 2004). Good correlation to penetration resistance was found, which implies that higher ECa values which might be a proxy for higher water content yields lower penetration resistance.

CONCLUSIONS

EM38 values showed clear patterns in the spatial variation, was correlated to water content and penetration resistance but was not correlated to CO_2 emission.

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