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‘VIS/NIR mapping of TOC and extent of organic soils in the Nørre Å valley’

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Organic soils represent a substantial pool of carbon in Denmark. The need for carbon stock assessment calls for more rapid and effective mapping methods to be developed.

The aim of this study was to compare traditional soil mapping with maps produced from the results of a mobile VIS/NIR system and to evaluate the ability to estimate TOC and map the area of organic soils.

The Veris mobile VIS/NIR spectroscopy system was compared to traditional manual sampling. The system is developed for in-situ near surface measurements of soil carbon content. It measures diffuse reflectance in the 350 nm-2200 nm region. The system consists of two spectrophotometers mounted on a toolbar and pulled by a tractor. Optical measurements are made through a sapphire window at the bottom of the shank. The shank was pulled at a depth of 5-7 cm at a speed of 4-5 km/hr. 20-25 spectra per second with 8 nm resolution were acquired by the spectrometers. Measurements were made on 10-12 m spaced transects. The system also acquired soil electrical conductivity (EC) for two soil depths: shallow EC-SH (0- 31 cm) and deep conductivity EC-DP (0- 91 cm). The conductivity was recorded together with GPS coordinates and spectral data for further construction of the calibration models.

Two maps of organic soils in the Nørre Å valley (Central Jutland) were generated: (i) based on a conventional 25 m grid with 162 sampling points and laboratory analysis of TOC, (ii) based on in-situ VIS/NIR measurements supported by chemometrics. Before regression analysis, spectral information was compressed by calculating principal components. The outliers were determined by a mahalanobis distance equation and removed. Clustering using a fuzzy c- means algorithm was conducted. Within each cluster a location with the minimal spatial variability was selected. A map of 15 representative sample locations was proposed. The interpolation of the spectra into a single spectrum was performed using a Gaussian kernel weighting function. Spectra obtained near a sampled location were averaged.

The collected spectra were correlated to TOC of the 15 representative samples using multivariate regression techniques (Unscrambler 9.7; Camo ASA, Oslo, Norway). Two types of calibrations were performed: using only spectra and using spectra together with the auxiliary data (EC-SH and EC-DP). These calibration equations were computed using PLS regression, segmented cross-validation method on centred data (using the raw spectral data, log 1/R). Six different spectra pre-treatments were conducted: (1) only spectra, (2) Savitsky-Golay smoothing over 11 wavelength points and transformation to a (3) 1’st and (4) 2’nd Savitzky and Golay derivative algorithm with a derivative interval of 21 wavelength points, (5) with or (6) without smoothing. The best treatment was considered to be the one with the lowest Root Mean Square Error of Prediction (RMSEP), the highest r2 between the VIS/NIR-predicted and measured values in the calibration model and the lowest mean deviation of predicted TOC values. The best calibration model was obtained with the mathematical pre-treatment’s including smoothing, calculating the 2’nd derivative and outlier removal.

The two TOC maps were compared after interpolation using kriging. They showed a similar pattern in the TOC distribution.

Despite the unfavourable field conditions the VIS/NIR system performed well in both low and high TOC areas. Water content in places exceeding field capacity in the lower parts of the investigated field did not seriously degrade measurements.

The present study represents the first attempt to apply the mobile Veris VIS/NIR system to the mapping of TOC of peat soils in Denmark. The result from this study show that a mobile VIS/NIR system can be applied to cost effective TOC mapping of mineral and organic soils with highly varying water content.

Key words: VIS/NIR spectroscopy, organic soils, TOC