Geophysical Research Abstracts
Vol. 12, EGU2010-10163, 2010
EGU General Assembly 2010

Near infrared spectroscopy as a potential tool to monitor the mineralization of exogenous organic matter within the soil

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Many studies have shown that near infrared spectroscopy (NIRS) is an effective method to characterize various soil properties and endogenous or exogenous organic matter. However, the ability of NIRS to monitor the dynamics of organic matter incorporated into the soil has not yet been tested. This method has a great potential as it can be faster, cheaper and more accessible than conventional techniques dealing with this topic.

The aim of this study was to evaluate the potential of the visible near infrared (Vis-NIR: 400-2500nm) to monitor the mineralization of organic matter added to the soil by quantifying, over time, its degradation products. This study focused on 2 types of soils, one from France (Neoluvisol developed on silt wind) and the other from Tunisia (Vertic Xerofluvents). Both soils received two types of organic input, poultry manure (C/N = 17.8) and composted pig manure on straw (C/N = 20.6). Moreover, a sample from each soil type, with no organic input, was kept as a reference. The samples were wetted up to field capacity and were incubated at 25°C during 58 days. Analytical data characterizing the mineralization of organic matter, as mineral carbon (C-CO2) and mineral nitrogen (N-NH4 and N-NO3) were collected following periodic measurements. The soil samples spectra were recorded at the same time using an ASD Fieldspec Pro (350-2500 nm). Principal components analysis (PCA) was performed with the analytical data and spectra to find correlations between the mineralization dynamics and changes of spectra, in relation to the exogenous organic matter degradation. Partial least squares (PLS) algorithm was used to calibrate models linking different mineralization parameters to spectral response. Owing to the low number of available samples (28 samples), the models were adjusted using leave one out cross-validation.

Direct observation of the spectra as shown that the level of spectral reflectance of soil samples has evolved over time, which means that the state of degradation of organic matter affects soil reflectance in the Vis-NIR. PCA performed with the analytical data discriminates the time according to the 1st axis that explains 50.1% of the observed variance. PCA performed with the reflectance spectra did not show any significant correlation with the time parameter in the 1st factorial plane. However, the 2nd axis of this factorial plane differentiates between soil types.

The models calibrated by the mean of PLS to predict direct analytical data (C-CO2, N-NH4 and N-NH3) were quite precise for the cumulative carbon and the mineral nitrogen produced after mineralization of the exogenous organic matter. The performance of these models were R^2=0.68-0.78, RMSE=64.92mg C/kg-109.91mg N/kg and ME=3.47mg C/kg-13.94mg N/kg, respectively. Moreover, we have calibrated models to predict the organic carbon (R^2 = 0.89, RMSE = 352.57 mg C / kg and ME = -50.16mg C / kg) and organic nitrogen (R^2 = 0.79, RMSE = 9.46% and ME = 0.69%) remaining in the soil samples. The predictions of these indirect variables related to mineralization process were satisfactory.

These first results are promising towards the development of a non-intrusive, cheaper and flexible tool to monitor the mineralization of exogenous organic matter within the soil.