Field specific mineralisation rate of SOC

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Abstract:

Mineralisation and build-up of soil organic matter are important features for recommendations on, e.g. fertilisation and carbon sequestration. A general figure of 2% mineralisation in mineral soils is still being used in practice. However, modelling approaches have shown effects of differences in land-use (e.g., arable, grassland) and soil heterogeneity (e.g. clay content, pH) to mineralisation. This research aimed to find and test a field-specific algorithm for the mineralisation in mineral soils, from an analysis of the relationships between soil characteristics and respiration rate.

A representative dataset was made for c. 150 soil samples in arable, vegetable, and grassland soils. Samples were incubated in the laboratory (20 °C), and after a conditioning period of three days, CO_2-emission was measured for one hour at 7, 14, 28, and 56 days after the first measurement using a photo acoustic gas analyser. Routine soil analysis was carried out including SOM, Ct, Nt, PMN, pH, and clay. Data were also collected regarding nitrogen fertilisation and crop residue management up to 12 months prior to sampling. The latter was used to assess the ratio fresh organic material and SOC stock (F/O-ratio).

Data were used for fitting a general exponential model that distinguishes two organic-C pools, a stable pool (b) and a decomposable pool (c) that decomposes according to first-order kinetics with rate (r), adding additional parameters for soil characteristics, land-use, and N-level. We calculated the relative decomposition rate (RDR) as RDR= LOG (Y_t / (Y_{t+1}) = LOG (Y_t / (b + c . r^{t+1}). Regression analysis (GLM) was performed on RDR and model parameters (b), (c), and (r). Based on statistical parameters, the best models were selected. The approach included a correction for temperature and other lab conditions. Resulting models were tested with measured SOM or SOC data from LTE's in arable farming systems at sandy soil (Vredepeel, organic system), clay soil (Lovinkhoeve), and reclaimed peat, now sandy soil (Valthermond), taking into account inputs of effective organic matter) from crop residue and/or fertilisers.

Models were found for RDR and model parameter (b), but not for (c) and/or (r). RDR itself could be explained for 66% by soil characteristics (C/N-ratio, N_t, and F/O) and land-use. For the stable pool, five regression models were found (each with $R^2_{adj.}$ = 0.91), having in common the soil characteristics C/N-ratio and N_t, each with optional soil characteristics from clay, F/O, pH, and/or N-use, with one model distinguishing between land-uses. Since total SOC is the sum of the stable and decomposable pools, we could assess the decomposable pool and calculate its RDR_{DE} (suffix to distinguish from the original RDR).

Mineralisation rates in the arable fields ranged from 0 – 8%. For the six arable fields at sandy soil in Vredepeel, the model for RDR_{DE} compared reasonably well with measured SOM-data (Figure 1). Over the period 2004 – 2016, a positive trend was found, albeit within the analytical measurement error. Further research may elucidate the potential for carbon sequestration. In the other case-studies the model also performed better than the original RDR and the 2% rule of thumb. In particular, in fields with high SOM-content as in Valthermond, the model suggested realistic amounts of SOC-loss.

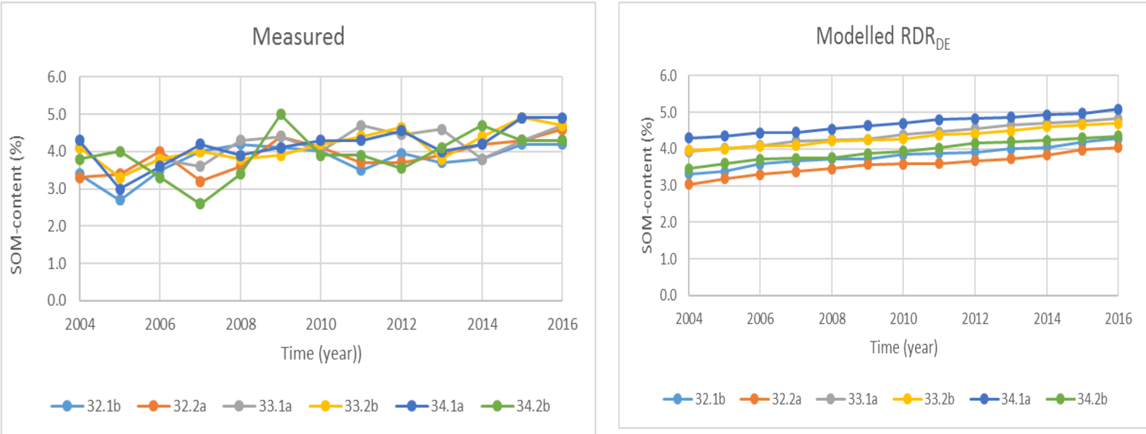

Figure 1. Evaluation of a field-specific algorithm for the mineralisation rate in six arable fields at sandy soil (Experimental Farm Vredepeel).

The results are obtained using the best guess for the correction factor from lab to field mineralisation data. Confirmation of this factor is most needed. A field-specific mineralisation rate may be advantageous in situations that deviate from a mean rate of 2%, and/or have a large stable pool. It could be helpful in assessing amounts needed to compensate SOC loss and/or indicate fields suitable for carbon sequestration. Also, a large stable pool may indicate that with carbon, also nitrogen mineralisation may be low. Fertiliser recommendations may be changed accordingly. In addition, by calculating the ratio stable/total SOC, an indication is obtained of possible further decline in SOC. This research also confirms the weakness in comparing, for individual fields, loss-on-ignition data between years.