Geophysical Research Abstracts,
Vol. 11, EGU2009-12027, 2009
EGU General Assembly 2009

Stable carbon and oxygen isotopes as an indicator for soil degradation

C. Alewell, M. Schaub, and B. Seth
Environmental Geoscience, Geosciences, Basel, Switzerland (christine.alewell@unibas.ch)

Analyses of soil organic carbon content (SOC) and stable carbon and oxygen isotope signatures (δ^{13}C) of soils were assessed for their suitability to detect early stage soil erosion. Results were validated with Cs-137 measurements. We investigated the soils in the alpine Urseren Valley (Southern Central Switzerland) which are highly impacted by soil erosion. Hill slope transects from uplands (cambisols) to adjacent wetlands (histosols and histic to mollic gleysols) differing in their intensity of visual soil erosion and reference wetlands without erosion influence were sampled. Carbon isotopic signature and SOC content of soil depth profiles were determined. A close correlation of δ^{13}C and carbon content (r $>$ 0.80) is found for upland soils not affected by soil erosion, indicating that depth profiles of δ^{13}C of these upland soils mainly reflect decomposition of SOC. Long term disturbance of an upland soil is indicated by decreasing correlation of δ^{13}C and SOC (r $\leq$ 0.80) which goes parallel to increasing (visual) damage at the site. Early stage soil erosion in hill slope transects from uplands to adjacent wetlands is documented as an intermediate δ^{13}C value (27.5 ‰) for affected wetland soil horizons (0 – 12 cm) between upland (aerobic metabolism, relatively heavier δ^{13}C of 26.6 ‰) and wetland isotopic signatures (anaerobic metabolism, relatively lighter δ^{13}C of 28.6 ‰). Cs-137 measurements confirmed stable isotope analysis.

Stable oxygen isotope signature (δ^{18}O) of soil is the result of a mixture of the components within the soil with varying δ^{18}O signatures. Thus, δ^{18}O of soils should provide information about the soil's substrate, especially about the relative contribution of organic matter versus minerals. As there is no standard method available for measuring soil δ^{18}O, the method for measurement of single components using High Temperature Conversion Elemental Analyzer (TC/EA) was adapted. We measured δ^{18}O in standard materials (IAEA 601, IAEA 602, Merck Cellulose) and soils (organic and mineral soils) in order to determine a suitable pyrolysis temperature for soil analysis. We considered a pyrolysis temperature suitable when the yield of signal intensity (mass 28 per 100 μg) is at a maximum and acquired raw δ^{18}O signature is constant for used standard materials and when the quartz signal from the soil is still negligible. After testing several substances within the temperature range of 1075 to 1375 ˚C we decided to use a pyrolysis temperature of 1325 ˚C for further measurements. For the Urseren Valley we have found a sequence of increasing δ^{18}O signatures from phyllosilicates to upland soils, wetland soils and vegetation. Our measurements show that δ^{18}O of upland soil samples differ significantly from wetland soil samples. The latter can be related to changing mixing ratio of mineral and organic constituents of the soil. For wetlands affected by soil erosion, we have found intermediate δ^{18}O signatures which lie between typical signatures for upland and wetland sites and give evidence for input of upland soil material through erosion.

To conclude, carbon isotopic signature and SOC content are found to be a sensitive indicator of short and long term soil erosion processes. Regarding stable oxygen isotopes, we consider δ^{18}O to have potential as a suitable tracer for soil erosion in transects from upland to wetland soils. However, soil erosion detection with δ^{18}O needs to be verified at other sites with differing geology, climate, altitude and vegetation to acquire an even broader understanding of δ^{18}O of soils.