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 (δ13C) 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 δ13C and carbon content (r > 0.80) is found for upland soils not affected by soil erosion, indicating that depth profiles of δ13C of these upland soils mainly reflect decomposition of SOC. Long term disturbance of an upland soil is indicated by decreasing correlation of δ13C and SOC (r ≤ 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 δ13C value (27.5 %) for affected wetland soil horizons (0 – 12 cm) between upland (aerobic metabolism, relatively heavier δ13C of 26.6 %) and wetland isotopic signatures (anaerobic metabolism, relatively lighter δ13C of 28.6 %). Cs-137 measurements confirmed stable isotope analysis.

Stable oxygen isotope signature (δ18O) of soil is the result of a mixture of the components within the soil with varying δ18O signatures. Thus, δ18O 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 δ18O, the method for measurement of single components using High Temperature Conversion Elemental Analyzer (TC/EA) was adapted. We measured δ18O 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 δ18O 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 δ18O signatures from phyllosilicates to upland soils, wetland soils and vegetation. Our measurements show that δ18O 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 δ18O 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 δ18O to have potential as a suitable tracer for soil erosion in transects from upland to wetland soils. However, soil erosion detection with δ18O needs to be verified at other sites with differing geology, climate, altitude and vegetation to acquire an even broader understanding of δ18O of soils.