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Publication

Oxygen isotope ratios (18O/16O) of hemicellulose-derived sugar biomarkers in plants, soils and sediments as paleoclimate proxy II: Insight from a climate transect study

JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

ID 2633447
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Year 2014
Title Oxygen isotope ratios (18O/16O) of hemicellulose-derived sugar biomarkers in plants, soils and sediments as paleoclimate proxy II: Insight from a climate transect study
Journal Geochimica et cosmochimica acta
Volume 126
Pages / Article-Number 624-634
The oxygen isotopic composition of precipitation (δ18Oprec) is well known to be a valuable (paleo-)climate proxy. Paleosols and sediments and hemicelluloses therein have the potential to serve as archives recording the isotopic composition of paleoprecipitation. In a companion paper (Zech et al., 2014) we investigated δ18Ohemicellulose values of plants grown under different climatic conditions in a climate chamber experiment. Here we present results of compound-specific δ18O analyses of arabinose, fucose and xylose extracted from modern topsoils (n =ă56) along a large humid-arid climate transect in Argentina in order to answer the question whether hemicellulose biomarkers in soils reflect δ18Oprec. The results from the field replications indicate that the homogeneity of topsoils with regard to δ18Ohemicellulose is very high for most of the 20 sampling sites. Standard deviations for the field replications are 1.5%■, 2.2%■and 1.7%■, for arabinose, fucose and xylose, respectively. Furthermore, all three hemicellulose biomarkers reveal systematic and similar trends along the climate gradient. However, the δ18Ohemicellulose values (mean of the three sugars) do not correlate positively with δ18Oprec (r =ă−0.54, p >ă0.014, n =ă20). By using a Péclet-modified Craig-Gordon (PMCG) model it can be shown that the δ18Ohemicellulose values correlate highly significantly with modeled δ18Oleaf water values (r =ă0.81, p >ă0.001, n =ă20). This finding suggests that hemicellulose biomarkers in (paleo-)soils do not simply reflect δ18Oprec but rather δ18Oprec altered by evaporative 18O enrichment of leaf water due to evapotranspiration. According to the modeling results, evaporative 18O enrichment of leaf water is relatively low (∼10%■) in the humid northern part of the Argentinian transect and much higher (up to 19%■) in the arid middle and southern part of the transect. Model sensitivity tests corroborate that changes in relative air humidity exert a dominant control on evaporative 18O enrichment of leaf water and thus δ18Ohemicellulose, whereas the effect of temperature changes is of minor importance. While oxygen exchange and degradation effects seem to be negligible, further factors needing consideration when interpreting δ18Ohemicellulose values obtained from (paleo-)soils are evaporative 18O enrichment of soil water, seasonality effects, wind effects and in case of abundant stem/root-derived organic matter input a partial loss of the evaporative 18O enrichment of leaf water. Overall, our results prove that compound-specific δ18O analyses of hemicellulose biomarkers in soils and sediments are a promising tool for paleoclimate research. However, disentangling the two major factors influencing δ18Ohemicellulose, namely δ18Oprec and relative air humidity controlled evaporative 18O enrichment of leaf water, is challenging based on δ18O analyses alone.
Publisher Elsevier Science
ISSN/ISBN 0016-7037

Digital Object Identifier DOI 10.1016/j.gca.2013.11.002
ISI-Number WOS:000329504800036
Document type (ISI) Article