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Analysis of hydrological components of the Wüstebach catchment by means of stable isotope measurements

M. Stockinger (1), H. Bogena (1), A. Lücke (1), B. Diekkrüger (2), and H. Vereecken (1)

(1) Jülich Research Center GmbH, Institute of Bio- and Geosciences, IBG 3: Agrosphere, Wilhelm-Johnen-Straße, 52428 Jülich, Germany, (2) University of Bonn, Department of Geography, Meckenheimer Allee 172, Room: 3009, 53115 Bonn

Over the past decades, interpretation of changes in stable isotope signatures of catchment waters have been used to assess hydrological flow paths under different flow conditions and estimating mean catchment residence times. However, despite of the many studies the timing, flow path, and source behavior of catchments are still not well understood. In this study we investigate the hydrological components of the Erkensruhr catchment (45 km^2), Germany, and the Wüstebach sub-catchment (10 ha^2) using stable isotopes of water (D/H and Oxygen-18/Oxygen-16) as tracers. We present first results of a more than two-year long measurement campaign in the Wüstebach catchment with respect to the magnitude and the temporal characteristics of isotope variations in precipitation, throughfall, groundwater and the Wüstebach stream. Later research will also incorporate soil water analysis and focus on the isotopic behavior and the hydrological components (slow and fast runoff components) of the Erkensruhr catchment.

First results demonstrate the expected seasonal effect on precipitation isotope ratio (Summer: -4.00‰ Oxygen-18 to Winter: -11.00‰ Oxygen-18) and that throughfall undergoes evaporation (differences up to +2.00‰ Oxygen-18 to precipitation). It is important to quantify this isotopic enrichment and the amount of throughfall to estimate the effect of evaporative changes in throughfall compared to unchanged precipitation on the isotope ratios of the outlets hydrograph. Both groundwater and streamflow samples show a tendency of lower isotope values over the course of the two-year long time series (linearly declining approximately -0.4‰ Oxygen-18). As precipitation does not show the same decline, ecological changes of the Wüstebach catchment might be the origin of this effect.

A clear seasonal effect on streamflow can be observed at the source of the Wüstebach, with higher concentrations in summer due to higher precipitation isotope concentrations and a fast decrease in concentration at the end of winter, probably due to snow melt. We observed a mixing effect of two separated stream sources. One source shows a clear seasonal behavior whereas the other source shows quasi-constant concentrations over time. The mixing of both sources leads to a dampening of the seasonal effect of isotope concentrations in the Wüstebach stream that does not disappear over the course of the measured stream (approximately 400 m). We argue that the invariable source is fed by deeper groundwater, whereas the seasonally variable source is fed by a shallow groundwater aquifer.

Our work indicates different groundwater sources for the Wüstebach river and shows an evaporative effect on throughfall. A decline of isotope concentrations for streamwater and groundwater has been found that might be due to ecological changes in the catchment. Future research will focus on hydrological modeling of the Wüstebach sub-catchment which will then be expanded to hydrological modeling of the Erkensruhr catchment.