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Inferring runoff generation processes through high resolution spatial and temporal UV-Vis absorbance measurements in a mountainous headwater catchment in Southern Ecuador

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The alpine grassland páramo - typically occurring in the headwater catchments of the Andes - plays an important role in flow regulation, hydropower generation and local water supply. However, hydrological and hydro-biogeochemical processes in the páramo and their potential reactions to climate and land use change are largely unknown. Therefore, we used a UV-Vis absorbance spectrometer to investigate fluxes of biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity and nitrate (NO_3-N) in a small headwater catchment (91.31 km^2) in the páramo in south Ecuador on a 5 min temporal and 100 m spatial resolution to gain first insights in its hydrological functioning.

Spatial sampling was realized during three snapshot sampling campaigns along the 14.2 km long stream between October 2013 and January 2014, while temporal sampling took place at a permanent sampling site within the catchment between February and June 2014. To identify the runoff generation processes the spatial patterns have been associated with local site specific (e.g. fish ponds) and sub-catchment wide (e.g. land use) characteristics. Storm flow events within the time series allowed to further study temporal changes and rotational patterns of concentration-discharge relations (hysteresis). In total, 35 events were identified to be suitable for analyzing hysteresis effects of BOD, COD, and turbidity. Nitrate concentrations could be studied for 20 events.

Regardless of the flow conditions nitrate leaching increased with a growing share of non-native pine forests or pastures in the study area. During low flow conditions, the high water holding capacity of the upstream páramo areas ensured a continuous supply of BOD to the stream. Pasture and pine forest sites, mostly occurring in the downstream section of the stream, contributed to BOD only during discharge events. Contradicting the expectations the trout farms along the lower part of the streams had a relatively closed nutrient cycle and only a minor effect on instream BOD and nitrate concentrations.

Precipitation events caused increasing concentrations of all investigated parameters. The hysteresis loops of all parameters presented a high consistency, possibly due to the relative constant climate. COD, turbidity, and nitrate values rotated mainly clockwise, BOD counterclockwise. However, BOD response varied in dependence on the precipitation intensity. COD and nitrate presumably originate from subsurface flow. Turbidity is mainly caused by erosion of temporary stored sediment in the channel. The vegetation and the litter layer in the riparian zone were found to be the main source of organic carbon to explain the BOD data. Results indicate a fast reaction of subsurface flow due to rapid infiltration and displacement of pre-event water, and a generally slower response of overland flow. However, varying reactions of BOD indicate that the response of overland flow could depend on the infiltration capacity of the soil.