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Stable Isotopes in Precipitation to Understand Moisture Transport Dynamics and the Distribution of Potentially Toxic Elements in Northern Sweden

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Precipitation is a critical component of the hydrological cycle influencing water resources, ecosystems and atmospheric chemistry. However, it can also act as a medium for transporting potentially toxic elements (PTEs) such as cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), vanadium (V) and zinc (Zn) which originate from both natural and anthropogenic sources. Atmospheric deposition rates of PTEs vary spatially and temporally and are a direct reflection of air quality which is impacted by e.g., release from mining sites, fossil fuel power stations, waste incineration, natural sources and other indirect contributions, which are poorly constrained from Northern Sweden. Hence, this study mainly focuses on the deposition rates of PTEs and the isotopic composition of oxygen (O) and hydrogen (H) in precipitation to trace moisture sources and atmospheric processes. To evaluate the controlling factors on stable isotopes of precipitation, the spatio-temporal variation of $\delta^{18}O$ & $\delta^{2}H$ was investigated from seven stations (Kiruna, Piilijärvi, Gällivare, Luleå, Kivijärvi and Jörn). Utilizing the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, backward trajectories were analyzed to identify the origins of air masses contributing to precipitation events. Additionally, multivariate analysis was employed to discern patterns and potential sources of PTEs in the collected seasonal samples. The overall datasets indicate that PTEs concentration are in the order of Zn>Ni>Mn>Cu>Fe>Cr>Pb>V>Cd. More pronounced seasonal PTEs variability was observed, particularly during the summer season, resulting in seasonal and regional variability in pollutant sources while remaining the negligible influence of pH. The isotopic composition revealed distinct seasonal variations, relatively high $\delta^{18}O$ and $\delta^{2}H$ values characterize summer air masses, and lighter isotope composition was observed during winter precipitation. Based on HYSPLIT backward trajectories, our results show the dominant influence of westerly oceanic-sea inputs and marginal easterly inputs. Our findings provide information on PTEs distribution in the periphery of active mining areas, stable isotopes in precipitation, which can be used as tracers that provide a fingerprint of water sources and processes to the kilometer-scale of moisture transport over time.