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Water age tracing under open stream conditions using iodine-129

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Environmental tracers are powerful tools for water resource management. Groundwater age is relevant to estimate aquifer recharge and vulnerability, while streamflow age is a crucial descriptor of how catchments transmit water. Rivers are a mixture of young and old water, but the relative contributions of each component and their seasonal variability are major unknowns. Determining river water age is challenging because most modern water tracers are dissolved gases that lose their age signal after atmospheric contact.

This study aims to develop anthropogenic ^{129}I ($t_{1/2}$=15.7 Myr) as an alternative tracer for modern water dating in open stream conditions. Initially released by nuclear bombs during the 1940s, ^{129}I is now continuously discharged from nuclear reprocessing facilities, resulting in higher concentrations being associated with younger water ages. Unlike gas tracers, the total dissolved ^{129}I concentration is maintained (under favorable pH conditions) after atmospheric contact. However, sorption of ^{129}I onto organic matter and iron oxide minerals alters dissolved concentration levels. Present-day ^{129}I/^{127}I environmental ratios range from 10^{-12} to 10^{-3} at/at, varying with sample type and geographic location.

These varying isotopic ratios require different analytical methods based on higher or lower expected values. Accelerator Mass Spectrometry (AMS) is the standard measurement method for low-concentration samples due to its high sensitivity (detection limit: ratio 10^{-13}), but requires the conversion of a water sample into a solid precipitate. In contrast, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) offers a more accessible technique to analyze higher concentration water samples with less preparation (detection limit: ratio ~10^{-9}).

To improve AMS water sample preparation, a low-^{127}I-carrier (0.2 mg), fast coprecipitation method is tested [doi:10.46770/AS.2021.071]. Using less carrier reduces intrinsic ^{129}I background thereby improving detection limits. For higher-concentration samples, we are developing a multi collector ICP-MS method with a collision-reaction cell to minimize isobaric and polyatomic interferences (e.g., ^{129}Xe), and improve analytical ^{129}I/^{127}I uncertainties. Establishing ^{129}I/^{127}I methods with common instruments promotes the use of ^{129}I as a hydrological tracer, opening up new opportunities to reveal seasonal shifts in contributions and ages of different streamflow compartments in rivers. This allows us to evaluate the resilience of rivers with respect to floods and droughts.