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Geochemical Dynamics and Anthropogenic Impacts on the Mur River Catchment: Insights from pH-Dependent Element Leaching of Sediment and $^{87}Sr/^{86}Sr$ Isotope Analysis of the Water Phase

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The impacts of climate change (e.g., increased runoff and erosion) and anthropogenic activities (e.g., industrial discharge, urban effluents and mining) can significantly alter geochemical processes in river catchments. The necessity of improving novel tools to detect and monitor such impacts is therefore crucial and requires advanced analytical approaches. Therefore, the following factors were analysed in the alpine river catchment of the Mur River in Austria and Slovenia: (1) the natural geochemical background, (2) major tributaries, (3) element interactions between solid and liquid phases, and (4) anthropogenic contributions. Water samples from the Mur River and selected tributaries were analysed across different seasons for $^{87}Sr/^{86}Sr$ isotope ratios and elemental mass fractions using MC-ICP-MS (Nu Plasma HR, Nu Instruments) and ICP-MS (Perkin Elmer NexION 5000), respectively. These analyses revealed a significant influence of the geological background on the river's chemical composition, as well as the role of tributaries in modifying the main channels water chemistry. The results also indicate partial anthropogenic impacts, most likely from mining activities or urban effluents. To complement the findings from the water phase, sediment samples were collected at six locations to investigate long-term element storage and mineral transformation. The ÖNORM EN 14346:2007-03 standard, typically applied to deposits, urban mines and slags, was adapted to assess the pH-dependent leaching behaviour of sediments around the inflows of two selected tributaries. Leaching controlling processes were modelled using LeachXS, allowing for a more targeted evaluation of geochemical interactions affecting element mobility. By integrating water and sediment analyses, this study provides a more comprehensive understanding of the geochemical dynamics in the Mur River system, offering new insights into both natural and anthropogenic impacts.