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Uniformity of Magnesium Stable Isotope Ratios in major Japanese Rivers

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Non-traditional stable isotopes of major elements provide a powerful tool for source attribution in riverine systems, yet their application remains limited in Japanese rivers despite pronounced geological diversity and large spatial variability. Here we present the first comprehensive dataset of Mg stable isotope ratios (δ^{26}Mg) for major rivers in Japan. The sampling was conducted at 15 rivers covering from Kyushu to Southern region of Tohoku. All samples were collected in downstream reaches but upstream of any detectable seawater intrusion. Riverine δ^{26}Mg values showed a mean of −0.81 ± 0.27‰ (1 SD, 15 rivers sampled in two seasons), with most samples tightly clustered around the seawater value. Although a wider overall range (−1.51 to −0.05‰) is present due to a small number of low-δ^{26}Mg samples, only limited seasonal differences were observed for the majority of rivers. Rivers with strong groundwater influence exhibited distinctly higher values, reaching up to -0.05‰, plausibly reflecting weathering signals of primary minerals. Although most river water samples exhibited δ^{26}Mg values close to seawater, Cl^--based estimation method indicated that the sea-salt contribution to dissolved Mg was <45%, revealing a clear discrepancy between isotope-based and elemental-ratio-based source apportionment. The observed uniformity of δ^{26}Mg may result from a combination of (i) marine aerosol inputs, (ii) mixing between silicate and carbonate weathering endmembers, (iii) anthropogenic Mg sources, and (iv) secondary processes that overprint primary isotope signatures. These results suggest that, for Japanese rivers, conventional source estimation methods that consider atmospheric deposition and stoichiometric release from bedrock may not be appropriate, highlighting the need to reconsider Mg source attribution in riverine systems.