

Substantial gadolinium enrichments in lake and river near metrocities in Korea

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We measured dissolved rare earth elements (REEs) in the water samples from Shihwa Lake (SL), which was assumed to be highly polluted, as well as in the downstream portion of the Han River (HR), which runs through, Seoul, Korea. Among the investigated REEs, only Gadolinium (Gd) was found to be significantly enhanced after REE concentrations were shale-normalized (SN). The calculated Gd anomaly ($Gd/Gd^* = 3 \times Gd_{SN} / (Sm_{SN} + 2 \times Tb_{SN})$) was about 1.5 ± 0.1 (n=16) in SL and 1.6 ± 0.3 in HR (n=26) water relative to other types of natural water such as groundwater, seawater, and river water in uncontaminated areas ($Gd/Gd^* \sim 1.2$, n>400). These significant Gd anomalies seem to be due to the inputs of anthropogenic Gd (Gd_{anth}), especially by the use of Gd-based contrast agents for magnetic resonance imaging (MRI) tests from a number of hospitals and medical institutes surrounding our study areas. The Gd_{anth} inventory was estimated to be 190 ± 80 g and 680 ± 360 kg Gd in SL and the HR (watersheds in our study area), respectively. The Gd_{anth} flux to the Yellow Sea from the HR is estimated to be 530 ± 330 g Gd day⁻¹. Overall, these results suggest that quantitative evaluation of man-made REEs for associated human risk assessments are needed, because considerable amounts of REEs are now used by modern high-tech industries.