Scandium-Rare Earth Element Relationships and Anthropogenic Gadolinium in the Wupper River, Germany

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While the rare earth elements and yttrium (REY) have been subject to numerous studies, Sc is usually excluded from REY studies because of its different geochemical behaviour and specific analytical issues. Therefore, knowledge of the distribution and behaviour of Sc in natural waters is rather limited and nothing is known about potential anthropogenic Sc (micro)contamination. This is different for Gd which is a REY that is used in MRI contrast agents and, as it is applied in the form of very stable water-soluble complexes, is not removed from sewage in waste water treatment plants (WWTPs). Therefore, the anthropogenic Gd enters rivers and lakes with the clearwater effluent from WWTPs and many rivers worldwide show a large positive Gd anomaly in REY patterns due to the presence of this anthropogenic Gd.

The 116 km long Wupper River in North Rhine-Westphalia, Germany, which is an important local drinking water resource, was sampled in 2010 and 2019 from its spring downstream to where it enters the Rhine River. In general, the shale-normalized REY (REY_{SN}) patterns of all 0.2 µm-filtered samples show a slight enrichment of heavy REY compared to light REY and a negative Ce_{SN} anomaly, i.e. patterns typically observed in temperate rivers. While the samples taken close to the spring show only a very small geogenic positive Gd_{SN} anomaly, the anomaly increases after effluent from the first WWTP reaches the river, indicating the presence of anthropogenic Gd. Along the course of the river the anthropogenic positive Gd_{SN} anomaly increases moderately as several small WWTPs release their effluent. However, the anthropogenic Gd_{SN} anomaly increases strongly when effluent from WWTP Buchenhofen, the largest WWTP in NRW, enters the river.

In our presentation we will discuss the change of anthropogenic Gd levels in the Wupper River between 2010 and 2019 and we will evaluate Sc-REY relationships and whether WWTP effluent may constitute a potential anthropogenic source of dissolved Sc to surface waters.