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Estuarine behaviour of anthropogenic Gadolinium as compared to natural Rare Earth Elements and its input into coastal seawater

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All rivers in northwestern Germany draining into the North Sea carry "anthropogenic gadolinium". Anthropogenic Gd is a micropollutant derived from contrast agents used in magnetic resonance imaging, that enters the rivers with the discharge from waste water treatment plants. The presence of anthropogenic Gd produces positive Gd anomalies in REE patterns and is, therefore, easily and cost-efficiently detectable by, for example, ICP-MS following REE separation and preconcentration. We studied a first sample set from the estuary of the Weser River (northwestern Germany) and from coastal waters in the North Sea off the East Frisian Islands (taken during a cruise with R.V. Heincke in November 2005) with the aim to investigate if anthropogenic Gd is able to enter the ocean. The North Sea data show normal coastal surface seawater REE distribution as expected. The REE patterns are gradually depleted in lighter REE (LREE) as compared to heavy (HREE) and show small negative Ce anomalies. Positive Gd anomalies fall within the range typical of open-ocean seawater. The Weser Estuary samples have salinities ranging from 2.6 to 20.4 psu. Due mostly to the presence of colloid-bound REE, REE concentrations in the Weser River are higher than those in the North Sea. The Weser River waters are less depleted in LREE and show smaller negative Ce anomalies. We emphasize that the dissolved REE load of water from the Weser River shows a pronounced positive Gd anomaly, demonstrating the presence of anthropogenic Gd. With increasing salinity of the samples, LREE concentrations decrease stronger than suggested by two-component mixing, suggesting that colloid-bound REE are removed due to salting-out. However, anthropogenic Gd appears not to be affected to the same extend, indicating that in contrast to the natural REE, anthropogenic Gd behaves conservative and is not removed during estuarine

mixing. This strongly suggests that the anthropogenic Gd is still truly dissolved and able to enter coastal seawater. Hence, semi-closed seabasins bordered by densely populated countries with a highly developed healthcare system, such as the Baltic Sea, will within the next years receive significant amounts of anthropogenic Gd that will obliterate any pristine REE distribution.