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Changes in biogeochemical processes in the Elbe estuary – Assessment by means of stable nitrate isotopes

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Over the past decades, river nutrient loads have increased significantly due to anthropogenic inputs, leading to eutrophication in coastal oceans. While replacement of phosphates in detergents has led to a reduction in phosphate loads, loads of reactive nitrogen are still problematic. In order to determine sources and sinks of nitrogen as well as turnover processes, stable isotopes provide information that simple concentration measurements cannot provide. This is because riverine inputs of nitrogen are usually enriched in isotopes due to fractionation processes that take place prior to the transport into the sea in both soils and estuaries. Furthermore, biological processes that remove or release nitrate may differ in their isotopic fractionation factor, so that nitrate sources or sinks in the estuary can be detected even if the mass flux is balanced. A prominent process is estuarine denitrification that is held responsible for removal of up to fifty percent of riverine nitrate loads.

We measured nutrient concentrations as well as δ^{15}N and δ^{18}O in nitrate in the river Elbe and its estuary, one of the largest German rivers discharging into the North Sea. To determine the riverine background signal before mixing with seawater, the isotope signal in the freshwater part of the river was determined on a monthly basis. Furthermore, samples were taken on a seasonal basis during five campaigns along the salinity gradient to assess the biogeochemical processes in the estuary that might lead to changes in nitrate concentration or shifts in the isotopic value.

Regardless of the season of sampling, both nutrient concentrations and isotopic signatures of nitrate suggest conservative mixing of riverine nitrate with that of seawater. Neither the concentration gradients nor the isotopic signatures of nitrate provide any

indication for a significant nitrate turnover within the estuary and thus we conclude that most of the river Elbe nitrate load is transported further into the German Bight. The comparison with historical data from the 1970s reveals that in contrast to the current situation the gradient of concentration versus salinity indicated a nitrate turnover in the Elbe estuary. We hypothesize that fundamental changes in the biogeochemical processes of the estuary have occurred over the last decades. We attribute this to extensive dredging and removal of sediment favourable for denitrification and nitrification in the Elbe estuary that connects the port of Hamburg with the North Sea.