Geophysical Research Abstracts
Vol. 20, EGU2018-8233, 2018
EGU General Assembly 2018

Phytoplankton dynamics drive nutrient and carbon spiraling in a river-estuary system

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The growth and decay of phytoplankton in eutrophic river-estuary systems is a worldwide phenomenon. Their complex regulation by nutrients, flow dynamics and light is rarely studied in an integrated way. We investigated the 580 km long inland river stretch of the Elbe (Germany) by a Lagrangian sampling approach followed by a two day survey of the 145 km long estuary. Nutrient and oxygen concentrations, the 15N and 18O isotopes of nitrate as well as biomass and composition of phyto- and zooplankton were determined. The measured data and water quality simulations with the model QSim show that beside the availability of nutrients, the increasing light limitation along the river-estuary gradient is an important regulating factor for phytoplankton growth. Light conditions are strongly influenced by the morphology of the river and the estuary and its anthropogenic alteration, as well as by feedbacks with the self-shading effect of phytoplankton in the river and the high suspended matter concentrations in the estuary. Concerning the nitrogen spiraling, we demonstrate by using dual stable isotope of nitrate the link between the assimilation by phytoplankton in the river and the remineralization of biomass and subsequently nitrification in estuary. The calculated water residence time of the system - ranging from few days for the river to several weeks for the estuary - and the increasing food resources due to primary production explain the development of the zooplankton abundances,which are able to control the phytoplankton biomass in the upper part of the estuary. We conclude that respiration processes in the Elbe estuary are regulated by the dynamics of phytoplankton biomass production in the upstream river stretches that in turn is mainly driven by flow dynamics respectively water residence time and light conditions.