Nitrate uptake during spring outflow from the nitrate-rich Curonian and Szczecin lagoon

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Background

Excess nitrogen inputs from rivers contribute significantly to eutrophication and adverse environmental effects such as hypoxia and harmful algal blooms1. Between 40 and 50% of the total nitrogen input in the Baltic Sea is via rivers (~500 k t N yr⁻¹ in the Baltic Proper)2,3. The rivers Nemunas and Oder are located along the southern coastlines of the Baltic Proper. On average, the Oder and the Nemunas provide 10 and 5% of the total N load of 500 k t N yr⁻¹, respectively. The catchments of both are highly populated, with intensive agriculture. Both rivers drain into lagoons before they enter the Baltic Sea. Here we sampled the outflow of the lagoons.

Dissolved inorganic nitrogen (DIN) is usually quickly consumed in the coastal zone or in lagoons and bays, as it has been observed for the Vistula outflow4. Besides DIN, the most abundant and to a certain degree also bioavailable form of nitrogen are dissolved organic forms (DON) which can make up half of all nitrogen draining into the Baltic Sea5. The fate of DON was studied as well but data are still being evaluated. Here an estimation of the DIN removal time in relation to the load will be carried out to test the hypothesis whether all of the riverine N loads can indeed be removed on short time scales along the coast (as suggested in Voss et al. 2005a).

Results

Fig. 1: Southern part of the Baltic Sea and its catchment area, which is colored according to the land use. The Oder and Nemunas river catchments are marked.

Fig. 2: Average monthly mean NO₃ loads for the period of 1970-1990 for the Nemunas and for the Oder from 1970-2000, based on data from the Baltic Environmental database BED.

Fig. 3: NO₃ concentrations (µmol/l) as a function of salinity for (a) 4 transects in the Nemunas outflow and (b) 3 transects in the Oder outflow. The lines represent the ideal mixing of riverine and Baltic waters without nitrate uptake.

Fig. 4: Map of investigation area in the Baltic Sea and the locations of sampling stations (a) Nemunas river (b) Oder.

Fig. 5: NO₃ uptake rates (mmol N/m²*d) and NO₃ concentrations (µmol/l) for (a) Nemunas transect 2 and 3 and (b) Nemunas transect 4 (c) Oder transect 2 and (d) Oder transect 3. Symbols are scaled linearly proportional to the measured values.

Fig. 6: Relationship between nitrate uptake rates (mmol N/m²*d) and chlorophyll a (mg/m³) for the Nemunas and Oder outflow.

Fig. 7: Relationship between nitrate uptake rates (mmol N/m²*d) and NO₃ concentrations (µmol/l) for the Nemunas and Oder outflow.

Outlook

With the help of this dataset and runoff values for the Oder and Nemunas nitrate and DON uptake budgets will be calculated.

Stable isotopes of nitrate (δ¹⁵N and δ¹³C) for both Nemunas and Oder transects will be measured with the denitrifier method to better understand the role of nitrate uptake vs. denitrification in the regions (see Poster S. Meyer et al. for the background of isotope data interpretation).

References


Goals

- Gain a better understanding of the dynamics of nitrogen in river outflows (DIN and DON) during peak outflow of the year.
- Relate the quantities of nitrate to nitrate uptake rates and budget the fate of the riverine loads.

Conclusions

- Uptake rates are in the range of other studies (0,25-250 mmol N/m²*d).
- NO₃ uptake rates in the Oder outflow were 8 times higher than in the Nemunas due to the already developed spring bloom in the Oder plume.
- Longer nitrate turnover times than residence time of the water (2-2,5 times higher) suggest that not all of the incoming nitrogen can be taken up by phytoplankton. Therefore it is suggested that nitrate may also be removed via denitrification.
- Since only a few rate measurements have been made in the coastal zone, we hope that our analysis of the stable isotope signature of nitrate will give an insight into the processes that take place.

Fieldwork

- In March 2009 a cruise with RV “Professor Albrecht Penck” took place.
- Nitrate uptake was measured using a ¹⁵N tracer technique (Dugdale and Goering 1967).

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