Leibniz Institute for Baltic Sea Research Warnemünde

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

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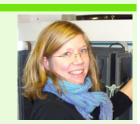

Background

Excess nitrogen inputs from rivers contribute significantly to eutrophication and adverse environmental effects such as hypoxia and harmful algae blooms[1]. Between 40 and 50% of the total nitrogen input in the Baltic Sea is via rivers (~500 kt 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 kt 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.

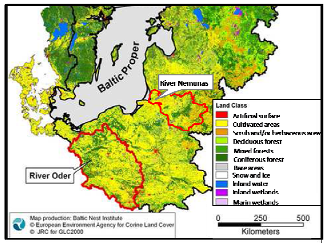

Fig. 1: Southern part of the Baltic Sea and its catchment area, which is colored according to the land use. The Oder and Nemunas river catchments are marked.

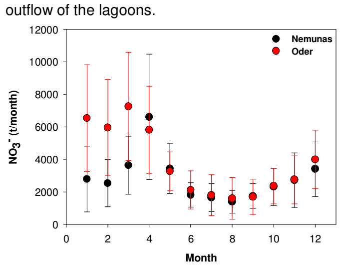

Fig. 2: Average monthly mean NO_3^- loads for the period of 1970-1990 for the Nemunas and for the Oder from 1970-2000, based on data from the Baltic Environmental database BED .

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 outflow[4]. Besides DIN, the most abundant and to a certain degree also bioavailable form of nitrogen are dissolved organic forms of nitrogen (DON) which can make up half of all nitrogen draining into the Baltic Sea[2]. 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).

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 nmol N/l*h)[5].**
- **N 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.**
- **During spring outflow the N load is dominated by DIN (60 -70 %).**
- **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.**

Results

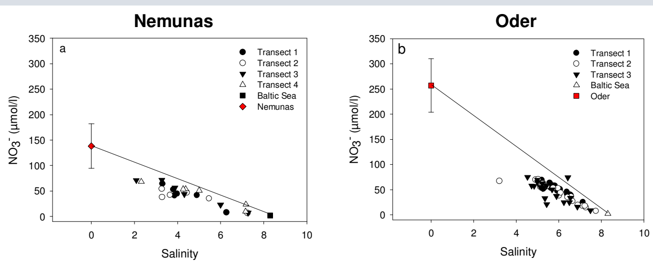

Fig. 3: NO_3^- concentrations (µmol/l) as a function of salinity for (a) 4 transects in the Nemunas outflow and (b) 3 transects in the Oder outflow. The lines represent the ideal mixing of riverine and Baltic waters without nitrate uptake.

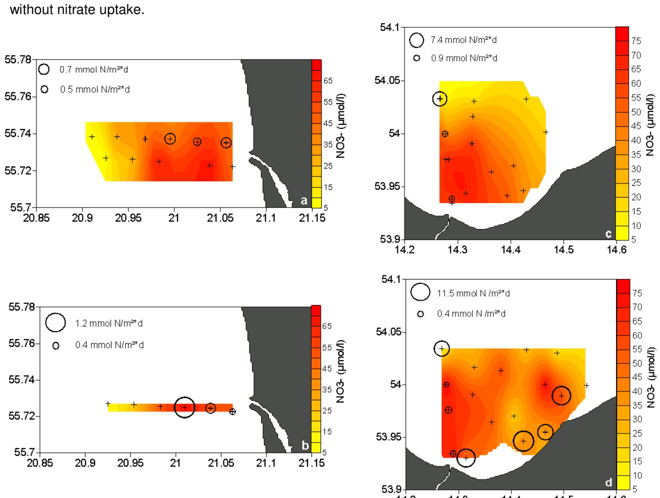

Fig. 5: NO_3^- uptake rates (mmol N/m²*d) and NO_3^- concentrations (µmol/l) for (a) Nemunas transect 2 and 3 and (b) Nemunas transect 4(c) Oder transect 2 and (d) Oder transect 3. Symbols are scaled linearly proportional to the measured values .

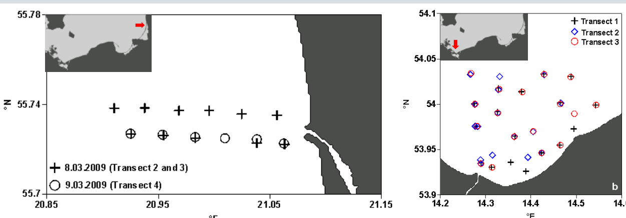

Fig. 4: Map of investigation area in the Baltic Sea and the locations of sampling stations (a) Nemunas river (b) Oder.

- On average, nitrate concentrations in the surface waters in the Nemunas and Oder outflow were 6.9 - 71.4 µmol/l (mean: 42.1 µmol/l) and 7.5 – 74.9 µmol/l (mean: 46.2 µmol/l), respectively. The concentrations decreased with increasing salinity.
- Nitrate uptake rates ranged in the Nemunas outflow from 0.5 – 1.2 mmol N/m²*d (mean 0.7 mmol N/m²*d). and in the Oder outflow from 0.4 – 11.5 mmol N/m²*d (mean 5.4 mmol N/m²*d)
- Nitrate turnover time in the Nemunas outflow ranged from 55 to 370 d (mean 164 d) and in the Oder outflow between 1 and 764 d (mean 141 d). The turnover of nitrate was slower than the residence time of water in the lagoons for both rivers (Nemunas: 81 d, Oder: 55 d).
- DON concentrations varied in the Nemunas outflow between 20 and 30 µmol/l.
- Chlorophyll a values in the Oder were three times higher (8.2-25.8 mg/m³, mean:16 mg/m³) compared to the values in the Nemunas outflow (1.5-8.9 mg/m³, mean 5 mg/m³).
- No correlations were found between the nitrate uptake and chlorophyll a concentrations or nitrate concentrations.

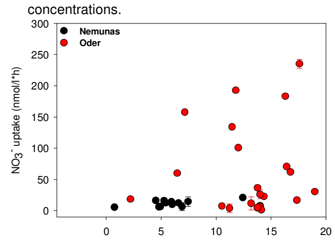

Fig. 6: Relationship between nitrate uptake rates (nmol N/l*h) and chlorophyll a (mg/m³) for the Nemunas and Oder outflow.

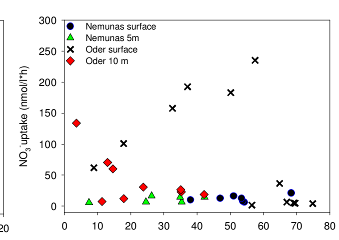

Fig. 7: Relationship between nitrate uptake rates (nmol N/l*h) and NO_3^- concentrations (µmol/l) for the Nemunas and Oder outflow.

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 ($\delta^{15}N$ and $\delta^{18}O$) 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.

Fieldwork

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

References

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Acknowledgements

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