Nutrient retention in riparian wetlands on landscape scale, the necessity of a monthly retention approach

S. Natho, M. Venohr

Leibniz-Institute of Freshwater Ecology and Inland Fisheries; Dept. of Lowland Rivers and Shallow Lakes; Müggelseedamm 310, 12587 Berlin, Germany; s.natho@igb-berlin.de; +049 (0) 30 6392 4088

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Background

In recent times, riparian wetlands have been considered as a cost effective means to manage nutrient (nitrogen (N) and phosphorus (P)) retention (BMU & BfN 2009) and to reach the goals of the WFD by 2015 (to reduce nutrient loads in German rivers). Projects, where dykes have been moved back to increase floodplain area have been and will be initiated. But, so far the newly gained nutrient retention capacity cannot be quantified properly. Processes of nutrient retention are not fully understood, and there is little knowledge on the distribution and degree of functionality of riparian wetlands in Germany (BMU & BfN 2009).

Methods

The Federal Institute of Hydrology (BfG) developed the River Hydrology Software FLYS 2.1.3 (BfG 2009), as a water level information and analysis tool for German Federal Waterways, which can be used to find the distribution, extent and frequency of flooded riparian wetlands. FLYS is not a hydraulic flow model but processes model results (1D) and basic and special geographical data to calculate flooded riparian wetlands in the German parts of the rivers Elbe, Main and Rhine at arbitrary discharges.

These three rivers differ strongly in their characteristics, ranging from semi-natural morphometrics to heavily modified to heavily modified with several locks. The software calculates the water level depending on discharges for official gauging stations in 100 m sections. Various features, such as dams or river valley features can be considered. In combination with digital terrain models (DTM) the water heights can then be projected onto riparian wetlands. Thus maps of flooded areas at certain discharges can be calculated, reflecting also the depth of water levels on the floodplain.

Seven gauging stations are considered along the river Elbe ten on the river Main and six at the river Rhine, so that approximately 330 km of the Elbe, 300 km Main and 250 km at the Rhine can be modelled at various discharges (ranging from low flow to high flow events that statistically occur once in five years). These discharges reflect events based on the gauging station’s longterm calculation.

The results are then provided in GIS compatible file format, so that further data processing with ArcGIS could be carried out. Detailed flooding maps for the above mentioned discharges were produced and inundated areas identified.

Different nitrate retention approaches from the literature were then used to calculate nutrient retention in riparian wetlands along the river Elbe. Generally, there are two groups of approaches: linear approaches which assume a certain percentage of incoming load (Mander & Mauring 1994, Jansson et al. 1998 and Saunders & Kallf 2001) and exponential retention approaches (Byström 1998, Dortch & Gerald 1995, Rassam et al. 2008) which also take hydraulic retention time, wetland area e.g. into account. Official water quality stations and the gauging stations were used to calculate nutrient loads of NO_3-N in the Elbe for the years 1999-2002.

Results

The river Main has the smallest and the Elbe the biggest riparian wetlands, caused by geomorphological constraints and by human impacts. Some analysed high discharges appear to have happened more often between 1990 and 2005 than the observed longterm events suggest. Thus, for each calculated year flooded riparian wetland areas were calculated based on an exponential relationship, which could be found between the ratio of long term mean discharge and current mean discharge and the percentage of flooded area on potential riparian wetland area. As input data for the model comparison these riparian wetland areas were applied.

The comparison of the nutrient retention models delivered large differences in the calculated NO_3-N retention, ranging from > 60% of the incoming load for linear approaches to only 2-52.9 % for the more complex models. Some input data were not readily available, such as the riparian wetland width. It was calculated as half the ratio of current inundated area to river section length, assuming to be equal on both sides of the river. Wetland shapes, though crucial for retention processes, cannot always be classified as Dortch & Gerald (1995) suggest for their model. The processed wetland maps clearly show the effect of oxbows and sinks that lead to non-linear increases in riparian wetland width with increasing discharge.

Conclusion

As most floods in rivers in Germany occur during winter time (especially in January and February), a monthly calculated nutrient retention might reduce uncertainties. Also the amount of load which enters the riparian wetland differs from flood event to flood event.

Trepel & Palmeri (2002) also compared three approaches for wetlands in small catchments in northern Germany, and also found differences that led to their conclusion that simple models tend to overestimate nutrient retention, whereas complex models often need data that is not available.

Thus a new NO_3-N retention approach in riparian wetlands is necessary to properly quantify monthly nutrient retention on landscape scales. This tool allows politicians to evaluate the effect of riparian wetlands on nutrient retention to find cost effective measurement to meet the goals of the WFD.

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