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Temporal trends in nitrogen concentrations and losses from agricultural catchments in the Nordic and Baltic countries

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A B S T R A C T

Long-term monitoring data from catchments with relatively uniform land use is important in order to cover management needs such as implementation of various EU Directives. This paper in a uniform fashion examines the temporal trends in nitrogen (N) concentrations and losses from agricultural catchments in the Nordic and Baltic countries. Thirty-five (35) catchments (range 0.1–33 km^2) in Norway (9), Denmark (5), Sweden (8), Finland (4), Estonia (3), Latvia (3) and Lithuania (3) were selected for this study. The longest time series were 23 years (1988–2010), while the shortest one was 10 years (2002–2011). The monthly nitrogen concentration and loss data series were tested for statistical trends ($p < 0.05$; two-sided test) using the partial Mann–Kendall (PMK) test with stream discharge as an explanatory variable.

The study results show a large variation in nitrogen concentrations and losses among the studied catchments, with a large interannual variability in all catchments. For nitrogen losses, 11 statistically significant trends were detected. Nine of these were downward (four out of five Danish catchments; four out of eight in Sweden; one out of three in Finland). Upward trends were detected in two catchments (one in Estonia and one in Latvia). For nitrogen concentrations, 13 statistically significant trends were detected. 10 of these were downward. Among the 11 catchments that showed trends in nitrogen losses, nine catchments also showed statistically significant trends in the in-stream concentration series. In addition, three more Swedish catchments showed downward trends in the concentration series, and one Estonian catchment showed an upward trend. These results indicate that targeted strategies towards reduced nitrogen losses from agricultural land (as in the case of Denmark and Sweden) may significantly improve nutrient surface water quality in small agricultural catchments

1. Introduction

Assessment of long-term trends is one of the key objectives in most national water quality monitoring programs, and many European countries have agreed to reduce the nitrogen (N) export to its Seas. Existence and possible causes of long-term trends in nitrogen transport in streams and rivers have in recent years been given increased attention especially in the Baltic Sea region. In 2007, the new Baltic Sea Action Plan (BSAP) was adopted by all the coastal countries of the Baltic Sea and by the European Community. BSAP aims at drastically reducing the anthropogenic nutrient load to the Baltic Sea and restore a good ecological status by 2021 (Helcom, 2007). To achieve this goal, ambitious country-wise annual nutrient input reduction targets were proposed. From a management point of view, questions like which measures has been implemented, what is the effect of these measures in small streams and how long

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Fig. 1. Location of the 35 agricultural catchments in the Nordic and Baltic countries.

it can take to detect the response in the water system have emerged. Thus, long-term monitoring data and retrospective analyses apparently are key factors to cover management needs and demands such as BSAP and implementation of various EU-Directives (e.g., WFD, the Nitrates Directive). In this context, data from small catchments and streams have become of increasing interest for many environmental and water managers given that such catchments are in close proximity of the source emissions.

Besides hydro-meteorological conditions, nutrient concentrations in agricultural streams and rivers might vary and respond differently to level in fertiliser application, type of agricultural management practices, crop types and intensity of land use (see e.g., Kyllmar et al., 2006; Bechmann and Stålnacke, 2005). Moreover, and as emphasised by Iital et al. (2010), there are many uncertainties and knowledge gaps in nutrient loss processes, making it difficult to draw direct cause–effect relationships between the implemented measures and water quality, and to answer the question why river systems respond differently even under similar hydro-geographical conditions. Several authors like Grimvall et al. (2000) and Stålnacke et al. (2003) have also stressed that the inertia in the soil-water column and retention factors in surface water might cause a time-delay and thus affect how quickly nutrient stream water quality respond to gross-emission changes.

In the Nordic and Baltic countries, most results from monitoring programmes in agricultural catchments have been published in national grey-literature reports (e.g., Fölster et al., 2012; Hauken et al., 2012) or in some cases in scientific journals for single countries (e.g., Gaigalis and Račkauskaitė, 2001; Sileika et al., 2005; Kyllmar et al., 2006; Bechmann et al., 2008; Lagzdins et al., 2012) or single streams (e.g., Mander et al., 2000; Bechmann and Stålnacke, 2005), but mostly with different chemical parameters, time periods assessed or various statistical methods. A uniform and systematic assessment of these data is however missing. Thus, the objective of this study was to, in a uniform fashion, explore long-term temporal trends and temporal variability in nitrogen concentrations and unit-area losses from small agricultural catchments in the Nordic and Baltic countries. Of particular interest were the questions if we can observe any common denominator in trends and determine any effect on nitrogen water quality in response to implemented measures or other agricultural management changes.

2. Materials and methods

Thirty-five (35) small agricultural catchments with long-term time series in nitrogen (N) losses and concentrations were selected