Assessment of Climate Change for the Baltic Sea Basin - The BACC Project - 22-23 May 2006, Göteborg, Sweden

Agriculture, Eutrophication and Climate Change

The present eutrophic situation in the Baltic Sea is associated with an increased external load of nutrients over the past several decades, with agriculture and nutrient runoff from rural areas playing an important role. Some 70% of the annual nitrogen (N) and phosphorus (P) loads to the Baltic come from waterborne discharges, half to two-thirds of these associated with agriculture. Poland, Sweden and Finland account for the largest contributions to the total N load; however, per-capita output levels are almost four times larger for Sweden and Finland than for Poland (Table 1)

Nutrient Losses from Agricultural Catchments

- Average annual nutrient losses from agricultural catchments ranged in 1994-1997 from 5-75 kgN/ha/year and 0.1-0.32 kgP/ha/year. Variation among catchments depends on *management practice – especially fertilisation and livestock intensity – land use structure, soil* and *climatic factors controlling water discharge.*
- Export rates from agricultural catchments are considerably higher than for undisturbed catchments (e.g. 14:1 ratio for total N, 4:1 for total P in Denmark). In addition, fluxes from undisturbed catchments are dominated by organic N, from agricultural catchments by mineral N (mainly nitrate).
- Landscape factors play a major role in nutrient leaching and transport from large watersheds. Mosaic (in some cases hilly) landscapes typically show lower export rates of both total N and total P than non-mosaic areas. Riparian areas (wetlands and strips with natural vegetation adjacent to rivers) can be highly effective in reducing losses.

Recent Trends

- Nutrient losses from agriculture in the Baltic Sea basin have increased markedly over the last 50 years, but have stabilised since the mid-1980s. The main causes for the recent stabilisation are probably *reduced fertiliser use* and *agricultural land abandonment*, due to stricter agricultural and environmental policy, and to the transition to a market economy in former eastern bloc countries (Fig. 1 and 2).
- Improvements in nutrient export rates are most apparent for agricultural catchments. In catchments with relatively small initial losses and/or well-established ecotechnological measures (riparian buffers, constructed wetlands) decreasing load may not result in significant water quality improvement (Fig. 2).
- Milder winters and changing precipitation patterns since the 1950s have influenced water discharge in continental areas, potentially contributing to lower nutrient runoff from some catchments.

Table 1: Population, loads of nitrogen, nitrogen load per capita and percent of the total nitrogen load in the Baltic Region countries in 2000 (after Granstedt et al. 2004).

	Population ×10³	Total N loads 10³ kg N yr⁻¹	N load per capita kg N capita⁻¹ yr⁻¹	Shares of N load % of total
Denmark	5,155	62,240	12	7
Sweden	8,500	175,610	21	21
Finland	4,938	146,560	30	18
Russia	9,028	53,720	6	7
Estonia	1,595	32,990	21	4
Latvia	2,606	54,070	21	7
Lithuania	3,446	35,560	10	4
Poland	37,764	229,990	6	28
Germany	3,300	31,510	10	4
Total	76,332	822,250		

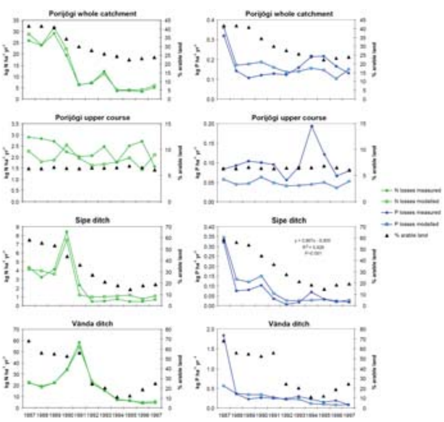

Fig. 1: Measured and modelled total inorganic nitrogen and total phosphorus flows in subcatchments of the Porijõgi river basin, Estonia in relation to agricultural land use, 1987-1997. Source: Mander et al. (2000).

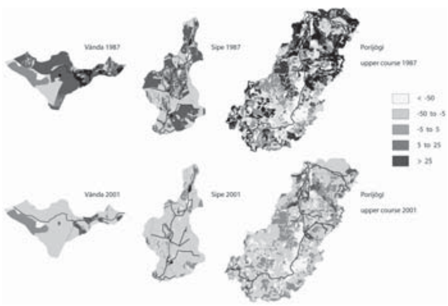

Fig. 2: Potential excess nitrogen (PEN, i.e. the balance of inputs to and outputs from the nutrient pool; negative values denote potential N sinks, positive values potential N sources) has generally decreased in the Porijõgi river basin, Estonia, over the period 1987-2001. Vända (3.8 km²) and Sipe (8.9 km²) subcatchments are agricultural, with Sipe subcatchment characterised by extensive riparian buffer strips. The Upper course (22.1 km²) is mainly covered by forests and semi-natural meadows. Overall, source areas decreased from 50.1% of the total area in 1987 to 17.8% in 2001. Source: Kull et al. (2005).

Potential Future Changes

- Changes in climate patterns and related runoff regimes can significantly influence nutrient losses from catchments. Future levels will be sensitive to:
  - Changes in the timing of seasonal and annual events (spring runoff, autumn low flow, ice and snow cover etc.)
  - Frequency and severity of extreme events (floods, droughts, erosion)
  - Climatic thresholds and ranges
- Climate scenarios point to moderate increases in mean annual river flow to the Baltic by the late 21st century. Common to all scenarios is a general trend of reduced river flow from the south of the Baltic Sea basin, with increased river flow from northern areas.
- Reduced influence of snow melt will increase the synchronisation between precipitation and stream discharge, reducing and extending summertime base flow but increasing wintertime runoff. Shorter periods of frozen surfaces and increased numbers of freeze-thaw cycles will lead to more intensive leaching during winter from arable land, especially in northern areas.
- Southern areas may become more vulnerable to rainstorms and flood events, with severe effects on agricultural activities in former floodplain areas, as well as nutrient losses.
- Responses of nutrient losses to climate change will be faster and more direct in small agricultural catchments; internal material cycles will lead to more complicated dynamics in large catchments.

Recommended Measures for further Decrease of Nutrient Flows to the Baltic Sea

- Sustainable agricultural practice (wider practicing of ecological agriculture and implementation of environment-friendly crop rotations).
- Changes in agricultural practices (technological solutions such as GPS-supported fertilisation schemes and shallow-injection technique for liquid manure).
- Ecotechnological practice: maintenance, sustainable management and restoration of wetlands and riparian buffer zones.

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