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Agricultural phosphorus losses and eutrophication in Nordic-Baltic countries

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Introduction

Although nutrient losses from point sources, such as municipalities, to surface waters have been strongly reduced in most Nordic-Baltic countries, there are still severe eutrophication problems in the area (http://www.eea.europa.eu/). Presently, agriculture is the major anthropogenic P source in Denmark, Finland, Norway and Sweden (Heckrath *et al.*, 2007). In Estonia and Latvia, most of the P losses also originate from diffuse sources; only in Lithuania do point sources still form the largest P input to waters (HELCOM, 2005; S. Knuuttila, pers. comm.). Below agricultural P losses in the Nordic-Baltic countries are briefly examined.

Agriculture in the Nordic-Baltic countries

There is a wide variation in temperature, precipitation and soil types in the Nordic-Baltic countries (Rekolainen *et al.*, 1997). Such differences in natural characteristics regulate average yields and agricultural production as well as P losses and their transport pathways in this region (Heckrath *et al.*, 2007).

The area of agricultural land totals 145,150 km^2 in the Nordic-Baltic countries (excl. Iceland, http://faostat.fao.org). The proportion of arable land is lowest (3%) in Norway and highest (60%) in Denmark. Denmark also has by far the highest stocks of pigs and poultry (in absolute numbers and per hectare of agricultural land).

The use of P in fertilizers has declined in all the countries and the P balances have been reduced by up to 60% between 1990–1992 and 2002–2004 (http://www.oecd.org). The present-day use of P ranges from about 4 kg ha^{-1} yr^{-1} in some Baltic countries to about 13 kg ha^{-1} yr^{-1} in Norway. Note that the use of P fertilizers, along with the entire agricultural sector, declined drastically in the Baltic countries after the collapse of the Soviet Union.

An array of national voluntary or compulsory programmes aim to control agricultural P losses in the area (e.g. Heckrath *et al.*, 2007). In addition, the countries have to adhere to several international agreements and pieces of legislation focusing directly or indirectly on agricultural nutrient loading (EEC 1991, 1992; EC 2000, 2008; HELCOM, 2008).

Phosphorus losses from agriculture in the Nordic-Baltic countries

Estimation of agricultural P losses is based on the monitoring of runoff quantity and quality in representative catchments. There is a tendency towards the use of automatic sampling devices and on-line sensors over traditional, more or less infrequent, manual sampling. Especially older estimates of P losses tend to be uncertain as flow peaks may have been missed. In addition, the quantification of the natural background leaching levels and the contribution of different sources in general is problematic; currently there are no harmonized principles for quantifying diffuse losses at catchment scale. Finally, extrapolation of results obtained at a scale of a few square kilometres of the experimental catchments to a national scale is challenging; usually there are not enough data on all typical combinations of soil type, slope, agricultural practices, etc. (see Rekolainen & Leek, 1996).

Compilations of P losses suggest that the losses are highest in Finland and Norway and lowest in Denmark and Sweden (Svendsen & Kronvang, 1991; Rekolainen *et al.*, 1997; Ulén *et al.*, 2007; Heckrath *et al.*, 2007). Vagstad *et al.* (2001) found that the P losses in 35 Nordic-Baltic agricultural catchments (<30 km^2) ranged from 0.1 to 4.7 kg ha^{-1} yr^{-1} in 1993−1997. High P losses were often associated with soil erosion, in which case the bulk of P was present in a particulate form. Thus, the P losses were highest in hilly, erosion-prone areas in Norway and on clayey soils in Finland. In turn, the losses were lowest in Estonia and Sweden. Yet, there was also a lot of variation within countries.

In Denmark subsurface losses and stream bank erosion appear to be important, whereas in Finland P is detached in a particulate form from soil surface and transported largely via surface runoff (Heckrath *et al.*, 2007). There is no uniform information on the availability of particulate P in the Nordic-Baltic countries (Rekolainen *et al*., 1997), which makes it difficult to estimate the effect of erosion control measures on eutrophication.

As the use of P has generally decreased and farmers have adopted more environmentally friendly cultivation practices in the Nordic-Baltic region (Heckrath *et al.*, 2007), one might anticipate that the agricultural P losses would decline in these countries. Although some decreasing trends have been found, the large nutrient reserves accumulated in the soil appear to slow down the desired development. In addition, fluctuating weather/hydrology easily hide the effect of agri-enviromental measures (Vagstad *et al.*, 2004; Kronvang *et al.*, 2005; Bechmann & Stålnacke, 2005; Kyllmar *et al.*, 2006; Ulén & Fölster, 2007). Finally, a reversal of eutrophication has only rarely been documented (Bechmann *et al.*, 2005; Kronvang *et al.*, 2005).

Finnish trends in P losses

Of the EU member states, Finland has the highest share (> 90%) of farms under the agri-environmental programme. Although farmers have been subsidized from 1995 for performing environmentally friendly practices, no clear decrease in nutrient losses, or eutrophication, has been detected (Ekholm *et al.*, 2007).

The failure to reduce nutrient losses has been a topic of political discussions in the country (Anon., 2008). There are several reasons for the low response (Turtola, 2007). For example, the measures have not been targeted at high-risk areas, the area of actively cultivated land has increased and the recent climate may have promoted e.g. erosion. Moreover, although the use of fertilizer P has been strongly reduced, the soil test P values have begun to decrease only recently (Uusitalo *et al.*, 2007). Currently, soil test P is often at a level at which annual P fertilization no more gives clear yield responses. Farms specialized in non-cereal plant production and in animal production tend to have the highest soil test P. In Finland, as in many other counties, there is an exacerbating imbalance in P cycling between plant (feed) and animal production (Uusitalo *et al.*, 2007). The soil test P values correlate with the concentration of dissolved reactive P in runoff (Uusitalo *et al.*, 2007). The superfluous use of P should thus be minimized to reduce the losses of plant available dissolved P.

Conclusions

The P losses from agriculture are controlled by natural characteristics, agricultural practices and national and international agricultural as well as agri-environmental policies. To reduce the P losses the measures should be targeted at the areas and activities that are responsible for the highest actual losses of bioavailable P. The response of an aquatic ecosystem to agricultural activities is a result of complex interactions between physical, chemical and biological processes. The P losses and their mitigation have traditionally been examined in the context of terrestrial and agricultural sciences; there appears to be little interdisciplinary research between terrestrial and aquatic sciences. Perhaps the lower than anticipated response found in many water bodies is partly due to the fact that we still do not understand all the relevant processes related to eutrophication caused by agriculture.

References

Anon., 2008. Maatalouden ravinnepäästöjen vähentäminen. Valtiontalouden tarkastusviraston toiminnantarkastuskertomus 175/2008.

Bechmann, M., Stålnacke, P., 2005. Effect of policy-induced measures on suspended sediments and total phosphorus concentrations from three Norwegian agricultural catchments. Sci. Total Environ. 344, 129-142.

Bechmann, M., Berge, D., Eggestad, H.O., Vandsemb, S., 2005. Phosphorus transfer from agricultural areas and its impact on the eutrophication of lakes - two long-term integrated studies from Norway. J. Hydrol. 304, 238–250.

EC, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Off. J. Eur. Commun. L 327, 1–73.

EC, 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Commun. L 164, 19–40.

EEC, 1991. Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Off. J. Eur. Commun. L 375, 1–8.

EEC, 1992. Council Regulation (EEC) No 2078/92 of 30 June 1992 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside. Off. J. Eur. Commun. L 215, 85-90.

Ekholm, P., Granlund, K., Kauppila, P., Mitikka, S., Niemi, J., Rankinen, K., Räike, A., Räsänen J., 2007. Influence of EU policy on agricultural nutrient losses and the state of receiving waters in Finland. Agric. Food Sci. 16, 282–300.

Heckrath, G., Bechmann, M., Ekholm, P., Ulén, B., Djodjic, F., Andersen, H.E., 2007. Review of indexing tools for identifying high risk areas of phosphorus loss in Nordic catchments. J. Hydrol. 349, 68–87.

HELCOM, 2005. Nutrient Pollution to the Baltic Sea in 2000. Baltic Sea Environment Proceedings 100. http://www.helcom.fi/stc/files/Publications/Proceedings/bsep100.pdf

HELCOM, 2008. HELCOM Baltic Sea Action Plan. http://www.helcom.fi/BSAP/en_GB/intro/

Kronvang, B., Jeppesen, E., Conley, D.J., Søndergaard, M., Larsen, S.E., Ovesen, N.B., Carstensen, J., 2005. Nutrient pressures and ecological responses to nutrient loading reductions in Danish streams, lakes and coastal waters. J. Hydrol. 304, 274-288.

Kyllmar, K., Carlsson, C., Gustafson, A., Ulén, B., Johnsson, H., 2006. Nutrient discharge from small agricultural catchments in Sweden – characterisation and trends. Agr. Ecosyst. Environ. 115, 15-26.

Rekolainen, S., Leek, R., 1996. Regionalisation of erosion and nitrate losses from agricultural land in Nordic countries. TemaNord 1996:615.

Rekolainen, S., Ekholm, P., Ulén, B., Gustafson, A., 1997. Phosphorus losses from agriculture to surface waters in the Nordic countries. In: Tunney, H., Carton, O.T., Brookes, P.C., Johnston, A.E. (Eds.), Phosphorus loss from soil to water. CAB International, pp. 77–93.

Svendsen, L.M., Kronvagn, B., (Eds.), 1991. Fosfor i Norden - metoder, biotilgængelighed, effekter og tiltag. Nord 1991:47.*

Turtola, E., 2007. Preface. Agric. Food Sci. 16, 279–281.

Ulén, B., Fölster, J., 2007. Recent trends in nutrient concentrations in Swedish agricultural rivers. Sci. Total Environ. 373: 473-487.

Ulén, B., Bechmann, M., Fölster, J., Jarvie, H.P., Tunney, H., 2007. Agriculture as a phosphorus source for eutrophication in the north-west European countries, Norway, Sweden, United Kingdom and Ireland: a review. Soil Use Manage. 23 (Suppl. 1), 5–15.

Uusitalo, R., Turtola, E., Grönroos, J., Kivistö, J., Mäntylahti, V., Turtola, A., Lemola, R., Salo, T., 2007. Finnish trends in phosphorus balances and soil test phosphorus. Agric. Food Sci. 16, 301-316.

Vagstad, N., Stålnacke, P., Andersen, H.E., Deelstra, J., Gustavson, A., Iital, A., Jansons, V., Kyllmar, K., Loigu, E., Rekolainen, S., Vuorenmaa, J., 2001. Nutrient losses from agriculture in the Nordic and Baltic region. Tema Nord 2001:591.

Vagstad, N., Stålnacke, P., Andersen, H.E., Deelstra, J., Jansons, V., Kyllmar, K., Loigu, E., Rekolainen, S., Tumas, R., 2004. Regional variations in diffuse nitrogen losses from agriculture in the Nordic and Baltic regions. Hydrol. Earth Syst. Sc. 8, 651-662.