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A CATCHMENT-ORIENTED AND COST-EFFECTIVE POLICY FOR WATER PROTECTION

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Introduction

Improved technologies have substantially reduced emissions from municipal activities and industries in western Europe. Conversely, water pollution caused by leaching and erosion losses from arable land, or indirectly by atmospheric deposition, has so far made the environmental goals difficult to attain. A resent study showed that the rootzone losses of nitrate from arable land have decreased in Sweden during the last decade but still there is no decline of the nitrate transport in major streams entering the surrounding seas.

Even in catchments with a small agricultural share, nitrogen from arable land, can be the dominating source. In the Laholm Bay drainage basin, SE Kattegat, 12 % of the 10100 km^2 is farmland from which about half of the river transported nitrogen originates. In turn, one third of the arable land is coastal farmland of high leaching sandy soils with potato production and high animal density. From a study on water quality in relation to land use it was concluded that a cost-effective nitrogen reduction must be based on a combination of agricultural measures and measures leading to increased retention during runoff. Restorations of wetlands and other buffer zones have shown promising results, and should be included in catchment oriented programs.

To control the overproduction in European agriculture a set aside program has been introduced in many countries. In 1996 the set aside area in Sweden should correspond to 17 % of the acreage for grain production. However, no account was taken to the spatial distribution to environmentally optimise the set aside area. From an environmental point of view this was waste of money. Due to the future need of food and clean water for the world population another strategy is necessary.

Future measures

Cropping management

To be effective the watershed perspective requires development and utilisation of more effective tools in the water quality management work. Such tools include creation of a comprehensive watershed database concerning governing factors for nutrient losses on a suitable GIS media, indexing procedure to locate critical pollution areas within the watershed, and interaction between the GIS media and predictive mathematical modelling of nutrient losses to prescribe cost effective and sustainable best management practices for pollution reductions. Without knowing the critical areas of concern, money and efforts may be wasted or spent in wrong order and non point source pollution may be hard to reduce. Every advisor in a region should have access to a GIS tool to be able to convince the farmer about necessary measures.

There are no conflicts between high production and low losses to the environment if sufficient protection as catch crops during the winter period are used and no overdoses of fertilizers in relation to crop yield are used. This can be represented by results from field experiments in the Laholm Bay area. The lowest loss per tonne produced grain yield was achieved in a normal fertilised treatment with a catch crop protection during the winter period. The catch crop also lowered losses of the greenhouse gas N_2O with the drainage water, except when overdoses were applied. A combination of commercial fertiliser and liquid manure was used in the experiment (Table 1).

Table 1. Losses of nitrogen in a field experiment in the Laholm Bay area.

	Unfertilised		Normal dose		Over dose	
Catch crop	No	Yes	No	Yes	No	Yes
Total loss, N kg ha^{-1} a^{-1}	28	10	62	15	69	39
Loss related to yield N (kg ha^{-1} a^{-1}) $tonne^{-1}$	25	4.2	12	3.3	14	8.8
Loss of N_2O-N with drainage water (µg l^{-1})	2.3	1.5	3.1	2.6	5.5	10.0

To keep up high and environmentally friendly production, including restricted losses of N_2O, in suitable areas of a farm or part of a watershed, according to GIS analyses, can create a possibility for the farmer to set aside land for ecotechnological measures in an optimal way. The farmer just not need to grow a crop on every square metre.

Echotechnological measures

Even if the farm will be managed according to best management practices there still will be a need for supplementary measures close to or in the water courses to achieve a good water quality. One of these measures do not decrease leaching or emissions from soil, but increase removal of nutrients during runoff, i.e. restoration of ponds and wetlands. Budget studies of existing ponds / wetlands showed a relationship between areal nitrogen load and the areal nitrogen removal.

Budget studies of full scale restored ponds later verified this general view. Per area unit, increased nitrogen loading implied increased nitrogen retention, but often decreased percent retention. Ponds with depths 0.4-2.0 m and hydrological loads 0.14-5.2 m^3 m^{-2} day^{-1} were created. Between 150-700 kg N ha^{-1} yr^{-1} and 18-404 kg P ha^{-1} yr^{-1} was removed in ponds loaded by stream water from semi urban and agricultural areas. A pond receiving pre-treated municipal wastewater removed 8000 kg N ha^{-1} yr^{-1} and 590 kg P ha^{-1} yr^{-1}.

The upper limit for N-removal is set by the hydrological conditions. Sedimentation of organic material must be favoured in order to obtain adequate conditions for denitrification at the sediment-water interface. In the long run, channelisation should be avoided by appropriate management. High loaded ponds are cost efficient, as they reduce much nitrogen in small created units, each with low costs.

Creation / restoration of wetlands has now become a part of the Swedish agri environmental programme. One problem is, however, that ponds and wetlands should be localised to strategic sites in the watershed, rather than to sites pointed out by the farmers. An inventory of optimal sites for pond must therefore be made for each watershed subject to pond / wetland restoration. This can be done with an effective GIS tool and presented for the farmer.

Advisory service and co-operation among farmers

With an effective GIS tool, a programme for effective measures to be included in an environmental plan for good and sustainable farming and water quality can be set up for any watershed. The program must also consider the impact on global change. The advisor and the farmer must work together in a positive way and the farmers can also work together to achieve the goals of the plan.

For water quality purposes the plan must at least include proposals of measures to:

- avoid overdoses of fertilisers
- improve manure management
- increase cultivation of winter crops, especially catch crops
- reduce soil tillage in autumn
- increase nutrient retention in ponds and wetlands by denitrification and sedimentation
- reduce erosion losses by leaving uncultivated strips of land alongside the watercourses

Conclusions

To achieve a good water quality both effective measures within agriculture and the use of echotechnological filters is a necessity. In this context one for the purpose constructed GIS tool could create new possibilities to optimise crop management and sites for echotechnological constructions in a watershed perspective. With such a tool it is also more likely that co-operation between advisors and framers as well as among farmers could be more efficient and shorten the way and time to achieve good water quality.