THE POTENTIAL OF ECOLOGICAL RECYCLING AGRICULTURE (ERA) FOR IMPROVED NATURE RESOURCE CONSERVATION AND REDUCED ENVIRONMENTAL IMPACTS IN THE BALTIC SEA DRAINAGE AREA

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INTRODUCTION

Excessive nutrient inputs to the Baltic Sea and the role of Agriculture.

Increasing eutrophication and the resulting increase in produced organic matter cause environmental problems when their decomposition consumes oxygen, and is contributing to depletion in deeper waters. Anoxic conditions have been frequent phenomena in the deeper basins of the Baltic Proper for a long time (Figure 1 and Figure 2). Eutrophication causing anoxic conditions is also affecting, with increasing frequency, vast areas in the Baltic Sea and the Gulf of Finland.

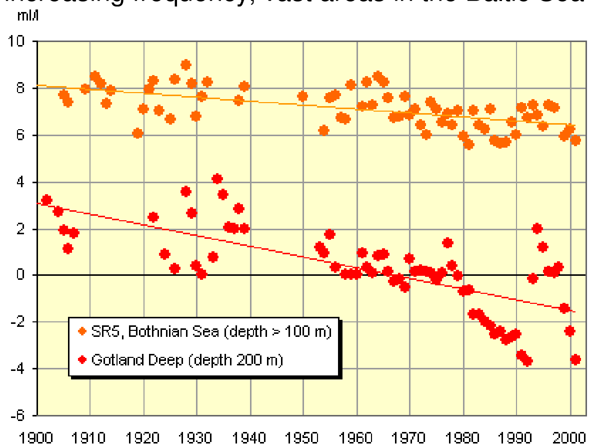

Figure 1. Oxygen trends in the Bothnian Sea and the Baltic proper (Gotland Deep).
(Source: Swedish Environmental Protection Agency: www.internat.naturvardsverket.se/pollutants)

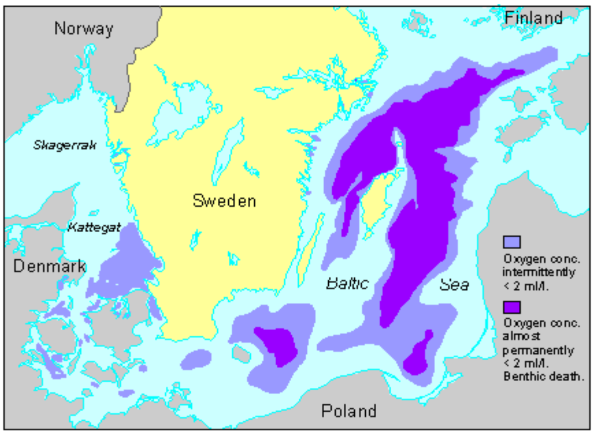

Figure 2. Oxygen deficiency at sea bottom.
(Source: Swedish Environmental Protection Agency: www.internat.naturvardsverket.se/pollutants)

Agriculture is responsibility for a large share of the leaching of nutrients to the aquatic environment finally the Baltic Sea. In Sweden about 50% of anthropogenic load of nitrogen (53 % of the gross load) and close to 50 % the anthropogenic phosphorus load (46 % of the gross load) can be attributed to agriculture for the period 1985 – 1999 according to reports from Swedish Environmental Protection Agency.

In the HELCOM Ministerial Declaration adopted on 25 June 2003 in Bremen (HELCOM 2003) it is declared:

> *"WE RECOGNIZE that a main source of waterborne nitrogen input is related to intensive agricultural practices taking place within current EU Member States. Also, losses of phosphorus give rise to concern in several countries.*
> *WE CONSIDER that the EU enlargement process will bring large new areas of the Baltic Sea catchment under the EU Common Agricultural Policy and that this may lead to even higher nutrient inputs into the Baltic Sea Area."*

No significant improvements to date

The reported annual loads into the Baltic Sea for 2000 are not lower than the 1995 estimates. High area-specific nitrogen and phosphorus loads are related to high rates of agricultural activity, including large scale intensive livestock farming as well as the intensive use of fertilizers in specialized conventional farming systems (Granstedt, 2000). No decrease, and in some cases even an increase, was observed in Finland, Sweden, Germany and Poland. A decrease was reported only from Latvia, Estonia and Russia for 2000 compared to 1995.

Table 1. Total drainage area, area of arable land, population and total annual nitrogen load in the Baltic Drainage Area for the year 2000 (HELCOM 2004). Only the small part of Germany and Russia (Leningrad and Kaliningrad) that are located in the Baltic drainage area are covered by the statistics here and more detailed statistics were not available.

	Total Drainage area (1000 ha)	Arable land (1000 ha)	Population (x 1000)	Tot N load (t a^{-1})	Tot N load (kg $capita^{-1}$ a^{-1})	% of total
Germany	2 860	2 051	3 300	31 510	10	4%
Poland	31 190	14 247	37 764	229 990	6	28%
Lithuania	6 530	3 527	3 446	35 560	10	4%
Latvia	6 460	2 826	2 606	54 070	21	7%
Estonia	4 510	1 160	1 595	32 990	21	4%
Russia	31 480	4 699	9 028	53 720	6	7%
Finland	30 130	2 387	4 938	146 560	30	18%
Sweden	44 004	2 698	8 500	175 610	21	21%
Denmark	3 111	2 077	5 155	62 240	12	8%
Total	**160 275**	**35 672**	**76 332**	**822 250**		

Of the calculated load in 2000, 24% originates from Estonia, Latvia, Lithuania and Russia together, 28% from Poland, 21% from Sweden and 18% from Finland (Table 1). However, per-capita level of nitrogen load is almost four times higher for Sweden and Finland than for Poland.

Goals and reality

Agreements to halve the quantity of nutrients reaching the marine environment by 1995 were made within the Helsinki Commission (base year 1987) and at the North Sea Conference/Paris Commission (base year 1985). According to the Fourth Baltic Sea Pollution Load Compilation (HELCOM, 2004) the concerned countries have not achieved these goals during the agreed period from 1987 to 1995, no improvements were observed between 1995 and 2000 and measurements showed no significant decrease of total nutrient load to the Baltic Sea.

MATERIAL AND METHODS

Surplus and potential losses of plant nutrients – field and farm gate balances

Surplus of nitrogen and other plant nutrients from agriculture production can be calculated from official agricultural statistics and data collected on farms. The on-farm data include the amount of used artificial fertilizer and imported fodder, data for known nitrogen load and estimated nitrogen fixation from the atmosphere (input) and the amount of animal and plant foods produced and sold from the farm (output). The difference between input and output of plant nutrients is defined as surplus of plant nutrients and equals potential losses (Granstedt et al 2004).

The term Ecological Recycling Agriculture (ERA) is used to characterize farming methods with high degree of recycling of plant nutrients. This can be achieved within the farming system through integration of plant and animal production based on own fodder combined with use of clover grass ley for biological fixation of nitrogen. Case studies on 40 farms in eight countries around the Baltic Sea (Fig. 3) including farm gate balances and direct nutrient load measurements were established in 2003 within the EU INTERREG IIIB project BERAS (Baltic Ecological Recycling Agriculture and Society). The test farms were compared with with conventional more specialized farming systems (www.jdb.se/beras).

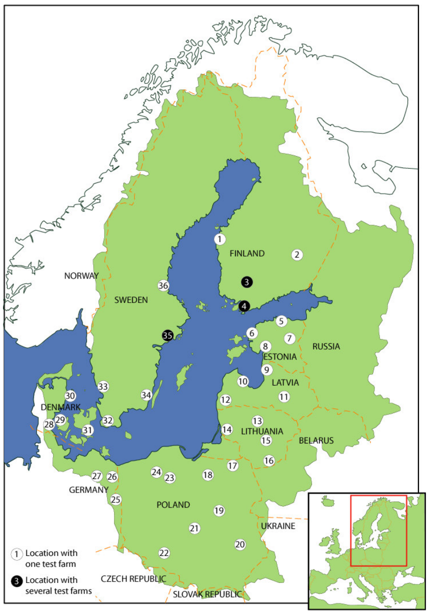

Figure 3. Baltic Sea Drainage area and locations of BERAS test farms.

RESULTS

The specialized agriculture of today – examples from Sweden and Finland

In Sweden the difference between nitrogen import to (106 kg N ha^{-1}) and export (27 kg N ha^{-1}) from the agricultural system represents a surplus of nitrogen (79 kg N ha^{-1}) that is potentially lost to the environment assuming steady-state nitrogen level in the soil. Although about half of the input of phosphorus is surplus (4 kg of 9 kg P ha^{-1}), only a smaller part is lost to the environment. However this is enough, when combined with the nitrogen load, to result in a large degree of eutrophication in the Baltic Sea.

Our studies compared with studies from the Swedish Environmental Protection Agency (Brandt & Ejhed, 2002; Johnsson & Mårtensson 2002) indicate that about 30% of the total 196 000 tons of nitrogen surplus in the agricultural sector is lost as anthropogenic leaching from the agricultural fields (61 600 tons of nitrogen per year calculated as leaching from the root zones as average for the period 1985 -1999) and after retention on average 60% of this is lost to the sea. Of the calculated field level surplus, after adjusting for losses in the animal production, 45% is lost as anthropogenic leaching from the agricultural fields.

In Sweden and Finland today, the input of nitrogen to the agricultural systems is about three times higher than the output of nitrogen as agricultural food products such as bread and cereal grains, milk and meat. About 80% of the arable land is used for producing animal fodder. This was also true in 1950, but during the last 40 years the number of animal production farms has steadily decreased, while the number of animals on the remaining farms has increased. Farms with only crop production and no animals are dependent on artificial fertilizers. They produce mainly fodder for animals. This fodder is exported to the intensively managed animal farms resulting in excessive nutrient load. For example, about 5% of Swedish farming enterprises produce 90% of the pork. In some counties in southern Sweden and in Finland this concentration is particularly marked (i.e. in Blekinge, Halland and certain parts of Skåne in Sweden, in Österbotten in Finland). A similar trend towards not only local but also regional specialization in agriculture within a county and within a whole country can be observed in other European countries. Denmark has a higher specialisation and average density of animal production (0.9 animal units per year) based on partly imported fodder than other countries around the Baltic Sea as for example Sweden with 0.6 animal units per year.

The Baltic drainage area – a diversity of situations

The situation in Sweden as described above is also representative for farms and regions in Finland and in other areas of Europe where agriculture is technically more advanced. This specialization can be found at both farm level and regionally within the countries. Manure produced by cows, pigs and poultry is generally not returned to the regions in the country where their feed is produced.

However the Baltic Sea drainage area also includes large areas where the structure of the agricultural sector is mostly pre-industrial. For example in large parts of Poland there is low input of artificial fertilizers and high diversity in both crop and animal production and also in the surroundings landscape**.** In these areas crop and animal production are integrated and nutrients are recycled within the system. Some of the agriculture production in the Baltic countries is also very extensive today. This is a result of the agricultural collapse in the wake of the Soviet Union break-up and the resulting loss of the Russian market coupled with the adaptation to a market economy characterized by cheap imports of heavily subsidized agricultural products from EU countries.

ERA - a model for the future Baltic Sea drainage area agriculture

ERA is defined as a system – a farm unit or farms working in closed cooperation – in which at least 85% of total nitrogen needs are produced within the system, thus, establishing a high degree of self-sufficiency in fodder. Crop and animal production must be integrated and balanced in such a way so that the clover-grass used for nitrogen fixation and soil improvement can be used as fodder and the plant nutrients in the manure can be carefully distributed over the whole farm area during a crop rotation time period.

The farm Yttereneby-Skilleby in Järna, Sweden, is managed according to the principles of ecological recycling agriculture (ERA), including the use of nitrogen fixation crops instead of artificial fertilizers, no use of pesticides according the standards for organic farming and an animal density (0.6 animal units per ha) in balance with the farm's own fodder production of 85% of its cropping area. The remaining 15% are used for food crops. These figures are in the same magnitude as the average for Swedish agriculture. The farm gate balance in Figure 4 shows that the total surplus of nitrogen is about half of the Swedish average. As the absolute emissions of ammoniac from animals are similar in both systems (ERA and conventional agriculture) the balance is even lower in ERA than in conventional agriculture. If only the field balances are included total surplus and potential losses of nitrogen are about 75% lower in ERA.

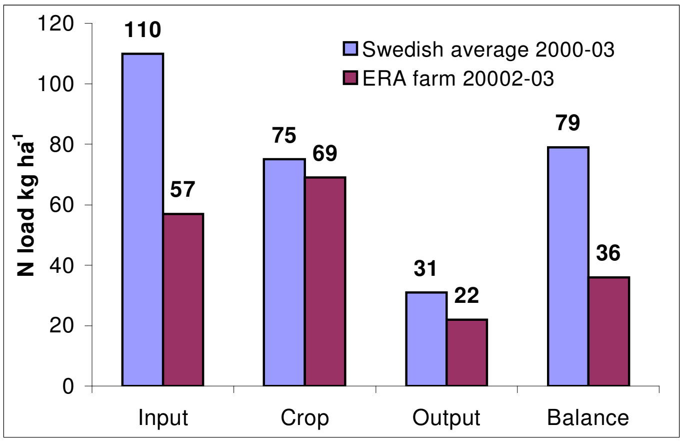

Figure 4. Farm-gate balances comparing the Swedish average agriculture, including separate specialized crop and animal farms and the an ERA farm (Yttereneby-Skilleby) which integrates crop and animal production.

The BERAS project contributes with a long-term strategy to the development of an environmentally, economically and socially sustainable agricultural food production in the Baltic Sea Drainage area. They case studies provide the basis for evaluating the consequences of converting the agricultural sector according to ERA principles (Granstedt et al 2004).

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