Schweizerische Eidgenossenschaft
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Eidgenössisches Volkswirtschafts-
departement EVD
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Agroscope Reckenholz-Tänikon ART

ETH
Eidgenössische Technische Hochschule Zürich
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aquatic research

COST Action 869, Working Group 4:

Evaluation of projects in example areas: The Swiss Midland Lakes.

June 24 - 26, 2009, Nottwil (CH)

Final Report

July 2009

Organization Committee

- Christian Stamm, Main Organizer, Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf
- Josef Blum, AgroEcoConsult, Sempach, formerly: Department for Agriculture and Forest Canton Lucerne
- Emmanuel Frossard, Swiss Federal Institute of Technology ETH Zürich, Lindau
- Astrid Oberson, Swiss Federal Institute of Technology ETH Zürich, Lindau
- Volker Prasuhn, Agroscope Reckenholz-Tänikon Research Station ART, Zürich

Scope and form of the workshop:

The goal of the workshop was to share experiences on mitigation success and failure stories across Europe. We used the case study of Lake Sempach as a starting point. On the first day (June 24), the participants were welcomed by the head of the Cantonal Parliament of Lucerne. Not only being the highest representative of the Canton, but also as biologist A. Borgula explained why mitigation was an important topic for the region where the workshop took place. Afterwards, two further introductory lectures were given. The first by E. Frossard put the workshop into the larger context of the entire COST Action 869. The second one by C. Stamm was devoted to present the study case and to highlight major steps during the process of eutrophication and mitigation experienced by the lake over the last 40 years. The bike tour after dinner got the participants around the entire lake with two stops for explanations. J. Blum, the local organizer, explained the technical details of the lake aeration and activities along the lake shore for teaching school classes.

The second day was devoted to field and farm visits in the region. On three farms with fairly different philosophies and economic structure the participants were introduced into specific aspects of mitigation programmes in Switzerland and in the specific region to tackle problems of P losses from agriculture. Nutrient balances and direct payments, retention ponds, buffer stripes and no-till practices were the major topics presented. The visits were guided by experienced people from Cantonal authorities (J. Blum, F. Stadelmann, W. Sturny) with the farmers (J. Ineichen-Bieri, H.-P. Fleischlin-Gloor, F. Rösli-Jurt) present for discussing specific questions. This opportunity was much appreciated and participants were intensively discussing their experiences with the farmers.

In the afternoon, the specific experiences on single farms were put into a larger socio-economic context. B. Meier presented an economic analysis of how mitigation programmes had affected structural change in agriculture of the study area. The results indicate that positive short-term effects might be counter-balanced in the long run because structural changes on farms may be severely slowed down rendering these farms vulnerable to economic problems in the future.
The second presentation of the afternoon session shed light onto an aspect very different from economics. It addressed how the behaviour of farmers may be affected by the exchange of ideas with other farmers and how this may be used by extension services. P. Fry introduced an innovative approach by using videos with interviews with farmers telling their experiences, e.g., on no-till farming, in their own language (Swiss dialects) on their own land. One of the videos had been subtitled in English and was shown the first time to an international audience.

The final two presentations were given by a representative of the association of the municipalities in the lake catchment, and by a speaker presenting on behalf of the Federal Offices for the Environment as well as the Federal Offices for Agriculture. These two talks gave the participants an impression of how authorities at different levels have experienced the problems of eutrophication and what will be important for the future development from their point of view. During the Conference Dinner at Lucerne, the participants had ample time to discuss their impressions and exchange ideas in a beautiful surrounding.

The third day was devoted to present and discuss the experiences from the different countries. The scope of the presentations was very broad. On the one hand, the talks and poster presentations demonstrated the large variability with regard to agricultural, economic or climatic conditions that need to be taken into consideration when talking about mitigation across Europe. Nevertheless, the involvement of stakeholders including farmers was a recurring theme and several promising approaches had been presented. On the other hand, topics like how to deal with scientific uncertainty regarding the efficiency of mitigation options or the question whether a change in human diet will be required were discussed. This wide perspective was also reflected in the (short) final discussion that was structured according to the three topics “What can we transfer to other regions or countries?”, “How is collaborative action possible despite significant uncertainties regarding mitigation options?”, and “Do we need to optimize within given boundary conditions or do we need to change them (e.g., less meat in human diets)?”.

The workshop was a successful event of scientific exchange. It was attended by participants from scientists from 20 countries. Given the topic, the audience was not restricted to researchers but entailed practitioners as well (from the host country as well as from across Europe). This was a fruitful combination fostering specific and targeted discussion and exchange of ideas on mitigation and implementation. In concrete terms, the workshop resulted in the possibility of linking activities on pilot farms in different countries and to present the Swiss videos on environmentally friendly farming practices abroad.

The discussions profited a lot from the high quality of most presentations. They were to the point and well prepared and presented. Obviously, the country coordinators had done a good job in selecting the people delegated to the workshop. Accordingly, the participants were actively involved during the entire duration of the workshop.

As a side effect of the lively scientific exchange the excursion gave the opportunity to a local newspaper to participate in the excursion. An article in the Swiss newspaper for the farming community (“Schweizer Bauer”) published on July 1, 2009, summarized important aspects that popped up during the discussion with the international experts on the issues (see attachment).

Programme:

Day 1: Arrival, Introduction

15:00 Arrival, Registration

16:00 **Welcome**
(Adrian Borgula, biologist, President of the Cantonal Parliament Lucerne)

16:10 **Introduction to the workshop**
(E. Frossard, P. Strauss)

16:30 **The Lake Sempach case study: Overview of 30 years of research**
(C. Stamm)

17:30 **Dinner**

19:00 Bike tour around Lake Sempach

Day 2: "The Swiss Experience"

08:30 **Field visits** (2 groups, on 3 farms)
(organizer: J. Blum, consultant)

12:45 Lunch (on a farm)

13:30 Return to conference center

14:00 **Socio-economic evaluation of mitigation programs in the Lake Sempach area**
(B. Meier, consultant)

14:45 **New approaches to communicate with farmers**
(P. Fry, consultant)

15:30 Coffee break

16:00 **Involving the public / municipalities**
(J. Peter, president of the association of the municipalities within the lake catchment, mayor of Neuenkirch)

16.30 **What are the lessons learned by the federal agencies?**
V. Kessler (Federal Office for Agriculture, FOA)

19:00 **Dinner in Lucerne**

Day 3: Experiences from other European countries and beyond

08:30 **How to account for the uncertainty of mitigation options in implementing management strategies?** (Brian Kronvang, Dk)

09:15 **Collaborative approaches to the development and implementation of agri-environmental measures in the UK** (Nigel Watson, UK)

09:35 **Pilot farmers as ambassadors of excellent agricultural practice**
(Frans Aarts, Wageningen, NL)

09:55 **Decreasing nutrient leaching at country and county level in Sweden**
(Anuschka Heeb, Se)

10:15 Coffee break, Poster presentation (Titles see below)

Day 3: Experiences from other European countries and beyond (Continuation)

11:00 **Integrated projects in the region of lake Vansjø, Norway for reduced phosphorus runoff from vegetable fields** (Anne Falk Øgaard, No)

11:20 **Measures for decreasing of water resources pollution in Slovak Republic** (Jaroslav Antal, Sk)

11:40 **Human nutrition as key to nutrient emissions into water** (Simon Thaler, A)

12.00 Lunch

13.30 **Nutrient mitigation options in agricultural landscapes– the New Zealand experience** (Deborah J. Ballantine, NZ)

13.50 **Mitigation measures to reduce agricultural nitrogen and phosphorus losses in Ireland** (Nicholas Holden, Ie)

14:10 **Irrigated agriculture improvements to reduce aquifer pollution: a case study from a Portuguese vulnerable area** (Daniela Valente Simões dos Santos, Pt)

14:30 **Pedagogic tools incorporated into Territ'eau Framework to protect the water quality** (Sylvie Guiet, F)

14:50 **How to ensure long term effects of mitigation? - Example from the EU-Life project AGWAPLAN** (Irene Wiborg, Dk)

15:10 Coffee Break

15:40 **Final discussion: what can we learn out of 30 years „Lake Sempach“ and examples from other countries?**

16:30 Closure

Posters:

Franz Stadelmann (CH) **Agricultural measures to restore the Swiss midland lakes (Sempach, Baldegg, Hallwil)**

Klaus Isermann (D) **Multiplicity, effectiveness and efficiency of a healthy human nutrition in respect both to human health and environment**

Uwe Schindler (D) **Land use and agricultural management effects on deep drainage and solute leaching**

Nick Holden (Ie) **Development of a sustainable nutrient management decision support system for Ireland**

M. Iggy Litaor (Is) **The Agmon lake-wetland complex: A Mediterranean example of land use change from farming to ecotourism**

Antanas Sigitas Sileika (Li)	**Drainage and groundwater quality change after construction of manure storage in the demonstration cow farm**
M.I.P de Lima (Pt)	**Vulnerability of water bodies to diffuse pollution in small islands: a hydrological perspective**
E. Filiche (Ro)	**The impact of soil erosion on the quality of groundwater as drinking water source in Perieni County**
Barbro Ulén (Se)	**Focus on phosphorus (P) at catchment level in Sweden**
Goswin Heckrath (Dk)	**A P Index-based mitigation planning tool for reducing phosphorus losses from land to water in Denmark**
Claudia Hahn (CH)	**Artificial rainfall experiments on the Swiss Plateau to assess phosphorus losses from soils and manure**
Frank Liebisch (CH)	**Soil and plant indicators to minimize phosphate inputs in permanent grasslands**
Nadine Kon (CH)	**Mapping of contributing areas for diffuse water pollution - a study of feasibility**

cs, July 7, 2009

Appendices

Appendix 1: Final list of participants

Appendix 2: Book of abstracts

Appendix 3: Excursion programme

Appendix 4: Copy of an article published in the newspaper “Schweizer Bauer” (in German)

Appendix 1: Final list of participants

Country	Delegate	Day of participation
Austria	Peter Strauss	Wed - Fri
Austria	Simon Thaler	Wed - Fri
Czech Rep.	Josef Hejzlar	Wed - Fri
Czech Rep.	Jindrich Duras	Wed - Fri
Denmark	Goswin Heckrath	Wed - Fri
Denmark	Irene Asta Wiborg	Wed - Fri
Denmark	Gitte Rubaek	Wed - Fri
Denmark	Brian Kronvang	Wed - Fri
France	Sylvie Guiet	Wed - Fri
France	Pierre Moreau	Wed - Fri
Germany	Uwe Schindler	Wed - Fri
Germany	Klaus Isermann	Thu - Fri
Germany	Markus Venohr	Wed - Fri
Hungary	Marton Vona	Wed - Fri
Ireland	Nick Holden	Wed - Fri
Israel	Iggy Litaor	Wed - Fri
Israel	Moshe Shenker	Wed - Fri
Lithuania	Antanas Sigitas Sileika	Wed - Fri
Lithuania	Kazimieras Gaigalis	Wed - Fri
Luxembourg	Andreas Krein	Wed - Fri
Netherlands	Wim Chardon	Wed - Fri
Netherlands	Frans Aarts	Wed - Fri
New Zealand	Deborah Ballantine	Wed - Fri
Norway	Marianne Bechmann	Wed - Fri
Norway	Anne Falk Øgaard	Wed - Fri
Poland	Leszek Hejduk	Wed - Fri
Portugal	Daniela Santos	Wed - Fri
Portugal	João Pedroso de Lima	Wed - Fri
Romania	Daniela Dana	Wed - Fri
Romania	Romulus Mocanu	Wed - Fri
Romania	Ana Maria Dodocioiu	Wed - Fri
Slovakia	Jaroslav Antal	Wed - Fri
Sweden	Barbro Ulén	Wed - Fri
Sweden	Anuschka Heeb	Wed - Fri
Switzerland	Emmanuel Frossard	Wed - Fri
Switzerland	Christian Stamm	Wed - Fri
Switzerland	Beat Meier	Wed - Fri
Switzerland	Patricia Fry	Thu
Switzerland	Josef Peter	Thu
Switzerland	Victor Kessler	Thu - Fri
Switzerland	Astrid Oberson	Wed - Fri
Switzerland	Volker Prasuhn	Wed - Fri
Switzerland	Sepp Blum	Wed - Fri
Switzerland	Frank Liebisch	Wed - Fri
Switzerland	Claudia Hahn	Wed - Fri
Switzerland	Georges Chassot	Fri
Switzerland	Nadine Konz	Fri
Switzerland	Anton Candinas	Fri
Switzerland	Arno Stöckli	Fri
Switzerland	Franz Stadelmann	Wed - Fri
Switzerland	Walter Richner	Fri
UK	Nigel Watson	Tue - Fri

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aquatic research

COST Action 869, Working Group 4

Evaluation of projects in example areas: The Swiss Midland Lakes

June 24 - 26, 2009, Nottwil, Switzerland

Programme and Abstract Book

cost

Scope and form of the workshop

The goal of the workshop is to share experiences on mitigation success and failure stories across Europe. We use the case study of Lake Sempach as a starting point. After introductory presentations on the first day (June 24) the second day is devoted to actual field and farm visits in the region. Participants will have the possibility to exchange experiences with farmers and representatives from public authorities. Additionally, innovative approaches in communication between science, administration and farmers are presented. The third day is devoted to present and discuss the experiences from the different countries with the goal to identify key features that are relevant for success stories in mitigation programs.

In this booklet, abstracts of the lectures are sorted chronologically according to the programme. Abstracts of posters follow, sorted alphabetically by first Author. All abstracts have been edited into a common style but not in their content.

Organizers

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Programme

Day 1: Arrival, Introduction
Wednesday, June 24th, 2009

15:00 Arrival, Registration

16:00 **Welcome**
(A. Borgula, biologist, President of the Cantonal Parliament Lucerne)

16:10 **Introduction to the workshop**
(E. Frossard, Peter Strauss)

16:30 **The Lake Sempach case study: Overview of 30 years of research**
(C. Stamm)

17:30 Apero & Dinner

19:00 Bike tour around Lake Sempach

Day 2: "The Swiss Experience"
Thursday, June 25th, 2009

08:30 **Field visits** (2 groups, on 3 farms)
(organizer: J. Blum, consultant)

12:45 Lunch (on a farm)

13:30 Return to conference center

14:00 **Socio-economic evaluation of mitigation programs in the Lake Sempach area**
(B. Meier, consultant)

14:45 **New approaches to communicate with farmers**
(P. Fry, consultant)

16:00 **Involving the public / municipalities**
(J. Peter, president of the association of the municipalities within the lake catchment, mayor of Neuenkirch)

16.30 **What are the lessons learned by the federal agencies?**
(V. Kessler Federal Office for Agriculture (FOA) and a representative of the Federal Office for the Environment (FOE); each 15 min)

19:00 Dinner in Lucerne

Day 3: Experiences from other European countries and beyond
Friday, June 26th, 2009

08:30 **How to account for the uncertainty of mitigation options in implementing management strategies?**
(B. Kronvang, DK)

09:15 **Collaborative approaches to the development and implementation of agri-environmental measures in the UK**
(D. Doody, UK)

09:35 **Pilot farmers as ambassadors of excellent agricultural practice**
(F. Aarts, NL)

09:55 **Decreasing nutrient leaching at country and county level in Sweden**
(A. Heeb, SE)

10:15 Coffee break, Poster presentation (Titles see below)

11:00 **Integrated projects in the region of lake Vansjø, Norway for reduced phosphorus runoff from vegetable fields**
(A. Falk Øgaard, NO)

11:20 **Measures for decreasing of water resources pollution in Slovak Republic**
(J. Noskovič, SK)

11:40 **Human nutrition as key to nutrient emissions into water**
(S. Thaler, AT)

12.00 Lunch

13.30 **Nutrient mitigation options in agricultural landscapes– the New Zealand experience**
(D. J. Ballantine, NZ)

13.50 **Mitigation measures to reduce agricultural nitrogen and phosphorus losses in Ireland**
(H. Tunney, IE)

14:10 **Irrigated agriculture improvements to reduce aquifer pollution: a case study from a Portuguese vulnerable area**
(D. Santos, PT)

14:30 **Pedagogic tools incorporated into Territ'eau Framework to protect the water quality**
(S. Guiet, FR)

14:50 **How to ensure long term effects of mitigation? - Example from the EU-Life project AGWAPLAN**
(I. Wiborg, DK)

15:10 Coffee Break

15:40 **Final discussion: what can we learn out of 30 years „Lake Sempach" and examples from other countries?**

16:30 Closure

Posters

First author	Title
P. Csathó (HU)	**Quo vadis, legislation on agro-environmental protection in the European Union? A Forum**
M.I.P. de Lima (PT)	**Vulnerability of water bodies to diffuse pollution in small islands: a hydrological perspective**
E. Filiche (RO)	**The impact of soil erosion on the quality of groundwater as drinking water source in Perieni County**
C. Hahn (CH)	**Artificial rainfall experiments on the Swiss Plateau to assess phosphorus losses from soils and manure**
G. Heckrath (DK)	**A P Index-based mitigation planning tool for reducing phosphorus losses from land to water in Denmark**
J. Hejzlar (CZ):	**The effect of fertilization rate and proportion of arable land/grassland areas on nitrate concentration in the catchments of four drinking water reservoirs in Czech Republic.**
N. Holden (IE)	**Development of a sustainable nutrient management decision support system for Ireland**
K. Isermann (DE)	**Multifunctionality, effectiveness and efficiency of a healthy human nutrition also in respect to the eutrophication of the hydrosphere**
N. Konz (CH)	**Mapping of “contributing areas” for diffuse water pollution – a study of feasibility**
F. Liebisch (CH)	**Soil and plant indicators to minimize phosphate inputs in permanent grasslands**
M. I. Litaor (IL)	**The Agmon lake-wetland complex: A Mediterranean example of land use change from farming to ecotourism**
U. Schindler (DE)	**Land use and agricultural management effects on deep drainage and solute leaching**
A. S. Sileika (LT)	**Drainage and groundwater quality change after construction of manure storage in the demonstration cow farm**
F. Stadelmann (CH)	**Agricultural measures to restore the Swiss midland lakes (Sempach, Baldegg, Hallwil)**
B. Ulén (SE)	**Focus on phosphorus (P) at catchment level in Sweden**

The Lake Sempach case study: Overview of 30 years of research

Christian Stamm

Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland

Signs of eutrophication have been observed in the Lake Sempach since the 1960s. Since that time, the implementation of mitigation measures tackling urban and agricultural sources of phosphorus input have been closely linked to research on the causes behind eutrophication and possibilities for remediation. This presentation summarizes the temporal evolution of the status of the lake and how research on the real system helped to elucidate interplay of lake-internal and external processes. Special emphasis will be put on the understanding of agricultural P losses. While these losses were considered of minor importance in the 1970s based on the available data, monitoring in the lake tributaries revealed strongly increased loads by the mid 1980s. This observation fostered investigations clarifying the role of different processes causing the high P export from the grassland dominated catchment.

Today, the P concentrations have been reduced below a critical concentration of 30 mg/m3. It will be demonstrated that the rate of decrease can only be understood by considering the interplay between lake-internal P cycling and reduced P input due to external mitigation measures. However, observations in the area as well as findings in the literature suggest that unexpected changes of the system might occur in the future. Hence, careful monitoring of the system remains a crucial task.

Socio-economic evaluation of mitigation programs in the Lake Sempach area

Beat Meier

bemepro, Winterthur, Switzerland

In order to reduce the inflow of phosphorus in the Midland lakes of Sempach, Baldegg and Hall-wil, the Canton Lucerne introduced specific P-projects, the first of them starting in 1999. These projects, financed by the Canton and the Swiss Federation, offer the farms in the catchments of these lakes several voluntary measures to reduce P-losses, the “Lake-Contract” being the most important element. Farms with a Lake-Contract agree not only to adopt different methods to re-duce runoff but also to bring down their farm phosphorus balance below 100% (while the national cross-compliance scheme allows a surplus of 10%). The latter requirement can be met by reducing livestock density, using N/P-reduced feed or exporting P via manure supply agreements.

Structural change in terms of the decrease of the number of farms between 1999 and 2006 is much slower in the Canton of Lucerne (-9%) compared to the Swiss average (-14%). Within the catchment area, the decrease is even lower (4%). The design of the analysis doesn’t allow to prove a causal influence of the P-projects, but such an effect seems possible. The relatively slow de-crease of the number of farms corresponds with a slower than average increase in farm size. In addition, it can be shown that within the catchments, compared to neighbouring areas outside, more often farms with relatively small production branches (dairy, pigs) invest in increasing them. What the P-balance allows (including possibilities of P-exports) seems to have more influ-ence than the disadvantages from a microeconomic point of view. These are major problems in a medium term perspective, as production costs are far from international competitiveness and economies of scale must play a key role in narrowing the gap.

Between 1999 and 2006 the total number of livestock increases in the districts of Sursee and Hochdorf by 6.3%. The increase is slightly smaller within the catchments of the lakes (5.4%) com-pared to the area outside (6.8%). Within the catchments the increase in farms that sooner or later sign a “Lake-Contract” is considerably higher at 8.5%. This can be explained by the lower live-stock density in these farms in 1999 and the fact, that farms willing to grow would only get a permission to construct new stables if they submit themselves to the conditions of the “Lake-Contract”. To meet the requirements of these contracts, N/P-reduced feed has become a standard and exporting P via manure supply agreements is essential. An analysis of these contracts shows that farms in the catchments triple their net exports of phosphorus (P_2O_5) from 25 tonnes in 1999 to 79 tonnes in 2006.

For future policies concerning water protection it is essential to clearly distinguish permanent payments for positive external effects from measures to eliminate a pollution problem. The latter must be temporary and the direction of the structural adjustment processes must be known and considered in design. This is the only way to assure that along with ecological improvements also economically sustainable structures can evolve.

New approaches to communicate with farmers: Enhancing social learning processes for soil and water conservation in Switzerland

Patricia Fry

Knowledge Management Environment, Zurich, Switzerland

Bridging the gap between scientific analysis and farmer action is a major challenge when implementing soil and water conservation measures (SWC). On the basis of the comparison between scientific and farmer perception of soil the innovative and transdisciplinary implementation project “From Farmer to Farmer” was conducted in the midlands of Switzerland 2002 - 2009.

The main ideas of the approach are the following: In a first step arguments of farmers are worked out by means of interviews and film. These farmers have successfully implemented soil conserving methods in collaboration with soil scientists during several years. By doing so the aims, methods and contexts of farmer work are integrated (Fry 2001). Five short films have been produced: “From plowing to direct drilling”, “mulch seeding”, “strip tilling”, “direct drilling” and “soil regeneration and activation”. The films show people working at the farm, special machines during action and crop in several stages. The experience and specific language of farmers enhances the credibility and enables a personal identification. In a second step these videos are shown at informal farmer assemblies as well as at agricultural schools in order to trigger social learning processes.

The project also bridges the gap between scientists and practitioners by building and organizing an accompanying group – a trading zone - which consists of all relevant actor groups, institutions of agriculture and soil protection as well as several agricultural associations. All these actors accompany the production of the films. This group meets regularly and in a way that all the actors can interact freely.

The project is supported by two federal departments - agriculture and environment -, all the cantons as well as four farmer organizations. The pilot phase started in 2002 testing the project steps. The main phase lasted from 2003 to 2007. Until the beginning of 2010 three additional films are produced and introduced to the farmers.

The project was accompanied by researchers from the University of Berne. Their findings show that this innovative way of communicating with farmers is effective on several levels (Schneider et al. 2009).

Experience of the federal government in implementing projects on phosphorus

Victor Kessler

Federal Office for Agriculture, Bern, Switzerland

For the last ten years the federal government has been providing contributions to support the phosphorous projects for Lakes Sempach, Baldegg and Hallwil according to Article 62a of the Water Protection Act. Two federal agencies involved - the Federal Office for the Environment (FOEN) and the Federal Office for Agriculture (FOAG) - now find the overall results to be positive. The lakes are doing much better. The experience shows that the strategy chosen and the measures taken were right. To continue the projects and to organise the best possible measures the federal government has to find answers to various research questions arising from the change in the quality of the water of the lakes.

The three lakes are now in much better condition. Lake Sempach has 21mg /m^3 P and Lake Baldegg has 26 mg/m^3 P. In the early 1980s the level of P in Lake Baldegg was still above 500 mg/m^3.

At the beginning of the 1980s, phosphates were banned in laundry detergents and P was removed in sewage treatment plants, which brought about a marked reduction in P inputs. Since 1982, measures have also been introduced within the lakes (aeration and assisted circulation) and, starting in 1998, projects have been implemented in the catchment areas of the lakes, according to Art. 62a of the Water Protection Act.

In the areas of the project, there is financial compensation for measures to reduce run-off, leaching and enrichment of P, which go beyond the requirements of the ordinance on direct payments. In addition to reduced P discharges, which must be lower than the needs of the cultures, direct seeding, wider buffer strips, non-fertilised areas and structural measures are all required. In addition, innovative projects are promoted when there is a reduction in the number of animals on the land.

The agriculture department is responsible for implementation. A six-year contract between the Federal Office for Agriculture and the cantonal specialised services guarantees payment of a federal contribution (50 to 80% of the costs). There is no compensation from the federal government for preliminary investigations and additional studies on the catchment areas, inflows, outflows and the lakes.

In the course of implementation, the legal framework was supplemented by the federal government and by the canton. In September 2002, under pressure from the federal government, the cantonal ordinance on phosphorus was brought into force, linking the number of farm animals to care for the soil. This actually fixed the number of animals. At the beginning of 2008, an 80% reduction of P fertilisation on land of types D and E became mandatory at the federal level. This measure, which was initially subsidised, can no longer receive compensation in future projects or in extensions of contracts.

Although there has been a decrease in algal-available P, the amount of particle bound P has risen. The source of this is currently under investigation. It is thought that this is attributable to P from land used for agriculture and from the beds of inflowing rivers and streams.

After the intermediate target of <30mg P /m3 was achieved surprisingly quickly, the target of the next phase of the project is to reach the ultimate objective of 20 mg/m^3. To organise targeted measures, some questions have to be clarified by research. The focus is on the causes of the increase in particle bound P and on the contribution towards reduction made by individual measures.

The projects for the Swiss Midland Lakes have now progressed to the home stretch. The federal government, the canton and farmers are all making a big contribution. In the future it will be a matter of promoting structural measures, in order to ensure the quality of lake water and the habitat with its unique landscapes in the long term. To do this it will be helpful to have collaboration between those involved in water protection, agriculture, spatial planning and politics.

How to account for the uncertainty of mitigation options in implementing management strategies

Brian Kronvang

National Environmental Research Institute, Aarhus University, Denmark

Quantification of uncertainties involved in the management of catchments is not an easy task. In order to manage nutrient pressures within a catchment you need to have gained sufficient knowledge on the driving forces, pressures, state and impact for being able to response correctly in the form of implementing and dose different mitigation options (Fig. 1). Thus, a catchment manager will need to have access to monitoring data for assessment of the state and impact of nutrients and a kind of model that can assist in analysing the importance of different pressures and the possible outcome of management strategies (Fig. 2). Furthermore, catchment managers may need to analyse in more details the source areas (field scale) of nutrients for the risks of mobilization and transport of nutrients along different hydrological pathways and the connectivity between the field and ground or surface waters. Finally, when you as a catchment manager have to select mitigation options to be dosed in the catchment you will have a suite of possible options to choose among and in many cases the uncertainty and possible side-effects of a certain mitigation option adopted at the field scale having certain natural boundary conditions are not fully understood.

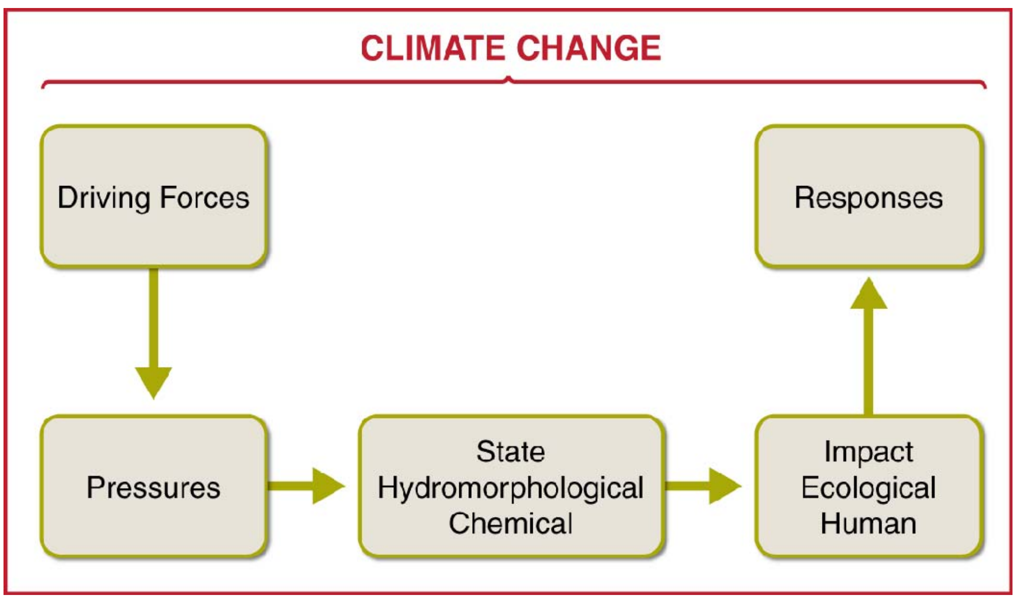

Figure 1: The DPSIR concept for management of a river basin.

Very few if any have tried to investigate the combined uncertainties for managing a catchment. The uncertainty for different parts of the whole managing cycle as exemplified by the DPSIR diagram is, however, known to some extent. We know from research project that monitoring of nitrogen and phosphorus loadings in streams are combined with an uncertainty that depends on the frequency of water sampling and the choice of load estimator. The EUROHARP project which compared the outcome of different models applied in European countries for source apportionment of catchment nutrient loads and quantification of the importance and timing of agricultural losses clearly showed that relatively high uncertainties may be expected with the model results depending not only in the model chosen but also other factors as data availability, existence of lakes in the catchment, etc. In the presentation examples of uncertainties along the route of decision for catchment management will be highlighted utilising findings and examples from Danish research projects and monitoring programmes.

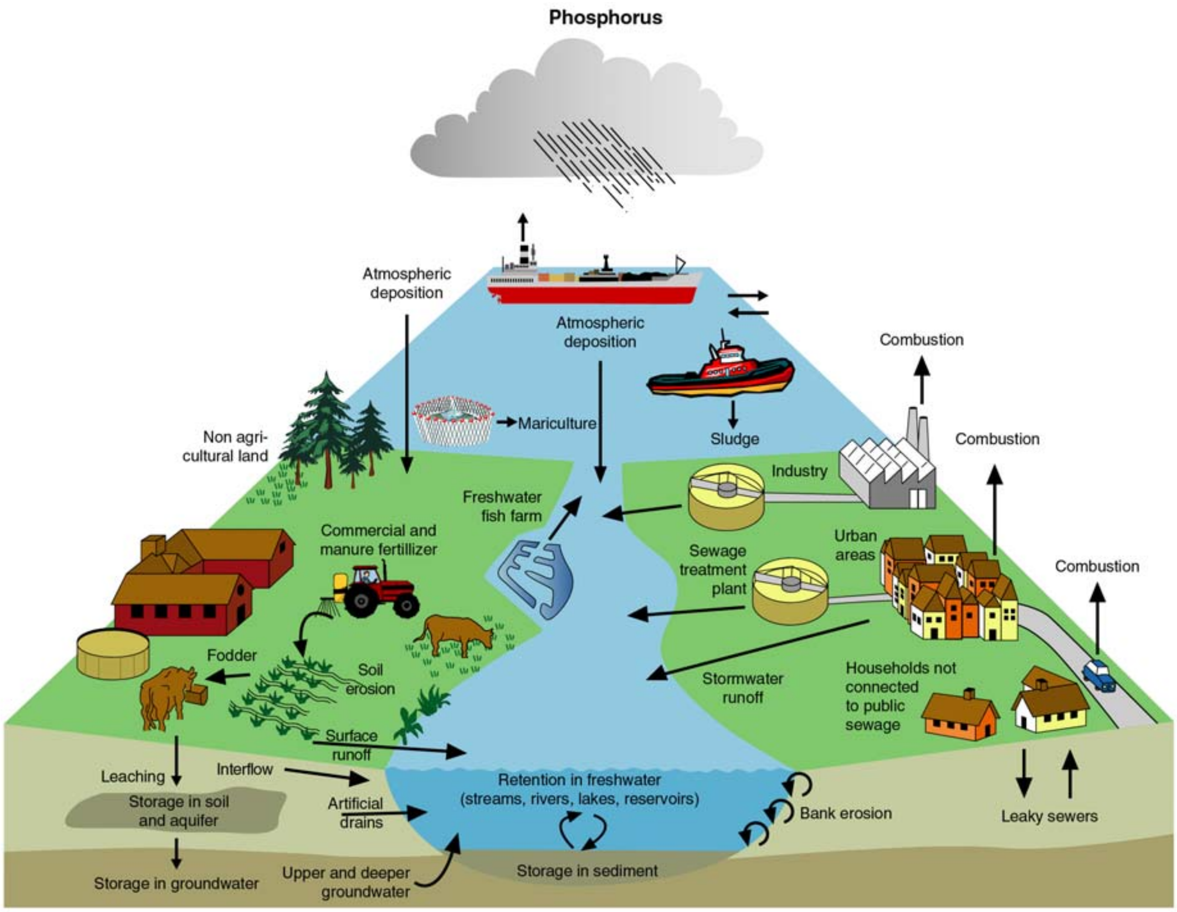

Figure 2: The different pressures to phosphorus loadings of surface water bodies.

Collaborative Approaches to the Development and Implementation of Agri-Environmental Measures in the UK

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The development and implementation of agri-environmental measures for diffuse pollution have to-date relied on the objectivity of scientific research to produce recommendations on mitigation measures through experiments and monitoring. While this approach has strong merits as it produces independent objective measures, it does not take into account the human factors that will impact the effectiveness of implementation nor differences in perception of how the problem could be solved. Consequently, it has not fully negated the potential for conflict and uncertainties which can impact the effectiveness of mitigation measures during implementation at farm-scale. Closer collaboration between researchers, policy makers and stakeholders has been proposed as one option for overcoming these barriers. In the UK a number of collaborative approaches to the development and/or implementation of agri-environmental measures have been employed. The Lough Melvin Nutrient Reduction Programme in Northern Ireland implemented a collaborative approach to the development of a suite of measures to decrease phosphorus export from farms in the catchment. This approach has resulted in a partnership agreement between farmers, researchers and other stakeholders for further collaboration to develop economically and environmentally sustainable agriculture in the Lough Melvin catchment. In the Loweswater catchment in the English Lake District, a community approach to catchment management is being taken through the establishment of the Loweswater Knowledge Collective (LKC). The stakeholders in the LKC are working closely together to try to understand why conditions in the lake have deteriorated and what additional measures might be introduced in an attempt to improve water quality. The Pontbren Farmers Group in Wales was established by neighbouring farmers who work together to develop sustainable farming systems in the Pontbren catchment. In addition, the farmers collaborate with the Pontbren Co-ordination Group, made up of a range of stakeholder groups, to disseminate and discuss ideas and findings arising from Pontbren activities. The aim of this paper is to evaluate these collaborative approaches to the development and/or implementation of mitigation measures and to identify criteria for successful collaboration between researcher, policy makers and stakeholders. The value of incorporating different forms of knowledge into the development and implementation of measures will be examined from the perspective combining subjective and objective data. The potential of collaborative approaches to improve the environmental outcomes of mitigation measures for diffuse pollution will then be considered.

Pilot farmers as ambassadors of excellent agricultural practice

Frans Aarts

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Low utilization efficiency of fertilizers and feeds led to high losses of N- and P-compounds and high costs of milk production on Dutch dairy farms. Therefore, in 1992, the ‘De Marke’ experimental dairy farming system was started on leaching sensitive soils with target reductions in nutrient losses of 75% for N and 99% for P. Central theme was maximizing the cycling of nutrients what reduces losses and therefore the needs for inputs. Result were used to start in 1999 the project ‘Cows & Opportunities’, to improve the nutrient management on 17 commercial pilot farms, all over the country, with target reductions of about 60% for N and 80% for P without lowering income. Representatives of the Dutch Dairy Farmers Board and the Ministry of Agriculture form the Steering Committee of the project, to guarantee a strong involvement of dairy sector and government. The pilot farmers are consulted by the government concerning the finding of most cost-effective legislation, needed for the Action Plan of the Nitrate Directive. Therefore, the project is also more or less a platform for government and farmers to exchange information and create mutual understanding.

Pilot farmers play an important role in communication with the dairy sector and therefore their motivation, skills to communicate and the image to be professional were important selection criteria. Ordinary farmers are helped by pilot farmers to define the best fitting strategy for farm improvement, taking into account farm specific circumstances, including personal skills and interests. Pilot farmers speak their language better than for instance scientists do. In general, farmers are only convinced of the value of innovations or better ways of working if these were shown in practice by colleagues they trust. As a result, between 1997 and 2006 the surplus for N of the Dutch dairy sector decreased with 40% (to 218 kg/ha) and for P with 52% (to 11 kg/ha) because of strong reductions in purchases of mineral fertilizers and concentrate feeds. Because reductions could be realized without reductions in milk production (Dutch average is 13,000 kg milk/ha) farmers are aware that these were financial profitable. Therefore, the acceptance of the dairy sector regarding the implementation of environmental measures by the government was high.

Based on the actual performances of the pilot farms, and the experiences that ordinary farms follow these at a distance of about three years, further reductions in dairy sector are expected. The nutrient management on the experimental farm De Marke now is on a level that no mineral fertilizer is needed because of excellent processing and application of the cattle manure produced on the farm. Expected is that most of the pilot farmers will demonstrate that level of excellent agricultural practice within 5 years.

Decreasing nutrient leaching at country and county level in Sweden

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Abstract Focus on Nutrients is a national advisory and information project in Sweden, driven as a joint venture between the Swedish Board of Agriculture, the County Administration Boards, the Federation of Swedish Farmers and a number of advisory organisations. It aims to provide farmers with the knowledge and tools to cost-effectively reduce nitrogen (N) and phosphorus (P) losses from agricultural land, through a combination of free advisory services at farm level, courses, seminars, field activities and information. Advice is given on fertilisation and nutrient balances, tillage practices, animal nutrition, livestock housing, manure storage, buffer strips along streams and wetlands. Focus on Nutrients was introduced in southern Sweden in 2001, and extended further north during 2005. In southern counties the project includes between 36-65% of arable land, whereas in more northerly counties it covers only 6-19%. In the period 1995-2005, a total decrease in N (24%) and P (14%) load to the seas was estimated to have occurred. The majority of the N reduction was from agricultural land and was attributed to farmers growing considerably more catch crops, delaying soil tillage until spring, and using N more efficiently. These findings agree well with data from farms within Focus on Nutrients. The project is expected to contribute a substantial proportion of the further N reduction needed to achieve the target agreed within the Baltic Sea Action Plan.
In the county of Östergötland, Focus on Nutrients started in 2005. It now covers 19% of arable land and 238 farmers have received 658 individual farm visits. A reduction in surplus nutrients cannot yet be demonstrated at county level, as it takes some years to implement and measure the effect of individual advisory sessions and actions at farm level.

Integrated projects in the region of lake Vansjø, Norway for reduced phosphorus runoff from vegetable fields

Anne Falk Øgaard

Bioforsk Soil and Environment Division, Aas, Norway

The western part of lake Vansjø in southeastern Norway has a very poor water quality due to growth of blue green algae. The water quality of lake Vansjø is of great concern because it is drinking water reservoir of 60.000 inhabitants and is an important recreation area for people living in the region. It has been shown that phosphorus (P) losses from a subcatchment where potatoes and vegetables are grown on 25 % of the agricultural area are large. Total 40 farms have all or parts of there fields within this subcatchment.

In 2008, the government funded two integrated projects in order to improve the water quality. Through the projects the County Governor of Agriculture, agricultural advisers, farmers and Norwegian Institute for Agricultural and Environmental Research (Bioforsk) collaborate to attain the target of better water quality. The farmers are encouraged to sign a contract where they against a financial support for covering extra costs, bind them selves for a period of three years to a set of restrictions and mitigation options aiming at reduced P losses. The requirements in the contracts include use of less P fertilizer than the national recommended level, no soil cultivation during autumn, 10 meters buffer zones along open water and making constructed wetlands if this is recommended. In 2008, 30 of total 40 farmers in the subcatchment signed the contract.

Fields where potatoes and vegetables are grown have a high concentration of available P. These fields therefore give large challenges when aiming at reduced P losses. To meet these challenges a research project, where the aims are to study the effects of the implemented mitigation options and the effect of other possible mitigation options are performed by Bioforsk. The research project also aims at getting more knowledge about the most important transport processes for P in the catchment.

Measures for decreasing of water resources pollution in Slovak Republic

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The intensification and concentration of agriculture during the socialist period in Slovakia (over the years 1948 - 1989) caused, inter alia, also more than tenfold growth of industrial fertilizers consumption (in 1948 - 22,6 kg NPK.ha-1 of farmland and in 1989 - 239,7 kg NPK.ha-1 of farmland). It resulted not only in the increase of agricultural crops harvest but it also participated, together with industrialization of Slovakia, in the environment pollution including water resources, and probably, in the decrease of the average age of the Slovak population (in 1992 - 67,56 years in men and 76,22 years in women), too.

After the year 1990 there was a striking, almost fourfold, reduction of industrial fertilizers consumption but different legislative and administrative proceedings, which should contribute even for the decrease of water resources pollution caused by agricultural activity in Slovakia, have been also taken. There can be ranked among them for example the declaration of:

- more than 1000 protective zones of water resources,
- 10 protective water-resources areas,

and worked-out The Codes of Good Agricultural Practice, for example:

- soil protection,
- principles of good use of fertilizers,
- water protection from nitrate pollution from agricultural resources.

These materials include for example:

- acceptable (limited) values of soil erosion losses,
- terms and conditions of fertilizers application during the year,
- dose determination of industrial fertilizers and manure,
- identification of protective zones boundaries of water resources, etc.

We would like to present the basic principles of these proceedings in our presentation on prepared workshop.

Human nutrition as key to nutrient emissions into water

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The western society is rested upon a strong animal-based nutrition, which is far of a healthy balanced diet. Furthermore, the production of animal based food consumes five to six times more resources (e.g.: area, fertilizer) compared to plant-based food and is closely connected to environmental pollution (e.g.: emission of greenhouse gases, water pollution). Especially the regional nitrogen turnover is highly driven by the request from human nutrition on agricultural production. While the efficiency of the transfer of applied nitrogen into the product is 60 – 70 % for vegetarian food, it is 15 – 25 % for animal based food. Thus population's diet is a material factor (a driver) for environmental pollution from food production.

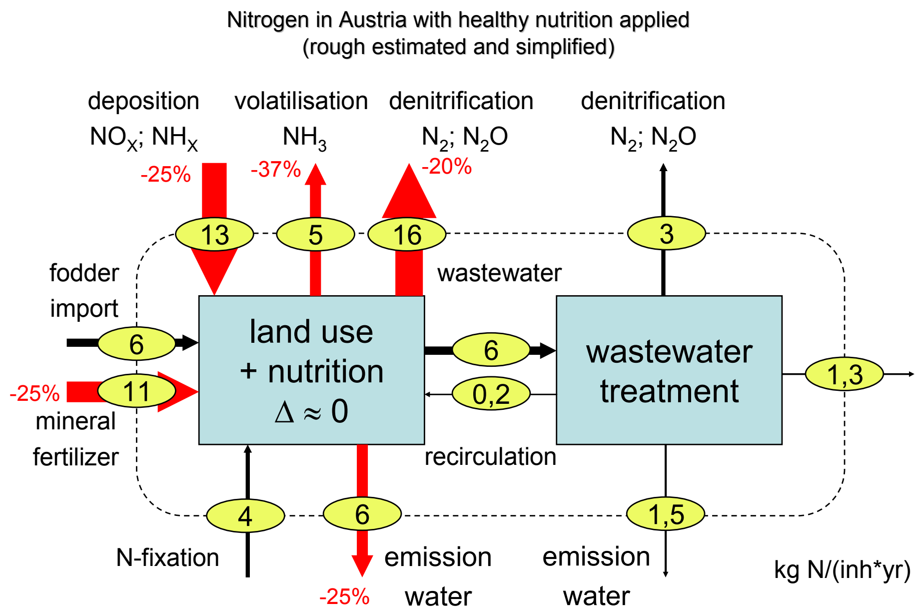

Figure 1: Possible changes in the national nitrogen balance of Austira by introduction of a "healthy nutrition"

This contribution will introduce a project investigating the relations between nutrition, health, food production, energy and water. The project is based on the hypothesis that a "healthy" diet for the population is a significant key to sustainable agriculture. Nutrition of the population in accordance to health recommendations (50 % less meet consumption, contra balanced by an increasing amount of vegetarian food) would dramatically change the environmental impacts. Assuming the same basic nitrogen efficiency of agricultural as it is performed at present, this shift in production would lead to a dramatic relief in respect to environmental pressure. Figure 1 shows a rough estimation of the changed nitrogen fluxes in Austria. The essential innovation of the project lies in the holistic investigation of the problem, the interlinking of different specialist fields and the combination of methodological approaches. Scenarios can be calculated through the quantitative description of these correlations and the effects of different strategies can be compared with one another. The results will then be edited for a broad public and tried out in cooperation with project cooperation partners within the project duration.

Nutrient mitigation options in agricultural landscapes: the New Zealand experience

Deborah Ballantine

NIWA, Aquatic Pollution, Hamilton, New Zealand

The latest review of surface water in New Zealand based on a long-term national sampling program has demonstrated deteriorating quality in many water-bodies, as has been seen in many European countries. While pollution from point sources is reducing, diffuse pollution, due to the expansion and intensification of agriculture, particularly in the pastoral sector, is increasing. Trend analysis of this data set showed that concentrations of TN, NO_3, DRP and TP are increasing, and that increases are positively and significantly correlated with the percentage of pastoral land cover in catchments. In an effort to reverse this concerning trend of reduced water quality, much attention is therefore currently being directed at the mitigation of nutrient loss from land to water, and various mitigation options have been put in place throughout New Zealand to protect water quality, selected examples of which are given below.

Grass filter strips

These are bands of managed grass that provide a buffer between possible contamination sources and water bodies. Grass filter strips are placed across intermittent overland-flow water pathways and are designed to intercept surface runoff during rainfall or irrigation events and remove key pollutants e.g. phosphorus, suspended sediment. These are being tested in the Rotorua Lakes catchment.

Livestock exclusion

This is highly applicable to New Zealand livestock farming and is suitable for margins of lakes, streams, water races, wetlands and estuaries. Many kilometres of streams which flow through grazed dairy pastures have been fenced in New Zealand through the Clean Streams Accord to ensure effective livestock exclusion.

Constructed wetlands

CWs attempt to replicate and optimise treatment processes that occur naturally in swamps, fens and marshes. CW performance has been measured in New Zealand for three constructed systems treating nitrate rich tile drainage from intensive dairy pastures in Northland, the Waikato and Southland. More recently Environment Bay of Plenty funded the establishment of a 2.4 ha wetland at Lake Okaro, near Rotorua which will provide valuable data on the performance of larger-scale systems. N removal has been observed for the wetlands; however P removal is generally negative.

Floating wetlands

These are a novel ecological water treatment technology in which emergent wetland plants grow hydroponically on floating mats or rafts. Their roots form dense growths below the floating mats, taking up nutrients from the underlying water. They are useful for nutrient removal in ponds, dams and irrigation storage reservoirs. Results from trials of floating wetlands undertaken in New Zealand suggest this technique has potential for both N and P removal.

Plant and algae harvesting

Dissolved nutrients can be removed from water by uptake into aquatic plant tissues and then harvesting and removal. Removal of the biomass ensures that nutrients incorporated in plant tissue are permanently removed rather than be returned to the water. In New Zealand watercress is currently being tested for its nutrient removal rates in the Rotorua Lakes catchment.

P sorbing materials

While constructed wetlands are generally quite efficient at N removal, P removal has been very low and even negative in New Zealand constructed wetlands. Various materials are currently being tested to enhance the P adsorption capacity of constructed wetlands. Similar techniques have been tested to reduce the P content of drainage water.

Mitigation of N loss

Nitrogen inhibitors work by preventing the accumulation of the mobile nitrate form of soil mineral N and are used in New Zealand to reduce losses of nitrogen from animal urine patches on grazed pastures.

Catchment management and best management practices

Five regionally representative dairying catchments are the subject of a long term monitoring programme. In these catchments, baseline water quality monitoring was carried out to establish water quality, the most appropriate best management practices have been put in place with the aim of improving water quality and monitoring has continued to assess changes in water quality after implementation of BMPs.

Management tools

Models are available to support farmers and assist with more efficient nutrient management on farms, the best known of which in New Zealand is OVERSEER. This model is widely used by researchers, farmers, industry and government for nutrient budgeting. Farm plans are encouraged by regional councils.

These options detailed above are a selection from a wider range of potential mitigation options which would be suitable in New Zealand, further details of which have been complied in a study undertaken to document main mitigation options for pastoral farming.

Mitigation measures to reduce agricultural Nitrogen and Phosphorus losses in Ireland

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Mitigation of N and P loss from agricultural systems is regulated largely by legislation in Ireland. Mitigation has largely focused on the *c.* 85% of agricultural land that is managed with grassland farming systems. National implementation of EU legislation and policy has addressed: (i) limiting the amount of excess N and P within production systems; (ii) ensuring that N and P in farmyard effluent and slurry are correctly managed; and (iii) limiting spreading of N and P at times when losses to surface or ground water are likely to be high. The Rural Environmental Protection Scheme (an Agri-Environmental Scheme) was introduced in 1994 and has been successful in introducing nutrient management measures on less intensive farms (<170 kg organic N/ha) and currently 45% of Irish farms participate. A review of trends in N and P fertiliser usage in Ireland reveals increases from the 1960 to 1990s and subsequent declines, and there are indications from national surface water monitoring data that water quality is improving with over 71% of river channel classified as unpolluted. Research results to date indicate that in general water quality and grassland production are compatible with the exception of catchments with sensitive receptors where eutrophication may be an issue even at low agricultural intensities. Soil test P should be at or near the lower end of the range required for optimum grassland production for good water quality. The implementation of SI 378/2006 (Nitrate's Directive in Irish law) on a whole territory basis has limited stocking rates, increased storage capacities and restricted spreading to non-winter months. It is too early to see positive responses to these measures in national monitoring data, but at present 8 agricultural catchments are being instrumented to assess the efficacy of the Nitrates Directive measures on water quality in Ireland. The results from agricultural catchments study may indicate if new mitigation options are required, perhaps under the Water Framework Directive and/or where the measures should be targeted. It is anticipated that the Nitrates Directive measures will continue to improve Irish water quality and ensure that good status for all waters, required by the Water Framework Directive, is achieved.

Irrigated agriculture improvements to reduce aquifer pollution: a case study from a Portuguese vulnerable area

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The Portuguese agriculture intensification on last decades has allowed several situations of surface and groundwater pollution with severe impact on water quality to domestic supply systems. These problems resulted mainly in irrigated areas due to the conjugation of misuse water management and excessive nitrogen fertilization rates particularly with intensive horticultural crops. Moreover the incorrect cattle manure application may lead to nitrogen pollution. This communication will present nitrogen levels in water resources and fertilizers consume, according to official Portuguese reports, to give an insight into this problem.

The Agriculture Ministry and the Water Institute are implementing and coordinating the Nitrogen Directive in Portugal. Three vulnerable zones were identified and established: the aquifers between Esposende and Vila do Conde (North), the quaternary aquifer of Aveiro (Center) and the miocene and jurassic aquifer of Campina de Faro (South). This communication refers to the vulnerable zone of Aveiro case that was established by Portuguese government in July 2003.

The agriculture is severely conditioned, with the purpose to conserve the quality of groundwater, which is a crucial resource to supply municipal systems in the area. The constraints refer to seasonal crop distribution, the fertilization doses and the special cases in which are forbidden the fertilization and manure application on soils, the requirement to plan and monitoring the nitrogen fertilization balance, the irrigation practices allowed and recommended. Also, the framework of official nitrates control is coordinated by the Portuguese Water Institute.

A guide on environmental agricultural practices was developed by the Agriculture Ministry and is nowadays applied to support farmers in the operations that influence the nitrogen dynamics on agrarian ecosystems. It includes fertilization and irrigation recommending better practices, considering the lixiviation risks, which depend on the crop systems, soil type and climatic pattern. The record of fertilizers applied on field is now an obligation allowing the monitoring and the risk control.

A research and farmers demonstration project, funded by the Agriculture Ministry, was carried out on this vulnerable zone that will be described in this communication. The traditional practices of high nitrogen consume was evaluated. A soil survey was done to characterize the hydrodynamic behaviour, the porosity and the hydraulic conductivity. The lixiviation potential was evaluated by RZWQM98 model, with several mineral nitrogen doses. The results showed that the macrospores are determinant on water and solute fluxes and the lixiviation of 7 and 17% of total nitrogen applied with a system of horticultural and forage crops. The communication will explain the results and the contribution to define the best manage practices in vulnerable areas.

Pedagogic tools incorporated into Territ'eau Framework to protect the water quality

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Territ'eau is a framework which includes useful tools to elaborate a diagnostic for agricultural catchments and propose mitigation options to recover the water quality. It is particularly dedicated to improve the landscape management. This framework is based on scientific knowledge, and aims at sharing it with end users. The tools have been co-built with farmer organizations. It intends to improve the understanding of the catchment functioning, the effect of landscape features (river bank, ditches, hedge rows, riparian wetlands,…) on water and chemical fate (nitrate, phosphorus, dissolved organic carbon, pesticide) in stream water.
This framework includes:
- A technical referential has been elaborated as well visual tools highlighting the catchment functioning which will be presented.
- The diagnostic include practical resources which can be the easy access to data base or maps, or expert rules.
- A list of positive and innovative experiences have been elaborated and written, to explain the context, the process of social learning, the funding, the difficulties of this experience which will be also presented.
Some test are know performed in order to evaluate this method, in terms of cost, time, required skills, change and satisfaction of the farmers.

How to ensure long term effects of mitigation? Example from the EU-Life project AGWAPLAN

Irene Asta Wiborg

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The EU- LIFE project AGWAPLAN (Agriculture and Water PLAN) project is an example of how stakeholders (farmers), could be involved in the implementation of the WFD through the selection of measures to reduce diffuse N and P pollution from agriculture to achieve the objectives of the WFD. In other words the aim of AGWAPLAN is to facilitate the practical implementation of the EU Water Framework Directive on farm level as well as on catchment level. A key issue for the project is "cooperation between the agricultural and the environmental sector" in order to get improved results for the environment as well as for the agricultural sector.

The issue “active participation of stakeholders” is emphasized in the Water Frame Directive (WFD). Specifically, Member States “Shall encourage the active involvement of all interested parties in the implementation of the Directive, in particular the production, review and updating of the river basin management plans” (Commission of the European Communities, 2000) . Active involvement refers to people actively participating in the planning process by discussing issues and contributing to their solution (Common Implementation Strategy, 2003)

Three pilot areas participate in the project. All areas are farmed intensively, and seen from an environmental point of view they have critical levels of N and P in either surface or groundwater. By using the best available farm and environmental data in an Integrated Advisory System we have created plans for the farmer for how to optimize his production in a way that is consistent with his wishes for farming and consistent with the surrounding environment.

The conclusions:

1. A common professional starting point – and a common understanding of the problems – is a key issue which takes a long time to gain.
2. Data must be precise, relevant and effective if they are to be acted on
3. Structure for cooperation must be anchored in the different organisations
4. Dialogue, cooperation, trust and insight are needed throughout the process.
5. Understanding and accepting the other side’s objectives provides a wider ability to act.
6. The easy measures are inexpensive to carry out for the farmers and for society. Which measures are inexpensive vary according to specific conditions on the farms.
7. By securing that the farmers take the goals into consideration in their daily planning a good basis for a long term effect on mitigation is secured.

Challenges:

8. Is the level of knowledge high enough in the EU to be able to work with Integrated Advising at farm and catchment level?
9. Integrated Advising – are the authorities and the farmers ready to invest in this method in order to find targeted methods for the implementation of the WFD?

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AGWAPLAN web site: www.agwaplan.dk

Posters

Quo vadis, legislation on agro-environmental protection in the European Union? A Forum

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According to Webster's Dictionary, the description of "Union" is: "A uniting into a coherent and harmonious whole". The poster deals with the question whether the plant nutrition practice within the EU 27 countries fits to this description of "Union", or not. The answer to this question is distressing. Instead of a trend towards equalization in surface NP balances and soil NP status in the EU27 countries, a further and accelerated polarization has happened in the last 15 years resulting in severe environmental threats in some of the former EU15 countries, especially in Belgium and the Netherlands, and causing severe agronomic, social, and rural development problems in most of the new EU 12 countries. The Nitrates Directive seems to be ineffective in stopping the disadvantageous trends and converting them into the right direction.

There is a need for a paradigm shift in the EU agro-environmental protection legislation. Instead of speaking about it, agro-environmental protection, social, and rural development principles should gain real priority over the financial interests.

Vulnerability of water bodies to diffuse pollution in small islands: a hydrological perspective

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Eutrophication of water bodies, resulting from anthropogenic activities, is one of the most serious problems of degradation of their physical, chemical and biological quality. The complexity of the processes involved includes the strong effect caused by climatic, orographic and hydrological characteristics of the regions affected. The vulnerability of the natural resources in small islands increases our concern about the extent of the eutrophication problem in their water bodies.

In this work we will report about the situation in some of the surface water bodies in the Portuguese archipelago of Azores, located in the North Atlantic Ocean. This archipelago is included in the Macaronesian region together with Madeira (Portugal), Canary (Spain) and Cape Verde archipelagos. The Azores archipelago is formed by 9 small islands, with areas ranging from 17 to 747 Km^2. These islands are of volcanic origin and are characterized by very steep landscapes. In general, orography is responsible for significant climatic variations among and within the islands. The Azores is strongly influenced by its oceanic location; it is characterized by high precipitation and high humidity. Precipitation shows a prominent east-west gradient with substantially higher annual rainfall in the westerly islands. The freshwater (surface and aquifers) systems in the Macaronesian islands are unique due to their volcanic origin and oceanic setting, catchment morphology, storage processes, and the presence of distinct freshwater communities.

In the Azores some of the water bodies have or are suffering a process of eutrophication boosted by the existence of intensive agriculture practices, in particular those that result from increased livestock in recent years. Tourism industry is also increasing; in same cases, natural lagoons are the pole of attraction. The degradation of the water quality and subsequent changes in the aquatic ecosystems are of concern to the population and to the regional governmental agencies. To follow the evolution of this problem periodic monitoring campaigns are sought.

Effects of climate change will probably lead to adjustments in the global hydrological cycle, which could affect the distribution, availability and sustainability of regional water resources. Climate variability on seasonal to interannual time scales can cause changes in e.g. precipitation and air temperature. Characteristics of small islands that increase their vulnerability to these changes are, for example: their small physical size; limited natural resources (particularly freshwater resources); highly sensitive small economies; rapidly growing populations with high densities. These characteristics often limit the capacity of small islands to mitigate and adapt to future climate change and sea-level rise. With respect to eutrophication of fresh water bodies, all these issues have to be carefully taken into account when planning mitigation and remediation measures towards the sustainability of the lagoons in these islands.

The impact of soil erosion on the quality of groundwater as drinking water source in Perieni County

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The Romanian groundwater resources are about 11.5 billion m^3 /year but only 9.0 billion m^3 /year can be tehnically and economically used.
From the grounwater resources - 4.00 billion m^3 /year are provided from surface aquifers (depth of exploitable water layer is under 50 m), and 5.00 billion m^3 /year are provided by deep aquifers (depth of exploitable water layer is more than 50 m).
Romania's areas that are considered deficient in groundwater resources are located in central part of Dobrogea, Moldova and Transilvania Plateau. Groundwater is a good source of drinking water, as a result of natural clearing in the soil, especially in the first 90-120 cm from soil surface.
Since 1997, the Research and Development Center for Soil Erosion Control, Perieni, supervised the water quality, under the impact of soil erosion, in nine wells (as sources of drinking water) which are situated in Perieni area along a cross section through a hill. Determinations of pH, turbidity, nitrogen, phosphorus, sodium, potassium and chlorides contents have been made.
The results of analysis that have been carried out for ten years led to the following conclusions:
-The content of the analyzed elements are depended mainly with the location of wells on the hill, and only those wells located on the plateau are depended on the seasons;
- Water quality in wells located on the plateau are within the limits of STAS for "locale source category", excepting the nitrates;
- The quality of water wells on the slope and valley area do not fit within the requirements for local sources of drinking water in all the season. The contents of analyzed elements exceed the STAS limits: nitrogen with 71.1-854.8 ppm, potassium with 1.4-32.8 ppm and chlorides with 46.4-112.2 ppm.
- Higher concentrations of nitrate (28-19.2%) and potassium (12 to 18 times) have been determined on hill slope and valley area as compared with plateau area.

Artificial Rainfall Experiments on the Swiss Plateau to assess Phosphorus Losses from Soils and Manure

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Eutrophication of surface waters is still a big issue regarding the water quality of some lakes located within the Swiss Plateau. While Phosphorus (P) losses from point-sources could be reduced drastically, diffuse P losses from agricultural land became the major cause for eutrophication. Talking specifically about lake Baldegg, an intensive mitigation program implemented in the year 2000 already brought substantial progress regarding the P concentration within the lake. However, to design more efficient and cost-effective mitigation schemes to further reduce diffuse P losses, we see a need to localise critical source areas (CSA) within the catchment.
Lazzarotto (2005) developed a semi-distributed model to predict such critical source areas in the Lake Sempach region, which is located also in the Swiss Plateau. In general, the model results were promising but several questions arose regarding the respective roles of incidental P losses (IPL) and P losses from soil. To investigate those questions sprinkling experiments were carried out in summer 2008 in the catchment of Lake Baldegg in the Swiss Plateau. They were performed on two different sites with a relatively low and with high concentrations of P in the topsoil, respectively. On each site 8 runoff plots were installed and manure was applied on half of the plots, simulating band application technique. Artificial rainfall of deionized water was applied 1 day and 8 days after manure application to investigate the dependence of IPL on the time between manure application and the runoff event. With this setup it is possible to investigate and compare the influence of soil P status and manure on P losses with surface runoff. In addition, these experiments are used to improve the database for water soluble P (WSP_{soil}) in soils and the corresponding dissolved reactive P in runoff (DRP_{runoff}) for high soil P status.
The artificial rainfall experiments clearly show that high P concentrations in soil lead to high DRP concentrations in runoff, indicating a linear relationship between WSP_{soil} and DRP_{runoff} for unmanured plots. This linear relationship however, is different for different runoff types. Manure has an effect on P concentration in runoff for low and high-P soils. However, the manure P cannot override the effects of different soil P status. The effect of manure is more pronounced for soils with low P status. In addition, the performed experiments indicate that runoff type and manure application technique strongly influence P concentrations in surface runoff. Based on these findings we want to adapt the input functions of the model and improve some model components. Scenario analysis using the enhanced model will hopefully give us more insight on how to enhance present mitigation schemes.

A P Index-based mitigation planning tool for reducing phosphorus losses from land to water in Denmark

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Despite substantial abetment efforts during the past twenty years, phosphorus (P) loss from agricultural land to water is still a serious and costly environmental problem in Denmark. Therefore, environmental authorities demand tools for identifying critical source areas within catchments for targeting cost-effective mitigation measures. Phosphorus indexing tools can rank fields according to their relative risk of P loss and screen large areas because they operate with limited and generally available data. In Denmark a web-based tool has been developed that links the mapping of high risk areas of P loss to mitigation planning (www.np-risikokort.dk). This tool consists of three major parts: 1) a GIS component for viewing P Index maps and other relevant data, 2) a mitigation planning component for guided scenario analyses of selected field blocks in catchments and 3) a facility for downloading P index and scenario data. The Danish P Index tool operates at the field block scale, a mapping unit comprising several fields, and establishes separate P Indices for the transport processes soil erosion, surface runoff, matric leaching and macropore transport. The indices have been calculated *a priori* for all agricultural field blocks with a default set of input data, some of which can be changed by the user. Three risk classes of P loss are distinguished and the 10% highest P Index ranks for each transport process are considered high risk. Since the P Index tool cannot quantify P loss, each risk class has been associated with a representative P load for mitigation planning purposes. These loads are the basis for calculating the effects of a range of mitigation options. The estimated costs of various options are used for calculating the cost-effectiveness of mitigation plans. The user can either automatically have the tool select the best mitigation option for field blocks or he may choose individually. The P Index and mitigation planning tool is being tested by environmental authorities and its future use in Denmark is currently subject to political debate.

The effect of fertilization rate and proportion of arable land/grassland areas on nitrate concentration in the catchments of four drinking water reservoirs in the Czech Republic

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Agriculture in the Czech Republic underwent significant changes after 1990 with a drop in fertilizer and manure applications and, especially at piedmont areas, also with a shift in the use of farmland from ploughed areas towards permanent grassland areas or pastures. The aim of the study was to investigate causes of contrasting patterns of long-term changes in nitrate concentrations at the catchments of Švihov, Žlutice, Lučina, and Římov Reservoirs where either no change or significant decreases occurred. Apparently, the largest effect on the decrease of nitrate concentrations had the change from ploughed to grassland areas while the change in fertilization rates itself seemed to be ineffective.

Development of a Sustainable Nutrient Management Decision Support System for Ireland

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Current mitigation of N loss from agriculture in Ireland, implemented as law (SI378/2006) assumes a 35% N availability for spread slurry (rising to 40% in 2010) and has implemented so called 'calendar farming' designating periods when farmers are not permitted to spread. For many farmers achieving a 40% N use efficiency from slurry will be very difficult and since its implementation, closed periods for spreading have caused anomalous management practices. Research is currently underway to develop a sustainable nutrient management (SNM) decision support system (DSS) that will allow farmers to: (i) optimise spreading when storage is not a limiting factor (built on existing research into maximising N utilisation); (ii) spread in the 'safest' possible location on their farm when storage is limiting (forecast using a soil classification for each parcel of land); and (iii) spread at times that are meteorologically appropriate (i.e. when a transport vector between source and target is not very likely to be present). If the system can be shown to work reliably it may offer an alternative to the 'calendar farming' currently enshrined in law. The SNM-DSS uses a combination of farmer input and ongoing prediction of slurry accumulation to decide whether storage capacity is going to be exceeded. It provides advice to maximise N utilisation efficiency when storage is not limiting, and a soil moisture deficit model to predict when a transport vector is likely to be available when spreading is critical. Current efforts are focusing on: (i) integrating the model components; (ii) sourcing spatial data required for site specific implementation; (iii) further developing the soil water deficit model at the heart of the SNM-DSS; (iv) obtaining user input into the system design; and (v) testing the quality of systems forecasts with respect to the occurrence of the transport vector.

Multifunctionality, effectiveness and efficiency of a healthy human nutrition also in respect to the eutrophication of the hydrosphere

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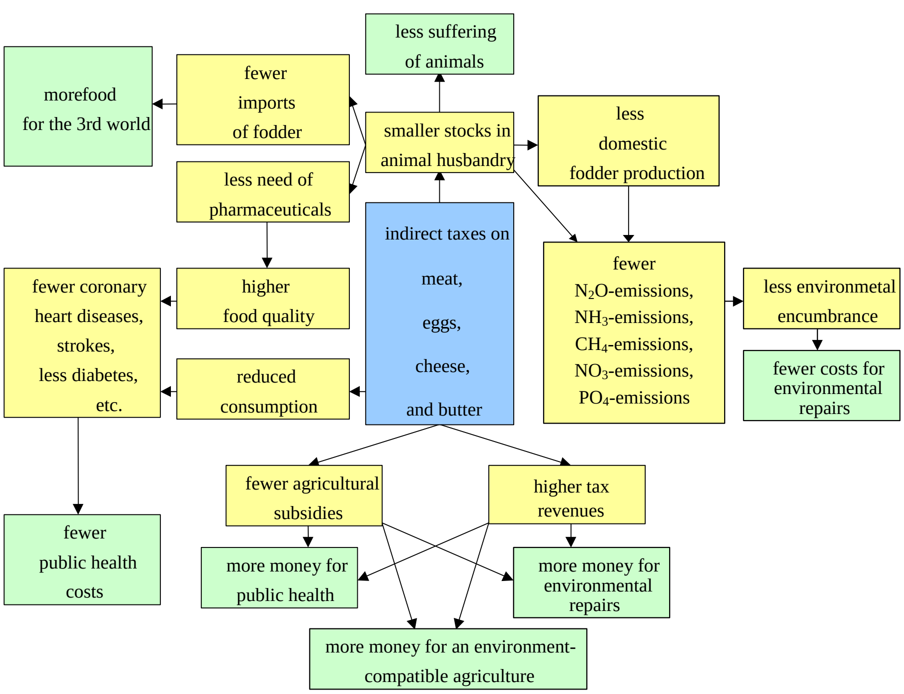
Taking the situation in Germany as an example, the nutrition system of agriculture, human nutrition as well as corresponding waste and waste water management contributes by emissions of reactive C, N, P, S to the total eutrophication 80%, acidification 40%, climate change 27%, decline of biosphere 80% and threatening of human health by over nutrition of 70%. Corresponding shares of a more than 2fold too high animal consumption and production are 70, 90, 70, 70 and 80% respectively. – Implemented in a first step by a value added tax (VAT) of 19% corresponding yearly to 20 billion € especially on animal food and give it back to the farmers (50 000 € $\cdot$ farmer^{-1} $\cdot$ yr^{-1}) as a return for a now fixed production system adjusted to sufficiency and sustainability, healthy human nutrition potentially and yearly:

a) Reduces all above mentioned environmental damages and overuse of mineral phosphorus by about -60%;
b) Reduces over nutrition illness costs of 120 Milliards €;
c) Economize 13 Milliards € subsidies for agriculture;
d) And so a win-win situation of (120-20+13=) 113 Milliards € exists with an efficiency of 100%.

No other mitigation option has those enormous positive without negative impacts. Fig. 1 shows both multifunctionality and the corresponding win-win situation of a healthy human nutrition.

Fig. 1 : Tax Levy Model for Animal Products to Relieve the Environment and Public Health (van der Ploeg 2002) (Re0715)



Mapping of "contributing areas" for diffuse water pollution - a study of feasibility

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Different field studies/investigations on diffuse water pollution indicate that losses of phosphorus, nitrogen, herbicides and sediments to surface water originate from a limited part of a catchment (contributing areas). Therefore, the pollution of water bodies could be effectively reduced by implementing mitigation options on these contributing areas. For that purpose, an accurate delineation of the locations of contributing areas is mandatory.

Contributing areas are characterized by site specific properties. To become a contributing area transport processes are necessary, the area has to be connected to the water system and the compounds of concern (e.g. pesticides, nutrients) materials have to be available for transport. For the spatially distributed prediction of contributing areas spatial information on topography, soil properties and climate condition are necessary.

The aim of this study is to investigate the practicability of the contributing area concept in the agricultural policy for the Swiss plateau. Based on literature studies, we will review the potential of the concept for the different substances (N, P, pesticides, sediments), examine potential predicting tools, analyze the availability of required input information and evaluate the reliability of the predictions. Furthermore, the agronomical consequences of the implementation of the contributing area concept are investigated for single farms.

Soil and plant indicators to minimize phosphate inputs in permanent grasslands

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Phosphate (P) losses to surface waters remain a major problem in many European agro-ecosystems supporting a high livestock density. Fertilization with animal manure based on nitrogen (N) demand results in excess P which accumulates in the grassland soils. Decreasing soil available P contents has been suggested as a measure to decrease P losses. However, because of the complexity of a permanent grassland ecosystem it is difficult to foresee how changes in P inputs will affect grassland productivity and soil P availability. The aim of the ongoing project is therefore to develop a set of soil and plant indicators to assess the effect of different P inputs on soil P availability, herbage production and on the fate of P in the environment.

We investigated six permanent grasslands at three locations in Switzerland in 2008 (Baldegg, Watt and Les Verriéres), which differ mainly in cutting regime and fertilization intensity, soil properties and local climate. Four grasslands in Baldegg are intensively managed by local farmers. The other two grassland sites are long term fertilizer experiments with lower cutting frequency and various rates of N, P or K fertilization. Plants were sampled on an area basis and separated in the three botanical fractions grasses, legumes and forbs. Nutrient concentrations were analyzed in above ground biomass and used to calculate the phosphorus nutrition index (PNI). Soil samples were taken in 0-5, 5-10, 10-20 and 20-40 cm depth. Plant available P was determined using anion exchange resins for P extraction. Subsequently available P was correlated to plant parameters such as yield and PNI, and to soil parameters like the degree of phosphorus saturation (DPS) as a measure for the risk of P losses to the environment.

At all locations P availability decreased with soil depth and augmented with increasing P input by fertilization. PNI as a plant indicator reflected the plant nutritional and soil P status. Still, differences in botanical composition need to be considered when interpreting the PNI because legumes have lower and forbs higher P concentrations in above ground plant tissue than grasses. With higher P fertilization the DPS increased, especially on soils with high accumulated P, and therefore indicated a higher risk of P losses from those grasslands. Using the specific P desorption factor (derived from a P33 exchange kinetic experiment) for DPS calculation seems adequate for field specific P loss risk assessment.

In conclusion we saw that even in little intensive managed grasslands relatively high yields were obtained, but with lower forage quality because of a late first cut. With management intensification the forage quality rises but also the risk of P losses to the environment. The investigated indicators can be used for a field specific risk and fertilization evaluation to improve grassland management and thus reduce P losses.

The Agmon lake-wetland complex: A Mediterranean example of land use change from farming to ecotourism

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The alteration of freshwater wetlands to farming have commonly resulted in higher loading of C, N, P and suspended material to downstream waterways. This alteration also induced rapid oxidation of organic matter and rapid peat soil subsidence and loss of soil fertility enhanced by the dry climate of the Mediterranean basin. To reverse some of the negative consequences of the drainage a reconstruction project was implemented in the mid 1990s which replaced the marginal farm land with shallow lake-wetland complex and enabled partial recolonization of the extinct wetland habitat while retaining the economic utilization of the land through a shift from conventional agriculture to ecotourism. The reconstruction project consists of reflooding of 1.1 km^2, rerouting and renewal of the entire drainage system, elevating groundwater levels (~ 0.6 m below surface) around the reflooded area and introducing native plant species and animals. Currently, the project aims at maintaining the economical viability of the farming and ecotourism industries, minimizing nutrient loadings to downstream water resources and conserving and studying the newly emerged ecosystem. Current research in this lake-wetland complex encompasses the biogeochemistry of nutrients, groundwater hydrogeology, agro-forestry along waterways, dynamics of terrestrial and aquatic plants, avian species behavior, nesting and diversity and economical aspects of ecotourism. Decadal monitoring program suggests that N loading to waterways has decreased significantly but P loadings may have slightly increased. The number of birds such as golden cranes, pelicans, cormorants, herons, kites and others has increased dramatically attracting large number of visitors providing a boost to the ecotourism industry and compensates for the loss of farm land. The huge flocks of the golden cranes (> 35000 individuals) descending on the lake-wetland complex and the nearby cultivated fields have created a major strain on the joint agro-eco-management of this area and necessitates a better sustainable solution in the future.

Land use and agricultural management effects on deep drainage and solute leaching

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We present tested a simplified method for the quantification of water and solute leaching and present some results of in-situ measurements.
Some techniques of monitoring the quantity and quality of soil water flow below the root zone are capable. Commonly, lysimeters are applied for measuring drainage fluxes and solute leaching. Costs are high and results may be biased due to typical “lysimeter errors”. Hydrological field measurements may provide an alternative. The aim of the paper was to test this under lysimeter and field conditions.
Soil water content and tension below the rootzone are important hydrologic variables that control leaching processes. Soil water content and tension measurements down to 3 m depth and soil water sampling were used to determine deep drainage dynamics and loss of nitrogen by leaching. The method of quantifying deep drainage rates based on soil hydrological measurements was tested in comparison with lysimeter discharge measurements from 2001 till 2008. Deep drainage rates and nitrate losses of forest, grass fallow and arable land managed under various farming regimes (integrated, integrated with irrigation, ecologic and low input) and tillage systems (plough and no till) were quantified in the Pleistocene region of Northeast Germany from 1994 to 2007.
Results confirmed the reliablity of the simplified method on sandy soils of a deep water table. Willmott’s index of agreement was d = 0.97 revealing the validity of this approach. Results underline the hypothesis of the well-balanced, slow and continuous progression of the soil water content below the root zone.
The field study revealed lowest annual leaching rates were measured at forest sites (0.9 kg ha^{-1}) and under grass fallow (1.7 kg ha^{-1}). They were higher under cropping. In dependence on annual deep drainage rates between 100 mm and 200 mm during the study period, nitrogen loss varied between 14 and 41 kg ha^{-1}. Nitrate concentration varied between 40 and 150 mg l^{-1}. This could be explained by different crop yields of management systems and irrigation effects. No-till treatment resulted in reduced nitrate leaching (18 kg ha^{-1}) as compared with the tillage system with plough and tooth cultivator (27 kg ha^{-1}).
It may be concluded, that in-situ measurement of deep drainage dynamics and solute leaching for quantifying arable management effects on ecological processes may be a proper method on many sites.

Drainage and groundwater quality change after construction of manure storage in the demonstration cow farm

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Drainage and ground water quality change in the territory of large cow barn after construction of manure pad and slurry reservoir has been analysed in the demonstration farm in Lithuania. It was determined that nutrient leaching from the territory of the cow barn has decreased substantially after construction of manure storage. The results of the water quality measurements have been successfully used for calculation of nitrogen and phosphorus type specific concentration and load to surface and ground waters per animal unit with proper installed manure storage and without.

Agricultural measures to restore the Swiss midland lakes (Sempach, Baldegg, Hallwil)

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After the remediation of the municipal sewage the main part of the phosphorus load, which pollutes the lakes (lake of Sempach, Baldegg and Hallwil), originates from agricultural areas in the catchment areas of the lakes. Since 1999 measures to reduce the phosphorus load from agricultural areas are subsidised by the Swiss government within the ordinance of water protection. This program is based on a voluntary participation of the farmers under the charge of the department of agriculture and forest in collaboration with the department of environment and energy of the canton Lucerne.

The main measures of the program are: Limited phosphorus fertilisation according to soil-P- analyses, buffer-strips on waterways, no manure application and no open soils during wintertime, direct sawing of corn and cereals, improving of drainage systems and infrastructure on farm yards. Furthermore the closedown of swine and poultry units, alternatives in production and the building of retention ponds are subsidised.

In 2008 78% of the agricultural surfaces in the catchment area of the lakes were cultivated according to the Phosphorus-Project with a total of 573 farms (72%). A total of 5.7 mio. SFr./year has been paid to compensate for lower yield and bigger efforts. 78 % of this amount is financed by the Swiss government and 22% by the canton of Lucerne. This compensation corresponds to 500 Euros/ha.

Artificial mixing in winter and the hypolimnetic oxygenation in summer are still applied. In the lake of Sempach air is used for the oxygenation, in the other two lakes pure oxygen. The department of environment and energy is responsible for the monitoring regarding the phosphorus content in the lakes. Within the last years the average phosphorus content has decreased very rapidly and is now in the lake of Sempach and Baldegg at 26 mg/m^3 and in the lake of Hallwil at 20 mg/m^3. The target value of 4 mg oxygen per litre at any time and any depth of the lake could be reached, except for some short periods. However the aim of natural spawn whitefish is not yet achieved. As can be seen, important steps for improvement of the lakes have been taken. Long term measures, however, are necessary in order to maintain the healthy condition of the lake

The project of restoring the Swiss midland lakes is a good example of teamwork between politicians, communities, authorities, researchers and the inhabitants of the catchment area. Thanks to the contribution of all these peoples, it is clearly visible, that the condition of the lakes is much better than it was 25 years ago.

Focus on phosphorus (P) at catchment level in Sweden

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A pilot project *Focus on Phosphorus* started in 2007 as part of the advisory campaign *Focus on Nutrients.* It aims to involve farmers in finding the most effective countermeasures against phosphorus (P) losses by testing established and experimental practices. The project is being carried out in three agricultural catchments with clay soils (470-750 ha) in southern and central Sweden. In a local working team, farmers, advisors and researchers discuss the topic on catchment scale. The farmers participate voluntarily and they are not obliged to follow any recommendations emerging from the project. Advice is given on fertilisation and nutrient balances, tillage practices, animal nutrition, livestock housing, manure storage, buffer strips along streams and wetlands.
In one of the selected catchments, in the county of Östergötland, poorly functioning and old drainage systems and surface ponding of fields were identified as being part of the problem. Systematic advice on drainage has therefore been given to all farmers. A total of 9 fields have been identified as being an important source of P transport, based on P soil content and studies of P sorption/desorption. In addition, at least 10 fields, or parts of fields, have been identified as being at high risk of high P transport to recipients, based on studies of the tile drainage systems and water movements within the soil. Independent on the project, farmers have tested countermeasures such as reduced tillage, direct drilling in autumn, and liming with sewage sludge or industrial lime products. However, they have re-cultivated some buffer strips along the streams, since subsidies for these have been reduced. To date, very few other countermeasures against P losses have been implemented in practice.

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COST Action 869, Working Group 4:

Evaluation of projects in example areas:
The Swiss Midland Lakes.

June 24 - 26, 2009, Nottwil (CH)

Excursion Program

Thursday 25 June 2009

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Lake Sempach

The 87 m deep Lake Sempach, with a surface area of 14.4 km^2 and a drainage basin area of 62 km^2, has been artificially aerated since 1984. Already in 1936 the lake exhibited anaerobic conditions in the deep sediments. Starting 1950 the lake was polluted by untreated sewage from settlements and industry. About 1965, intensive farming and high animal stocking have caused an additional phosphorus loading. The history of eutrophication is illustrated by sediment analysis and in addition by chemical analysis of phosphorus and nitrogen since 1950.

It soon became evident that agriculture also played a great role in the problem of eutrophication of the lake. Farmers found this reasoning extremely hard to accept as they had up till then been of the conviction that phosphorus is well bound to soil and can hardly be washed away.

Up to then little experience existed of how to deal with the problem of eutrophication of lakes; therefore small steps had to be taken in order to find a solution to this kind of problem. The main challenge was and remains up to now, reconciling agriculture and a healthy lake.

A first major step (1985) in this process was the establishment of the Ecological Agency which was charged with the task of sensitizing the farmers by consulting them and informing them of the problems of the lake. The crucial point was that the consulting was done by the agricultural department and therefore they had to finally face this problem and deal with it from within.

A second step (1986) was establishing a zone around the lake where it was prohibited to use fertilizers. This had a great impact on the whole surrounding area because it demonstrated the seriousness of the authorities when it came to taking measures for the improvement of the lake. It also laid the groundwork for the natural protection zone around the lake because the non fertilized zones were later turned into natural habitat zones.

These two steps were followed by a period of research into the possible reasons why and how phosphorus kept creeping into the lake. This research was only possible thanks to the assistance of the Federal Research Institute Agroscope FAL, the Federal Institute of Technology in Zurich (ETH) and several other tertiary institutes. Various research projects have resulted in the fact that the Lake Sempach is probably one of the best documented areas, concerning phosphorus, in Europe.

With the phosphorus project, which was only possible thanks to the support of the Swiss Federal Office for Agriculture (BLW) and the Swiss Agency for the Environment, Forests and Landscape (BAFU) and the strict limitation of phosphorus input in the area, the crucial tools are now in place to bring the lake on the path to restoration. As can be seen, therefore, in this time, important steps for improvement have been taken. Long term measures, however, are extremely necessary in order to maintain the healthy condition of the lake.

The reaction of Lake Sempach to applied water protection measures has been described in detail with the help of physical, chemical, biological and sedimentological investigations. With the combination of external and lake internal measures the concentration of phosphorus has decreased from 160 to 26 mg P/m^3 during the period 1984 to 2009. The target value of at least 4 mg of oxygen per liter at any time and any depth in the lake was reached by artificial aeration. Species diversity of phytoplankton increased and the water became clearer, which enabled better growth of macrophytes along the lakeshore. Benthic animals such as worms (*Oligochaeta*) and insect larvae (*Chironomidae*) were able to live at greater depths and caused bioturbation and better mineralisation of the sediments.

Long-term investigations of the annual phosphorus input from tributaries and from treated and untreated sewage show that at present 70% of the annual phosphorus load into the lake originates from over-fertilized agricultural land. The present annual phosphorus loading for the period 1998 to 2003 is 24 tons of total phosphorus and 4.6 tons of soluble phosphorus respectively. The critical loading for Lake Sempach is assumed to be about 4.7 of soluble phosphorus per year. The high value of 20 tons particulate P per year shows a high erosion of fine material from agricultural land.

The project of restoring the Lake Sempach is a good example of teamwork between politicians, communities, authorities, researchers and the inhabitants of the surrounding area. Thanks to the contribution from all these people, it is clearly visible that the condition of the lake is much better than it was 25 years ago.

Program of field visits 25 June 09, 08.30 AM to 14.00 PM

Farm	**Farm 1: Joe and Edith Ineichen, Sonnhof 6204 Sempach**	**Farm 2: Hans-Peter and Beatrice Fleischlin, Schlachthof 6204 Sempach**	**Farm 3: Franz and Marianne Rösli, Wartensee 6203 Sempach-Station**	
Topic	Water retention Puffer stripes	Phosphorus Project P-Balance	Direct Sawing	Lunch
Guide	Josef Blum, AgroEcoConsult	Franz Stadelmann, lawa	Farmers of farms 1-3 Wolfgang Sturny, Bodenschutzfachstelle Kt. Bern	
Group A	08.45-10.15	10.30-11.30	12.00-13.30	
Group B	10.15-11.45	09.00-10.00	12.00-13.30	

Farm profile Joe and Edith Ineichen-Bieri, 3 kids

Sonnhof, 6204 Sempach

Age of farmer	47
Side job	Korporationsrat (35 %)
Employee	Agriculture worker 8 m/y

Climate	
Altitude / Precipitation / Average temperature	510 amsl / 1'100 mm / 8.8 ° C

Crops		acreage (ha)	yield (dt/ha)
Arable crop	Winter wheat	1.81	60
	Spelt	1.22	50
	Corn, Silage	2.71	180
	Buntbrache *	0.51	
Forage	Natural meadow	8.93	120
	Seeded meadow	4.19	127
	Extensively managed meadow	2.29	30
	Pasture	1.12	75
	Hedge	0.22	
Fruit	Apple orchard	0.32	
Agricultural area in use		23.32	
Fertilised agricultural area		20.30	
Forest		3.12	

*an ecological compensation area

Livestock	Number	
Fattening calf	98	
Dairy cow	44	300'000 kg / year
Fattening pig	175	
Sheep	10	
Layer	5	
Animal Dung Unit (ADU)*	73.5	

* Animal Dung Unit of nutrients 105 kg N and 15 kg P

Nutrient balance	ADU *	
Total on farm	73.5	
Export	- 23.5	
Corrected to export	50.0	
ADU / fertilised agricultural area	2.5	

Phosphorus balance	P_20_5 [kg]	%
Input animal manure	2'558	126
Demand of plant production	2'025	100
Export of animal dung	- 851	- 42
Import of mineral fertiliser	+ 8	
Balance	**- 310**	**85**
Requirement of P Project (according to soil P-test)		**88**

Farm profile Hans-Peter and Beatrice Fleischlin-Gloor, 2 kids

Schlachthof, 6204 Sempach

Age of farmer 45
Side job agricultural service supply agent (40 %)

Climate	
Altitude / Precipitation / Average temperature	657 amsl / 1'100 mm / 8.8 ° C

Crops		**acreage (ha)**	**yield (dt/ha)**
Arable crop	Winter wheat	3.80	70
	Spelt	2.61	50
	Corn, Silage	8.00	170
	Rapeseed	2.60	35
Forage	Natural meadow	0.50	120
	Seeded meadow	7.30	115
	Extensively managed meadow	2.06	30
Fruit	Apple orchard	2.70	
	Plum orchard	0.30	
Agricultural area in use		29.88	
Fertilised agricultural area		27.82	
Forest		1.50	

*an ecological compensation area

Livestock	**Number**	
Beef	65	
Fattening calf	50	
Horse	2	
Animal Dung Unit (ADU)*	42.5	

* Animal Dung Unit of nutrients 105 kg N and 15 kg P

Nutrient balance	**ADU ***	
Total on farm	42.4	
Import	+ 14.3	
Corrected to import	57.0	
ADU / fertilised agricultural area	2.0	

Phosphorus balance	**P_20_5 [kg]**	**%**
Input animal manure	1'496	56
Demand of plant production	2'655	100
Import of animal dung	+ 477	+ 18
Balance	**- 685**	**74**
Requirement of P Project (according to soil P-test)		**80**

Farm profile Franz and Marianne Rösli-Jurt, 3 kids

Wartensee, 6203 Sempach-Station

Age of farmer	48
Side job	agricultural service supply agent (60 %)

Climate	
Altitude / Precipitation / Average temperature	559 amsl / 1'100 mm / 8.8 ° C

Crops		acreage (ha)	yield (dt/ha)
Arable crop	Winter wheat	6.40	65
	Spelt	7.70	50
	Rapeseed	6.35	40
	Horse bean	6.40	40
Forage	Natural meadow	4.65	45
	Extensively managed meadow	2.89	20
Agricultural area in use		34.39	
Fertilised agricultural area		31.50	
Forest		8.41	

*an ecological compensation area

Livestock	Number	
Layer	20	
Goose	8	
Animal Dung Unit (ADU)*	1.5	

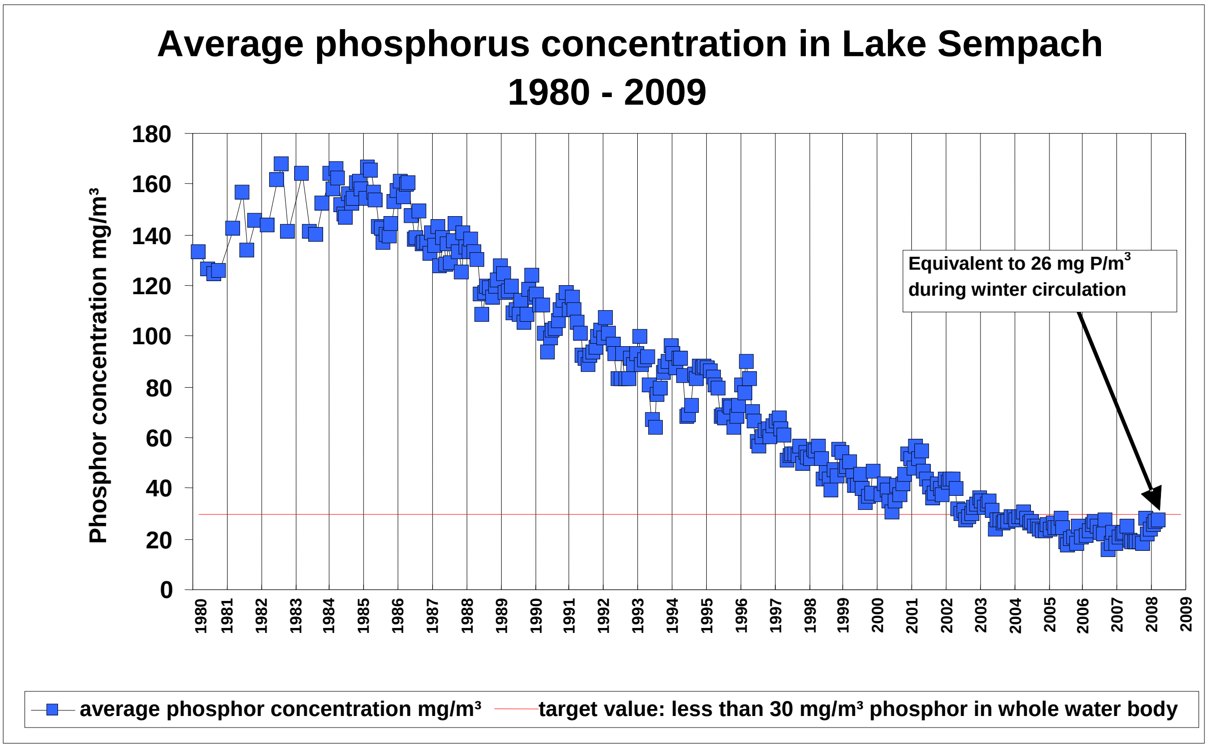
* Animal Dung Unit of nutrients 105 kg N and 15 kg P

Nutrient balance	ADU *	
Total on farm	1.5	
Import	+ 20.5	
Corrected to import	22.0	
ADU / fertilised agricultural area	0.7	

Phosphorus balance	$P_2 0_5$ [kg]	%
Input animal manure	54	3
Demand of plant production	1'825	100
Import of animal dung	+ 716	+ 39
Import of mineral fertiliser	+ 652	+ 36
Balance	**- 403**	**78**
Requirement of P Project (according to soil P-test)		**99**

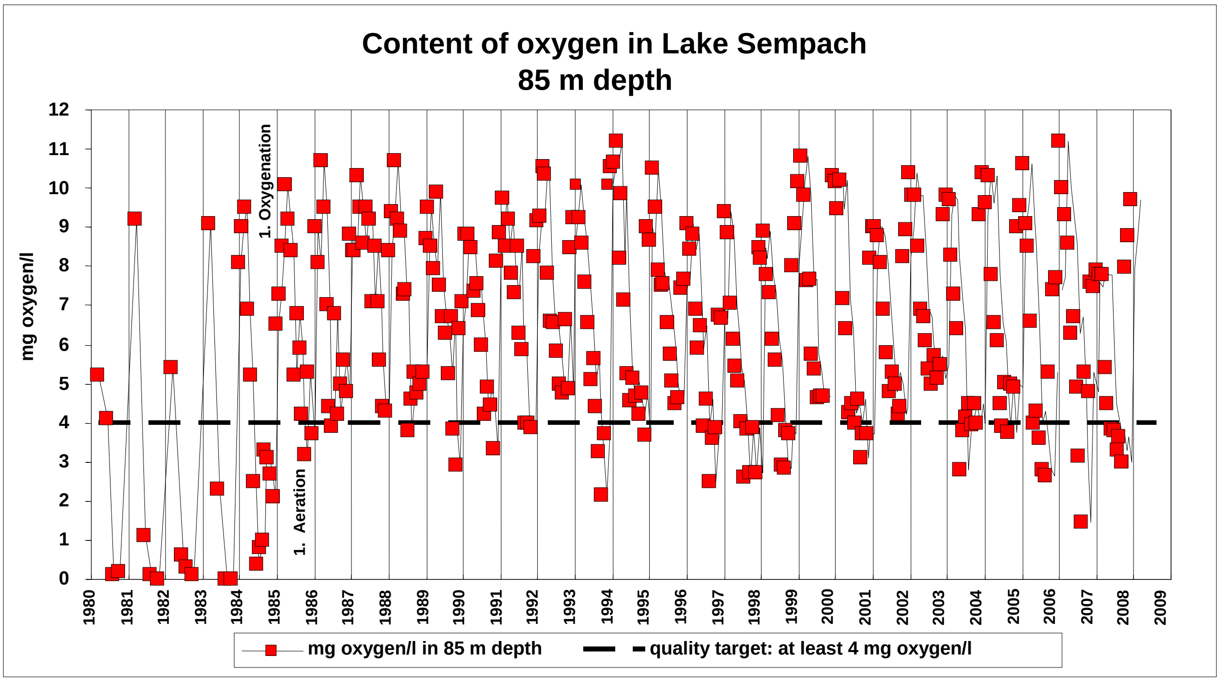
Lake Sempach in 2008/2009, according to Environmental Agency (uwe), Lucerne

In spring of 2009 the phosphorus concentration of the Lake Sempach lays by 26 mg/m^3. The target value of maximal 30 mg P/m^3 could be met during the last 6 years.

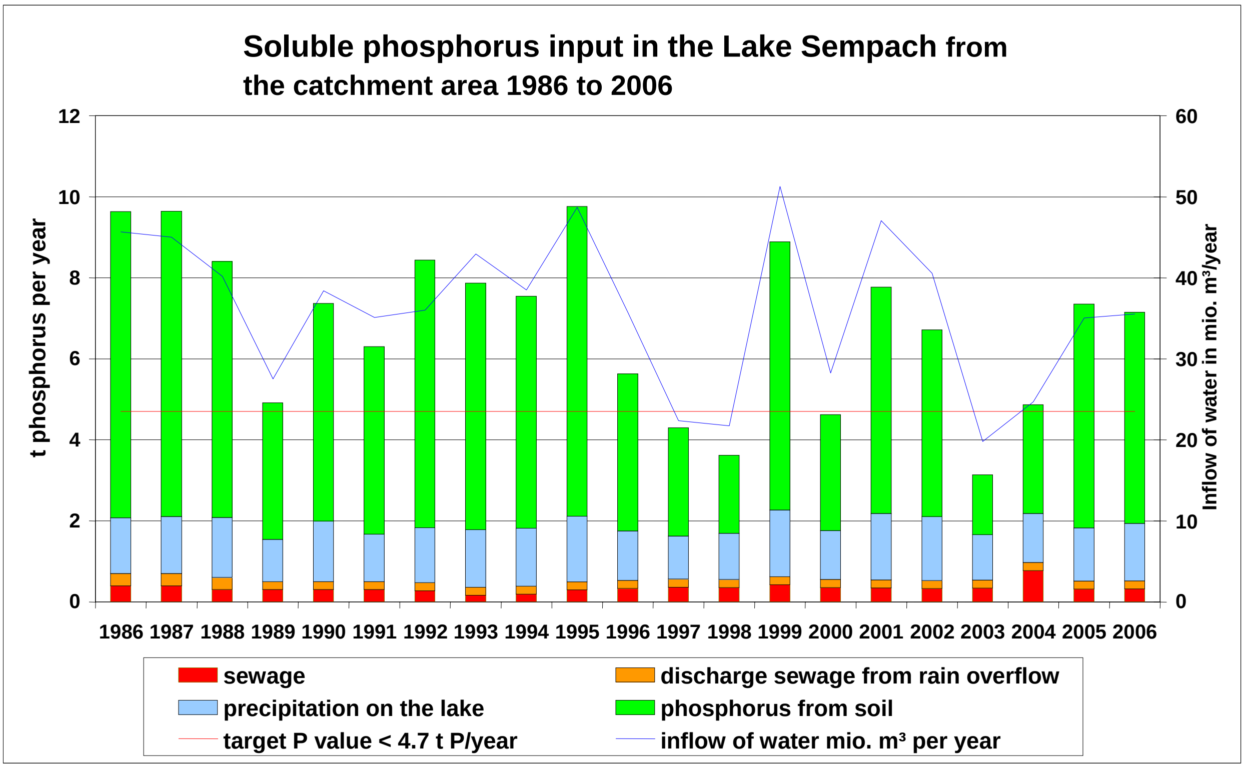


The content of oxygen on the bottom of the lake in a depth of 85 m was as good as it has not been for several years. Only in august 2008 it fell shortly little below the target value of 4 mg/l. During the rest of the year, the target value could be reached, thanks to the aeration with about 90 tons of oxygen per year. This is much less than in the first years of the restoration. 1986 a total of 589 t of oxygen was pumped into the lake.

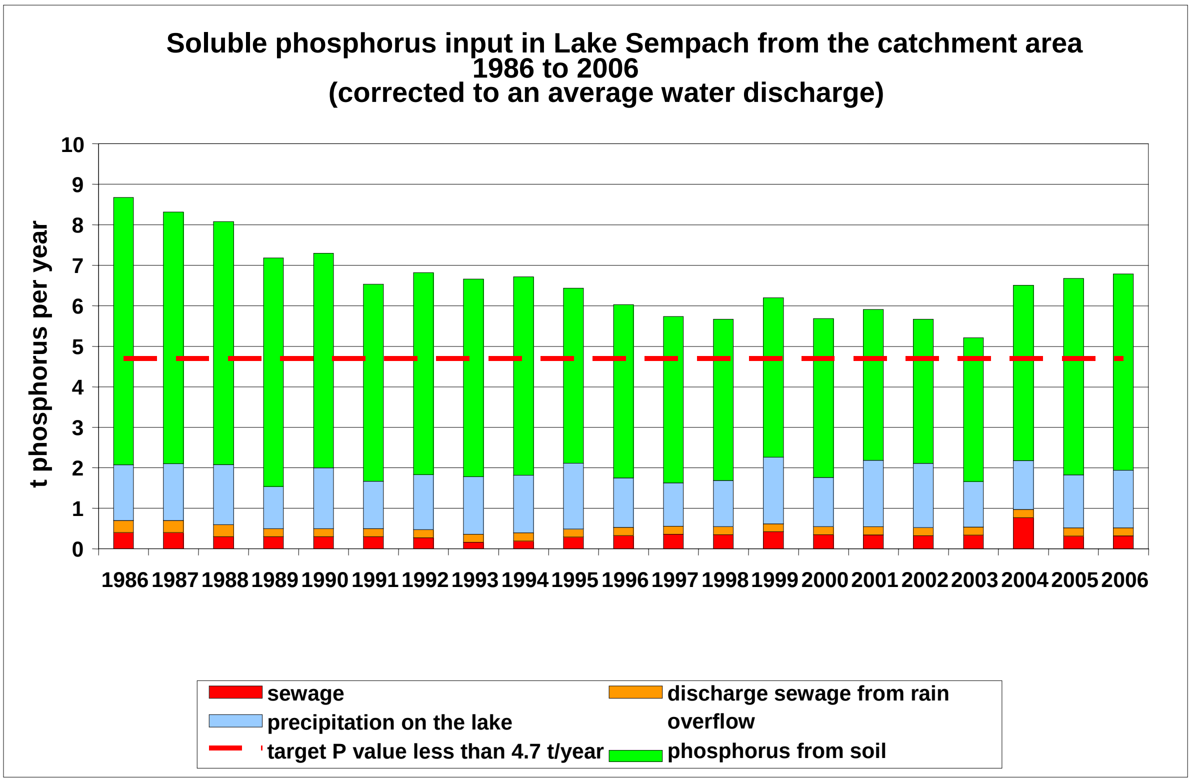
By the current phosphorus concentration of about 26 mg /m^3 the production of algae biomass is still too high. Therefore the requirement of oxygen must be covered by artificial aeration.



Up to the year of 2003 the input of soluble phosphorus from the catchment area could be reduced. In the dry year of 2003 the lowest value since 1986 could be reached. Since 2003 the input increased again according to the inflow of water. The input of phosphorus was above the target value.



The input of soluble phosphor corrected to an average water discharge shows also an increase of the phosphorus input since 2004, compared to 2003. This corresponds to an average input of 0.7 to 0.8 kg soluble P per ha and year.



www.sempachersee.ch

SEMPACH LU: «Cost Action» – Informationsaustausch unter Wissenschaftern

Den Nährstoffen auf der Spur

Zu viel Phosphor in den Gewässern ist nicht nur im Schweizer Mittelland ein Problem. Forscher aus ganz Europa trafen sich, um am nährstoffbelasteten Sempachersee Lösungsansätze vorzustellen und zu diskutieren.

ROSMARIE BRUNNER-ZÜRCHER

Die Phosphorbelastung des Sempachersees soll weiter sinken *(Bild: bru)*

Das grosse Fischsterben kam 1984. Daran erinnert sich Joe Ineichen, heute 47, noch gut: «Ich war grad in der Ausbildung, und dieses Ereignis hat mich geprägt», sagt er während der Führung auf seinem Hof in Sempach. Ineichen ist einer von gut 570 Bauern im Einzugsgebiet des Sempacher-, des Baldegger- und des Hallwilersees, der beim so genannten P-Projekt des Kantons Luzern mitmacht. P steht für Phosphor; dieser Nährstoff ist neben Nitrat einer der Hauptverantwortlichen für die Verschmutzung des Seewassers.

Phosphor-Teich

Seit zehn Jahren versucht der Kanton Luzern mit verschiedenen Methoden, den Phosphorgehalt des Sees zu senken. Auf Ineichens Hof zeigte Josef Blum von der AgroEcoConsult eine dieser Massnahmen: Einen extra ausgehobenen Teich, in dem Phosphor zurückgehalten wird.

Bei optimalen Bedingungen, das heisst, wenn das Wasser aus dem 20-ha-Einzugsgebiet des Hofes von Ineichen sieben bis zehn Tage im Teich bleibt, werden 50 Prozent des Phosphors zurückgehalten. Übers Jahr gesehen sind es durchschnittlich 23 Prozent oder rund 5 von 22 Kilo reinem Phosphor.

Schaut man sich die Kosten an, ist diese Methode laut Blum relativ teuer, zwischen 500 bis 1000 Franken kommt das Kilo zu stehen. Alle fünf Jahre muss der Teich ausgebaggert werden. Der Aufwand wird durch das P-Projekt entschädigt – so wie andere Auflagen, die von den mitmachenden 72 % Bauern rund um die drei Seen erfüllt werden.

Obst und Drainagen

Hans-Peter Fleischlin auf dem Schlachthof in Sempach hat auf seinem Betrieb nicht viel umstellen müssen, um diese Auflagen zu erfüllen. Im Gegensatz zu Ineichen hat er mit seinen 66 QM-Mastrindern auf 30 Hektaren keine intensive Tierproduktion und darf sogar Dünger zuführen. Auf dem Schlachthof werden gemäss dem P-Projekt unter anderem Mais und Getreide direkt gesät, die Drainagen verbessert, alternative Kulturen wie Obst angebaut.

PROJEKT COST ACTION

Cost Action ist ein EU-Forschungsprogramm, das Wissenschaftern aus ganz Europa den Austausch über landwirtschaftliche Themen ermöglicht. Die Gruppe 4 der Cost Action befasst sich insbesondere mit der Nährstoffproblematik. In einem drei Tage dauernden Symposium tauschten die Forscher dieser Gruppe von Mittwoch bis Freitag in Sempach ihre Ergebnisse aus. *bru*

Direktsaat

Gänzlich ohne Tiere funktioniert seit Jahren der Hof von Franz Rösli. Er hat 1997 auf Direktsaat umgestellt und baut heute ausschliesslich Raps, Ackerbohnen, Dinkel und Weizen an. Da die Direktsaat durch das P-Projekt unterstützt wird, kann Rösli die teure Maschine als Lohnunternehmer gut auslasten.

Weniger Geld im Ausland

Für die teilnehmenden Forscher waren die Ansätze der Schweizer Kollegen sehr interessant. «Bei uns in Dänemark sind die Verhältnisse anders», sagte zum Beispiel Irene Asta Wiborg, Beraterin beim Dänischen Landwirtschaftsdienst. «Wir haben finanziell weniger Spielraum, um umweltschonende Massnahmen umzusetzen. Deshalb müssen wir viel mehr auf den Konsens mit den Bauern setzen und das intensive Gespräch suchen.»

Anuschka Heeb vom Landwirtschaftlichen Beratungsdienst Östergötland in Schweden bestätigt, dass die Unterschiede zwischen den Ländern gross sind. «Massnahmen wie diese hier können nicht eins zu eins übernommen werden, doch es geht darum, neue und vielleicht ungewöhnliche Ideen zu sammeln», sagt sie.

P-Projekt geht weiter

Die aktuelle Phase des P-Projekts des Kantons Luzern läuft Ende 2010 aus, doch es soll für weitere sechs Jahre fortgesetzt werden. Wie die konkrete Umsetzung aussehen wird, kann Franz Stadelmann vom Amt für Landwirtschaft und Wald des Kantons Luzern noch nicht sagen. «Wir werden Anpassungen vornehmen müssen, auch wegen der AP2011», erklärt er während der Führung durch die Betriebe. Sicher ist, dass Phosphor auch nach diesen sechs Jahren im intensiv genutzten Gebiet rund um die drei Seen weiter ein Thema sein wird.