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Nutrient load assessment from agriculture in the Leningrad Oblast

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Content

Preface

The project ”Monitoring and assessment of nutrient loads from agriculture in the Leningrad Oblast” was carried out in 2006. The main objective of the project has been training and capacity building, directed towards participants from the Reference Center of Rosselhoznadzor, RosHydromet and the Committee of Natural Resources in the Leningrad Oblast.

The project leader has been Johannes Deelstra, Soil and Environment Division, Bioforsk. Other participants from Bioforsk were Heidi Grønsten and Adam Paruch.

The project was carried out both in Estonia and Norway. In Estonia, the project focussed on the practical aspects related to the operation and maintenance of monitoring stations. The main partner in Estonia was Arvo Iital, Institute of Environmental Engineering, Tallinn University of Technology.

The second part of the project was carried out in Norway and focussed on the design and operation of monitoring stations, water sampling routines collection of secondary data and the interaction with farmer extension services. The project was terminated by a seminar, including participants from Sweden, Finland, Leningrad Oblast, Estonia, Latvia, Kaliningrad and Norway and covered aspects related to monitoring and assessment of nutrient loads from agricultural dominated catchments, scales issues, data analysis, nutrient modelling and good agricultural practices as practiced in the Baltic and Scandinavian countries.

This report has been written by Johannes Deelstra, Arvo Iital, Heidi Grønsten and Adam Paruch.

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Summary

The main objective of the project" Monitoring and assessment of nutrient loads from agriculture in the Leningrad Oblast" has been to carry out a programme for training and capacity building in both Estonia and Norway. Both countries have been actively involved in the implementation of harmonised methods in projects related to agriculture and nutrient pollution of the Baltic Sea.

The project concluded the following;

- Monitoring methods from agricultural dominated catchments in the Leningrad Oblast should be in line with those applied in the Baltic - and Scandinavian countries and be implemented at a newly established monitoring station in the Leningrad Oblast.
- Exchange of knowledge between experts from the Leningrad Oblast, Estonia and Norway in the operation, management and reporting of monitoring results should continue.
- Monitoring systems in the Leningrad Oblast should include different land use systems and be established at different scales. Contacts with Estonia and Norway, but also Latvia are proposed to initiate such systems.
- Exchange of experiences related the laboratory methodologies showed to be necessary and should continue.
- Point source pollution can be an important source of nutrients to open water systems and groundwater. A pilot project for the ecological treatment of sewage runoff should be considered.
- The necessity of a close linkage between monitoring programmes, extension services and farmer organization in obtaining improved water quality was clearly demonstrated in the project.
- The establishment of a network in the field of monitoring and assessment of nutrient losses from agricultural dominated catchments between researchers from Leningrad Oblast, Baltic and Scandinavian countries has given promising results and should continue.

1. Introduction

The Baltic Sea is an ecosystem under severe stress, and actions are needed to ensure its sustainable development. Agriculture contributes a significant portion of the nutrient losses to the environment, being to a large degree responsible for the eutrophication of inland surface waters and coastal zones in the Nordic and Baltic countries (Stålnacke 1996, HELCOM, 2004). In the quantification of nutrient losses, common methods have been used in the Scandinavian countries. Since the beginning of the 1990's, similar methods were introduced in the Baltic countries through joint projects between Scandinavian and Baltic countries. A main component in the co-operation has always been capacity – and institutional building. Many projects were carried out in close cooperation between the Swedish Agricultural University (SLU) and Bioforsk, Norway. Bioforsk has been responsible for the design of the monitoring and nutrient assessment component in the Baltic Sea Regional Project (BSRP), financed by the World Bank/GEF and executed in Estonia, Latvia, Lithuania and the Kaliningrad region. Because of its experience in monitoring and assessment of nutrient loss from agriculture, Bioforsk was invited to take part in the project "AELO - Agriculture and Environment in the Leningrad Oblast", carried out by Reference Center of Rosselhoznadzor (FGU; previously CAS - Central Agrochemical Service, Pushkin) in cooperation with Niras AB (formerly Scanagri Sweden). From the beginning, an important aspect in the AELO - project has been the quantification of nutrient loss from agricultural dominated catchments. The AELO-project initiated a monitoring programme which resulted in the construction of a monitoring station in the Suida catchment in the Leningrad Oblast. The station was constructed in line with those used in the Baltic and Scandinavian countries. To guarantee proper operation of the monitoring activities in the Leningrad Oblast, the idea to initiate a project for training and capacity building in the operation and management evolved.

Funds for were granted by the Nordic Council of Ministers (NCM) to carry out such a project in both Estonia and Norway. From Leningrad Oblast, the Reference Center of Rosselhoznadzor, RosHydromet and the Committee of Natural Resources participated in the project. The lead partner of the project was Bioforsk, Norway. In Estonia, the main partner in the project has been the Institute of Environmental Engineering, Tallinn University of Technology (TUT).

During the first part of the project, representatives from the FGU (Yulia Razumovskaya, Vitali Dvurechenskiy, Irina Korolenka and

Yuri Khomyakov) visited Estonia. It was anticipated that in a follow up to the AELO – project, the monitoring and assessment of nutrient loss from agricultural dominated catchments in the Leningrad Oblast jointly would be carried out by the Leningrad Reference Centre (FGU) and the Leningrad Regional Centre on Hydrometeorology and monitoring of the environment (RosHydromet). Therefore, during the second part of the project, representatives from FGU (Alexander Pertsovic, Valentina Soboleva) and RosHydromet (Yuri Malashin) in addition the Vice Head of the Committee of Natural Resources (Boris Prokhorov) visited Bioforsk – Norway. Also Natalia Schagina (HydroMet/Kaliningrad) and Natalia Haluk, (LIU, BSRP/Kaliningrad) visited Norway.

In both Estonia and Norway, the participants were presented with several aspects in monitoring and assessment including;

- design of monitoring stations and water sampling routines
- operation and management and data quality control
- analysis methods for soil and water samples, their interpretation and use in farm management
- data analysis including trend analysis and modelling
- collection and use of farm management, including nutrient budgets at farm and catchment level
- root zone nitrate leaching and experimental plot layout
- nutrient losses reduction through vegetation ponds
- interaction between monitoring programmes, extension services for farmers and agricultural education
- soil mapping and its application
- ecological treatment systems for diffuse and points source pollution

The programme was terminated in Norway with a seminar, included additional participants from Sweden, Finland, Estonia and Latvia.

2. Monitoring and assessment of nutrient losses

The objective of a monitoring programme is to provide data on nutrient loss from representative agricultural areas, in order to support national authorities in their development of sustainable agricultural production systems and to meet the data requirement for the reporting to various regional and international organisations (e.g HELCOM, EU, OECD). Therefore, in addition to the specific national needs, a monitoring programme will have a regional perspective. Furthermore, in designing a monitoring programme it is important to consider its “sustainability”, i.e. the proposed activities should not be extravagant with regard to future capacities. One way to enhance this sustainability is to design monitoring programmes that are both suitable and attractive for research and educational purposes. For these reasons it is also important that the applied measuring methods and procedures are sufficiently advanced to comply with international scientific standards. An important secondary objective of monitoring programmes is to demonstrate the efficiency of different nutrient reduction measures to land owners.

The monitoring system to be implemented in the Leningrad Oblast, complies with the methodologies applied in the riparian countries to the Baltic Sea. The backbone of monitoring and assessment of nutrient loss from agricultural dominated catchments is the measurement of discharge in combination with water sampling. However, a number of additional measurements should be carried out to be able to interpret, analyse and report on the measured nutrient loss and include among others climatological data, soil data and information on farming practices in the catchments.

2.1 Discharge measurement

Discharge measurements in small agricultural catchments in the Leningrad Oblast should preferably comply with the methods as applied in most Scandinavian and Baltic countries. In most cases discharges are measured using fixed discharge measurement structures in those countries. The advantage such structures is the availability of a readily available stage - discharge relation, expressing the relation between the water level measured upstream from the measuring structure and its discharge.
During the training and capacity period in both Estonia and Norway, a significant amount of attention was paid to the design, management and

operation of the discharge measurement systems. In Estonia, the Rägina and Jänejögi monitoring stations were visited while in Norway the Skuterud and Mørdre station were visited. Those monitoring stations form part of the national programmes to quantify nutrient and soil loss from agricultural dominated catchments.

2.1.1 The V-notch

Although not extensively used in the Estonian and Norwegian monitoring programme for agricultural dominated catchments, the V- notch is widely used as discharge measurement structure in many programmes (Fig. 1). It is therefore considered relevant to present its main characteristics in addition to guidelines on how to design the V – notch. The stage discharge relation is;

$$Q = \mu \times {}^{8}/_{15} \times tg(0.5 \times \alpha) \times \sqrt{2 \times g} \times h^{2.5}$$

in which

Q	- discharge ($m^3\ s^{-1}$)
α	- angle of V-notch
g	- acceleration of gravity($m\ s^{-2}$)
h	- effective water level (m)
μ	- discharge coefficient

The discharge coefficient is, $\mu = 0.565 + 0.0087 \times h^{-0.5}$, in which h is the effective water level in meter. (Otnes, J. and E. Ræstad, 1978).

Limits of application for V-notch.

- When erosion and the subsequent transport of suspended matter are dominant in the catchment, the V-notch is not proposed. The structure has a low capacity to transport sediments and as a consequence, maintenance requirements will be high.
- The V-notch has to operate under free flow conditions meaning that the head loss must be bigger than the measured upstream water level (h).
- The water level (h) should be measured at a distance 3 - 4 x h_{max} from the V-notch
- The upstream water level (h) should preferably be bigger than 6 cm. For lower values the uncertainty in the discharge coefficient and thereby in discharge measurement increases.
- Sedimentation upstream from the structure influences the discharge coefficient thereby affecting the accuracy.

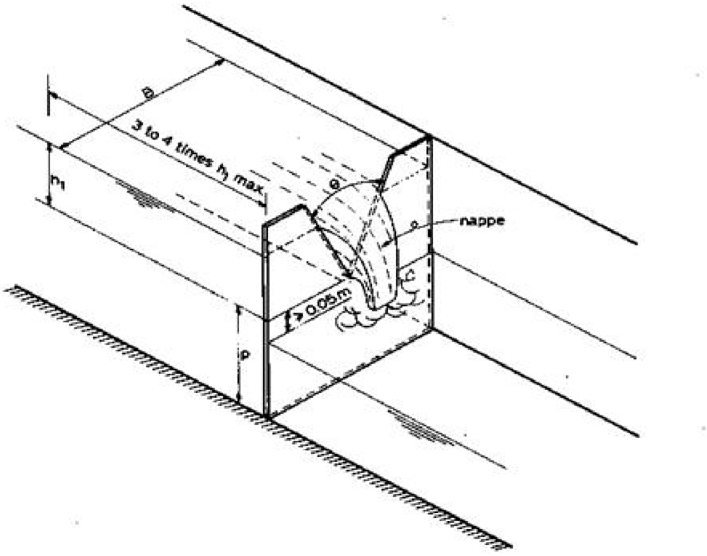

Figure 1. V-notch sharp crested weir (From Bos, 1978)

Example of the calculation of discharge for a V-notch

An example is given for a V-notch with an angle, $\theta = 120^0$. The detailed calculation is presented for a water level, $h_1 = 0.50$ m.

The discharge coefficient (μ) is calculated as $\mu = 0.565 + 0.0087 \times h^{-0.5}$

For $h_1 = 0.5$ m, the discharge coefficient, $\mu = 0.5773$.

With an angle, $\theta = 120^0$, the value for tg (0.5 x angle) = 1.7321.

The discharge is then

$$Q = \mu \times {}^{8}/_{15} \times tg(0.5 \times \alpha) \times \sqrt{2 \times g} \times h^{2.5}$$

$$Q = 0.5773 \times 0.5333 \times 1.7321 \times 4.4294 \times 0.1767 = 0.4176 \text{ m}^3$$

Results of discharge calculations for additional water levels are presented in Table 1.

Table 1. Calculation of the discharge for a V-notch with an angle, $\theta = 120^0$.

water level (m)	0.05	0.10	0.25	0.50	0.75	1.00
angle (degrees)	120	120	120	120	120	120
μ	0.60	0.59	0.58	0.58	0.58	0.57
tg(0.5 x angle)	1.73	1.73	1.73	1.73	1.73	1.73
Q ($m^3\ s^{-1}$)	0.00	0.01	0.07	0.42	1.15	2.35

2.1.2. Crump-weir

The Crump-weir is a short crested weir, extensively used in the agricultural environmental monitoring programme in Norway (JOVA) as well as in Estonias environmental monitoring programme. One of the main advantages is the ability to transport sediments over the crest. The weir is developed at the Hydraulics Research Laboratory, Wallingford, England and is credited to E.S.Crump (1952). The Crump weir is widely used in the Baltic countries and Norway. In Estonia, two different monitoring locations were visited, i.e. Rägina and Jänijögi. The Rägina station was established through cooperation between Bioforsk (then Jordforsk) and SLU. The Jänijögi monitoring station (Fig. 2) has been established as part of the Baltic Sea Regional project.

During the final stage of the AELO – project, a Crump –weir was constructed in the Suida catchment in the Leningrad Oblast.

Figure 2. Visit to the Jänijögi monitoring station

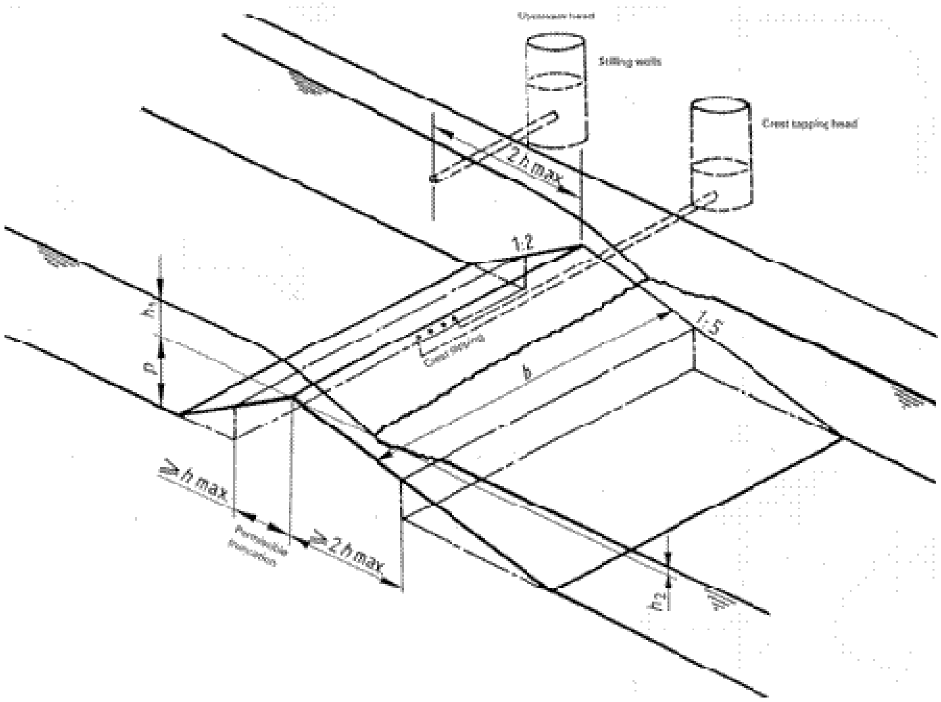

Figure 3. Sketch of the Crump weir (Bos, 1978)

There is a unique relation between the discharge (Q) and the water level at the gauging station (h_1) for a Crump weir (Fig. 3)

$$Q = B_c \times C_d \times C_v \times {}^2/_3 \times \left({}^2/_3 \times g\right)^{0.5} \times h_1^{1.5}$$

in which

Q	- discharge (m^3/s)
B_c	- width of the crest (m)
C_d	- discharge coefficient
C_v	- approach velocity coefficient at gauging station
h_1	- water level measured at control section

Discharge coefficient, C_d

The following relation between the discharge coefficient (C_d) and the water level (h_1) exists,

$C_d = 1.163$	for $h_1 \leq 0.10$ m
$C_d = 1.163 \times \left(1 - {}^{0.003}/_{h_1}\right)^{1.5}$	for $h_1 > 0.10$ m

Approach velocity coefficient, C_v.

The approach velocity coefficient, C_v, corrects for the flow velocity at the gauging location. Table 2 presents C_v - values as a function of the dimensionless ratio of C_d x A^*/A_1 for a rectangular cross section in which $A^* = B_c$ x h_1 and $A_1 = B_c$ x $(p + h_1)$ in which p is the crest height of the Crump weir.

Table 2. Values for the approach velocity coefficient(Cv) for a rectangular weir.

CdxA*/A	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.1	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.01
0.2	1.01	1.01	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02
0.3	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.03	1.04
0.4	1.04	1.04	1.04	1.05	1.05	1.05	1.05	1.06	1.06	1.06
0.5	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.09	1.09	1.09
0.6	1.10	1.10	1.11	1.11	1.12	1.12	1.12	1.13	1.14	1.14
0.7	1.15	1.15	1.16	1.16	1.17	1.18	1.19	1.19	1.20	1.21
0.8	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.31	1.32
0.9	1.34	1.36	1.38	1.40	1.42	1.45	1.48	1.52	1.57	1.63

Limits of application

- When installing the Crump weir in an earthen channel, the upstream section has to be straight over a length, $L_t = 5$ x B_c, while the water level has to be measured at a distance, 2 x h_{max} upstream from the crest.
- To avoid too large flow velocities at the gauging station, the following limits of application are to be considered

$$B_c/h_1 \geq 2$$
$$h_1/p \leq 3.5$$

- The Crump weir can operate under submerged conditions. However, the submergence ratio should never exceed

$$h_d/h_1 \leq 0.75$$

  in which h_d is the downstream water level over the crest. If this condition can’t be fulfilled, special arrangements have to be made to cope with the submerged flow conditions (Bos, 1978).

Example of the calculation of discharge for a Crump - weir

An example is given for a Crump weir with a crest height, p = 0.5 m and a crest width, B_c = 1 m. The discharge will be calculated for a water level, h_1 = 0.5 m

The discharge coefficient (C_d) is calculated using

$$C_d = 1.163 \times \left(1 - \frac{0.003}{h_1}\right)^{1.5}$$

yielding $C_d = 1.163 \text{ x } (0.994)^{1.5} = 1.1525$

The cross section (A) and imaginary cross section (A*) are calculated as

$A_1 = B_c \text{ x } (p + h_1) = 1 \text{ x } (0.5 + 0.5) = 1 \text{ m}^2$
and
$A^* = B_c \text{ x } h_1 = 1 \text{ x } 0.5 = 0.5 \text{ m}^2$.

The velocity coefficient (C_v), is calculated as a function of $C_d \text{ x } A^* \text{ x } A_1^{-1}$ and can be read directly from table 2. $C_d \text{ x } A^* \text{ x } A_1^{-1} = 0.5763$ giving a value for the velocity coefficient, C_v = 1.09.

The discharge has been calculated for additional water levels and is presented in Table 3.

Table 1. Discharge calculation for a crump weir with crest height, p = 0.5 m and crest width, B = 1 m.

width of stucture, B (m).	1.00					
crest height , p (m).	0.50					
water level, h_1 (m)	0.05	0.10	0.20	0.50	0.75	1.00
discharge coeff, Cd	1.06	1.11	1.14	1.15	1.16	1.16
A* (m^2)	0.05	0.10	0.20	0.50	0.75	1.00
A_1 (m^2)	0.55	0.60	0.70	1.00	1.25	1.50
C_d x A* x A_1	0.10	0.19	0.32	0.58	0.69	0.77
C_v	1.00	1.01	1.02	1.09	1.14	1.19
Q ($m^3 s^{-1}$)	0.02	0.06	0.18	0.76	1.46	2.36

2.1.3 Other discharge measurement structures

Besides the V-notch and Crump weir, there is a wide range of fixed discharge measurement structures with known heads-discharge relations available. An excellent overview over different discharge measurement systems/structures is given by Bos (1978).

2.1.4 Errors in discharge measurements

The main errors, affecting the accuracy in discharge measurement, can be divided into a) spurious errors, caused by human mistakes or instrument malfunction and b) systematic errors which are constant or variable (Bos, 1978).

It is often possible to locate and eliminate spurious errors from data series because of their magnitude. An example of a spurious error can be the sudden malfunctioning of a sensor, shown in a data series as a non-realistic, outlying value.

Systematic errors are constant or can develop over time. They can have a serious effect on the final result and one is often unaware of their presence. Many systematic errors can be avoided through good maintenance and operation routines while others can be corrected for, once one is aware of them. Below an overview over the most common errors are given.

Errors in water level measurements

For both the V-notch and the Crump weir, the location for water level measurements is specified. Deviation from this location will lead to errors in the discharge. An example of this is given for a V-notch with an angle, $\theta = 135^o$. The magnitude of the error varies with the height of the water level over the crest (Fig. 4)

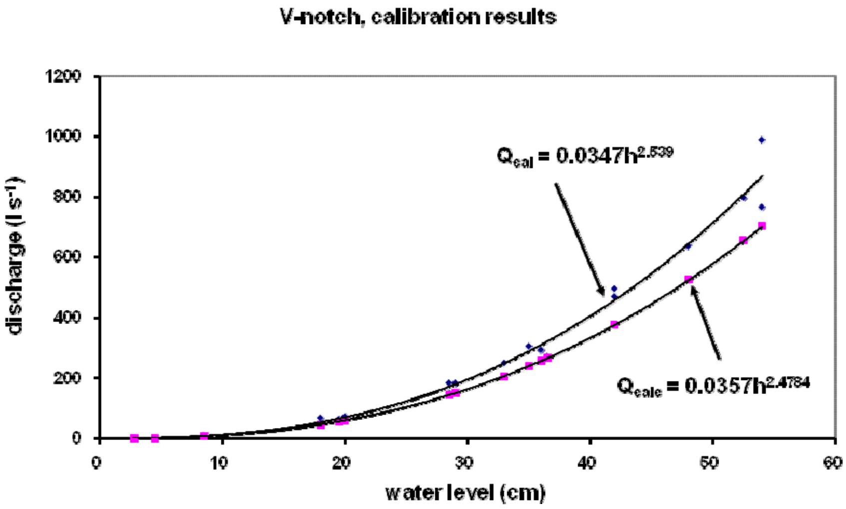

Figure 4. Calibrated and calculated discharge for a V-notch with an angle, $\theta = 135^o$.

It is recommended that at a staff gauge is installed at the monitoring location. During regular visits the "true" water level is read on the staff gauge and checked against the water level, read by the pressure transducer. Adjustments should be made when the deviation from the "true" water level exceeds a specific value, depending on the allowable error in discharge measurement.

Constructional errors

The effect of constructional errors on the discharge can sometimes be adjusted for by recalculating the head - discharge relation. This applies for example to an error in the width of the Crump - weir or an error in the angle of the V-notch. However, no correction is possible when errors in geometry of the structure have occurred, in which case a new head-discharge relation has to be established using alternative discharge measurements.

Sedimentation

Sedimentation problems often lead to errors in discharge measurement. Sedimentation in front of a V-notch will discharge coefficient, C_e. In a similar way will sedimentation upstream the crest of a Crump weir will lead to a change in the approach velocity coefficient, C_v.
The effect of sedimentation of the discharge can be calculated for a Crump weir (Fig. 5).

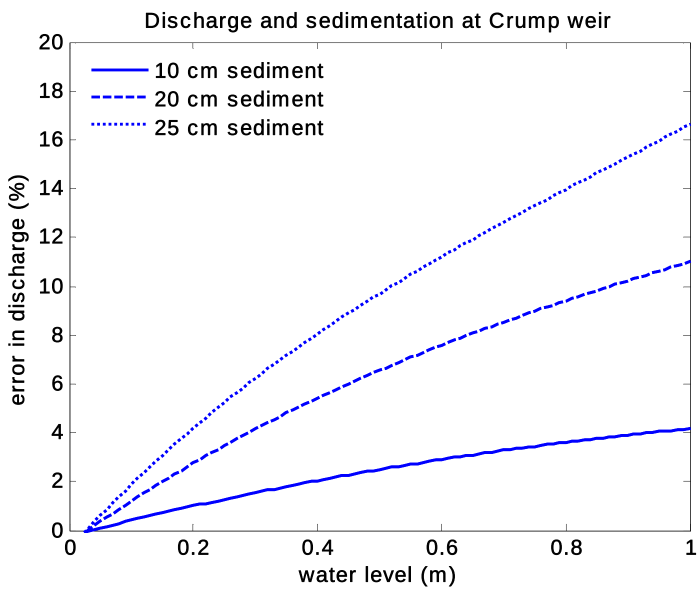

Figure 5. Error in discharge due to sedimentation at a crump weir with a crest height, p = 0.50 m

Submerged flow

Submerged or partly submerged flow conditions occur due to high water levels downstream of the measurement structure and can lead to serious errors in discharge measurements. For the V-notch, submerged flow occures as soon as the downstream water level comes above the vertex of the V-notch. No correction can be made this conditions occurs.
For the Crump weir, submerged flow conditions occur when the downstream water level (h_2) exceeds 75 % of the upstream water level (h_1). In this case additional measurements of the downstream water level have to be carried out and a correction to the head – dischargre relation has to be introduced (Bos, 1978)

Floating debris

Floating debris, when stuck on the crest of the measurement structure can lead to errors in the water level measurement (Fig. 6). Regular visits to the monitoring stations can prevent the long lasting influence on the discharge measurement. Especially the V - notch is prone to the blockage of floating debris.

Figure 6. Debris on crest of Crump weir

2.2 Water sampling.

Runoff, nutrient losses and erosion from agricultural dominated catchments are very much determined by a combination of climate, crop types and farming practices. In setting up a monitoring system, special consideration has to be given to the geo–hydrological conditions, which to a large degree determine the flow paths involved in the transport of nutrients, pesticides and soil particles. The flow paths have a significant influence on the discharge intensities in runoff and concentrations of both solutes and suspended material can show large variations both over time (Fig. 7). In a monitoring programme, water sampling routines should be utilised which best can handle these variations.

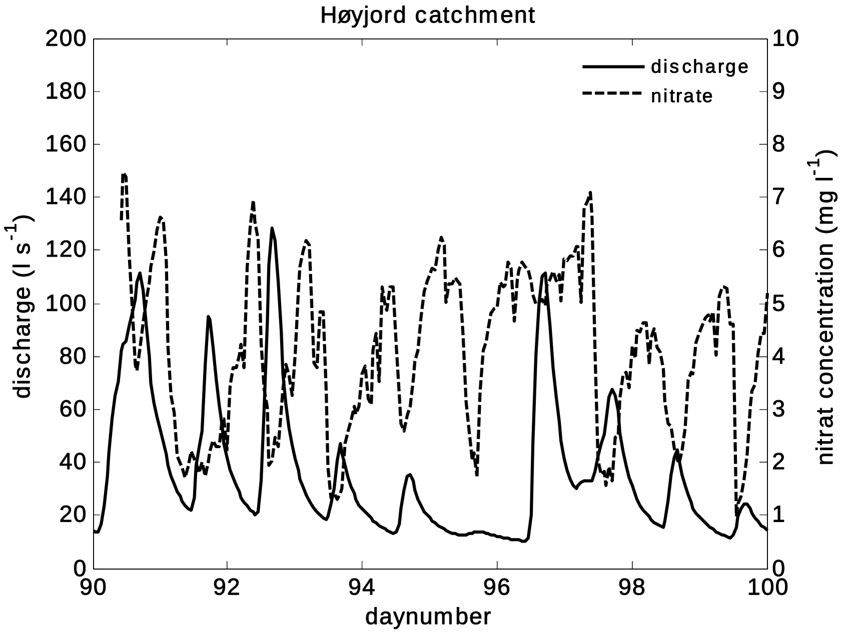

Figure 7. Variation in discharge and nitrate concentration, Høyjord catchment, Norway

Water sampling strategies

In general one can differentiate between point sampling routines and volume proportional water sampling. Point sampling can be divided into routines with variable and fixed time intervals. When the discharge is dominated by large variations in intensities, point sampling systems can lead to erroneous results in the calculation of nutrient loss. In this case, the best alternative to point sampling is volume proportional composite water sampling.

This routine can only be carried out when the discharge is measured automatically, using a data logger (Deelstra and Øygarden 1998, Deelstra *et al.* 1998). Each time a predetermined volume of water has past the monitoring station a small water sample is taken. All sub-samples are accumulated and stored into a container, preferably placed in a refrigerator or cool environment to prevent chemical reactions. The composite sample represents the average concentration of the runoff water over the sampling period. Volume proportional water sampling gives very satisfactory results compared to other sampling methods and is recommended in load estimation studies (Haraldsen og Stålnacke, 2005; Schleppi et al., 2006; Rekolainen et al. 1991). Richards (1998), in a report to the EPA/USA, describes this sampling method as a very precise and accurate method in the estimation of loads. The volume proportional composite water sampling system is applied both in Estonia and Norway and was extensively demonstrated during the project.

Chemical analysis

Water analysis is an important component in monitoring programmes. During the course of the project, water laboratory facilities both at the Tallinn University of Technology, Estonia and at Bioforsk, Norway were visited and a thorough presentation of relevant methods was carried out.

In Norway, the collected samples are usually analysed for a range of determinants, including total nitrogen (TN), total phosphorus (TP) and SS. Often unfiltered samples are used to determine TP by digestion with $K_2S_2O_8$ and analysed spectrophotometrically by the ammonium molybdate method of Murphy and Riley (1962), with ascorbic acid as a reducing agent. Suspended sediments were determined by filtering an exact sample volume of 25 to 250 ml after thorough mixing (containing at least 5 mg SS) through a pre-weighed fibreglass filter (Whatman GF/A). Total nitrogen is determined by persulfate digestion followed by analysis by spectrophotometer (Norwegian standard NS-EN ISO 13395).

In Estonia the analysis on the water samples is carried out using standardized methods. (ISO 6878 for TP, ISO 11905 for TN and ISO 10304-1 for nitrate). Ammonium and nitrite were determined spectrophotometrically using Finnish standards SFS 3030 and SFS 3032 respectively and includes all the main nitrogen and phosphorus components.

Lengthy discussions concerning methodology and equipment were held between participants from the Leningrad Oblast and laboratory personnel, showing the need for further knowledge exchange.

2.3 Farming practices

Both in Estonia and Norway attention was paid to the collection of information concerning farming practices which is important in interpreting measured nutrient loss and should be collected on a yearly basis. Farmers participating in the agricultural environmental monitoring programme in Norway (JOVA) are requested to fill out yearly a questionnaire providing information concerning crop type, sowing and harvesting dates, yield level, type and amount of fertiliser and pesticide application in addition to timing and type of tillage operations (Fig. 8).

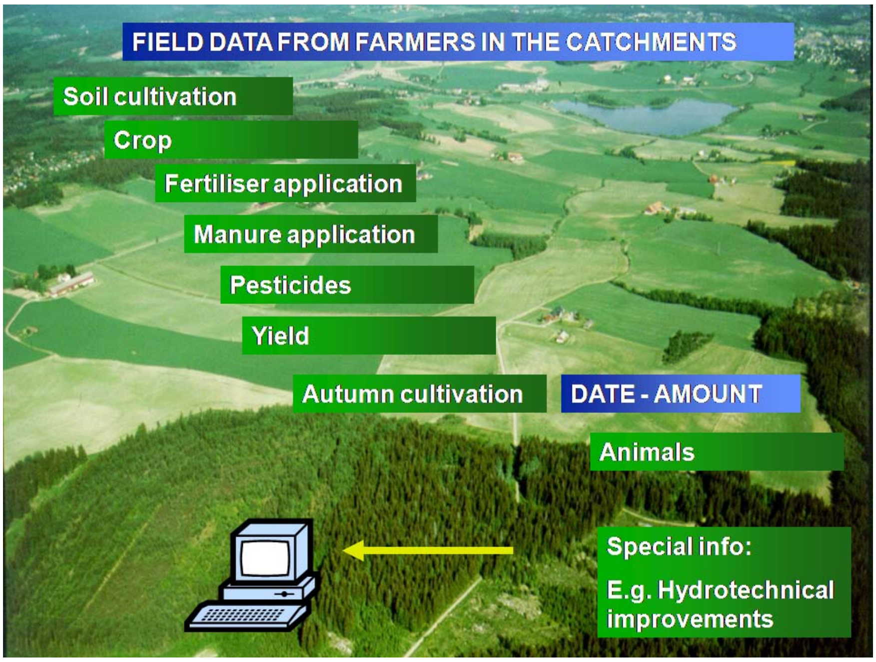

Figure 8. Data collection at catchment scale

On the basis of the collected information, nitrogen and phosphorus surplus can be calculated and compared to the calculated load measured at catchment scale. Information about nitrogen and phosphorus contents of both type of crops and fertiliser/manure has to be available. Table 4 and Table 5 present the nitrogen and phosphorus content for some major crop and manure types in Norway. However, one should be aware that these figures may vary between countries.

Table 4. Nitrogen and phosphorus content (%) in some crops in Norway (grain and straw).

	Nitrogen		Phosphorus	
Crop type	**crop**	**residue**	**crop**	**Residue**
Barley	1.75	0.6	0.31	0.29
Oat	1.75	0.6	0.32	0.35
Spring wheat	2	0.6	0.31	0.08
Winter wheat	2	0.6	0.31	0.08
Winter rye	1.75	0.6	0.3	0.08
Potatoes	0.31	-	0.05	-
Grass	3.2	-	0.3	-

Table 5. Nitrogen (total and effective), phosphorus, potassium and dry matter content (%) in some manure types (JOVA - program, Norway)

Manure type	$N_{Tot.}$	$N_{Eff.}$	P	K	Dry matter
Cattle, solid manure	0.46	0.13	0.12	0.43	20
Cattle, slurry	0.33	0.18	0.06	0.28	7
Pig, solid manure	0.52	0.28	0.26	0.31	20
Pig, slurry	0.58	0.41	0.15	0.26	6.8
Chicken,manure, solid	1.48	0.70	0.64	0.81	25

The obtained results on nutrient losses from agricultural catchments are partly a result of farming practices and a feedback to both farmers and governmental institutions is important. In both Estonia and Norway, extension services were visited and information and experiences were exchanged on the interaction between farming practices and nutrient losses from agriculture.

2.4 Data collection and quality control

The collection of data at the monitoring stations in Estonia and Norway is based on a combination of different sensors, a water sampler and a data storage module. In case an online telephone connection between the catchment monitoring station and the main office is available, the data are downloaded on a daily basis and subjected to a quality control. A schematic overview of data collection and quality control and reporting is presented in figure 9. Besides the daily downloading and data control routines in the main office, regular checks of the station, preferably weekly or bi-weekly, have to be carried out. An important observation during these checks is the control of the water level recording (see chapter 2.1.4).

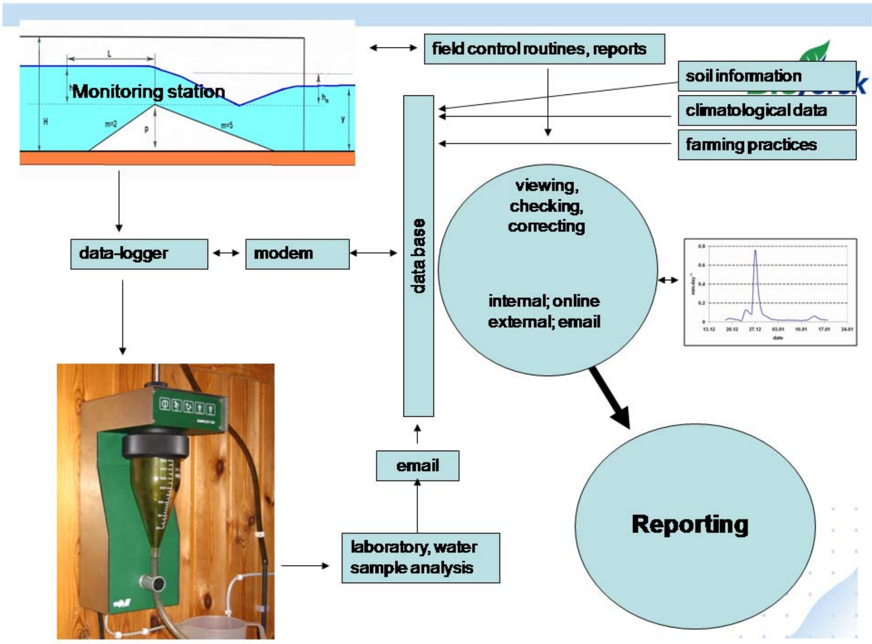

Figure 9. Schematic layout of monitoring system as used in the JOVA-programme, Norway)

2.5 Additional data collection

2.5.1 Climatological data

A prerequisite in the analysis of the results from monitoring and assessment programmes is the availability of meteorological data (Fig.10). If possible these should be included in the design of the monitoring station. Otherwise, those data should be obtained from the nearest climatological stations. A minimum requirement is access to temperature and precipitation but preferably also wind speed, relative humidity and incoming solar radiation should be available. A minimum requirement is that the data have a daily resolution. Also the availability of information concerning the wet and dry deposition of nitrogen (kg/ha) is an advantage, but this is not expected to show large variation and most likely can be obtained from national institutions having air quality under their jurisdiction. All meteorological equipment should maintained according to prescribed procedures, provided by the supplier of the equipment.

Figure 10. Russian participants visiting the Vandsemb – LMT climatological station.

2.5.2 Soil data

Information about soils is necessary in the interpretation of measured losses. The minimum information required is the distribution of the different soil types in the catchment and their main soil physical and chemical characteristics. Soil physical data are necessary when modelling tools are to be applied in scenario studies concerning best management practices. They also provide information about the susceptibility of soils to erosion.

2.5.3 Topographical data.

Information about the topography is necessary in the interpretation of the collected data. They provide among others a means to depict areas prone to erosion.

3. Conclusion and recommendations

During the project, the Russian participants have been presented with several aspects concerning monitoring and assessment of nutrient loss from agricultural dominated catchments in both Estonia and Norway. Experiences obtained through this project are important assets in the further planning of monitoring and demonstration activities in the Leningrad Oblast. As a result of this project, several actions could be taken, a short summary of which is given below.

The Suida monitoring station

The Suida station was established during phase the first phase of the AELO – project. The design of the Crump weir was carried out by Professor Shamil Daishev from St Petersburg University of Railway Transport, while the construction of the station was supervised by the FGU–institute. The actual operation of the station should start as soon as possible. An important issue has been the responsibility for the operation and maintenance of the newly established Suida station and data ownership. Also during this project, discussions were held on data ownership. In Norway, Bioforsk has a leading competence in issues related to agriculture and environment which is one of the main reasons Bioforsk is in charge of the JOVA programme. The same applies to the Tallinn University of Technology in Estonia.

The Suida station should become fully operative as soon as possible. It is proposed that during the initial phase, a calibration of the Crump weir is carried out with the objective to check the theoretical head - discharge relation for the station and to observe whether the station functions under free flow conditions year round. Such a calibration could be carried out as part of a MSc. degree to be carried out partly in Russia and Estonia/Norway.

No automatic water level recording equipment is yet available however for the time being the water level can be read using a mechanical water level recorder. Also a staff gauge should be placed both upstream and downstream of the crest of the measuring structure. Routines for the optimal recording of the water level, as described in this report, should be followed. For the time being the water sampling has to be carried out using point sampling, preferably at a fixed time interval.

Several order actions have to be undertaken to get the monitoring catchment operational. Additional data collection, as indicated in this report, should be carried out. Of highest priority are climatic data and data on farming practices. In addition, information on soils and soils physical parameters should be collected.

Additional studies, relevant for the monitoring and assessment of nutrient losses from agricultural catchments could be carried, partly in fulfilment of an MSc degree. As a follow up the AELO project, the Harmobalt project has been initiated. This project has a strong focus on modelling. Besides the data on runoff and nutrient loss obtained from a well functioning Suida monitoring station, important input to simulation models is information about soil physical parameters (soil moisture retention, hydraulic conductivity). Also the study on variability in soil physical parameters could be another assignment for MSC-studies.

The establishment of a network in the field of monitoring and assessment of nutrient losses from agricultural dominated catchments between researchers from Leningrad Oblast, Baltic and Scandinavian countries has given promising results and should continue.

Back ground losses.

Information about back ground loss is important information is source apportionment studies. Within the vicinity of the Suida catchment, locations are available for the construction of an additional monitoring station to measure background nutrient loss.

Establish observations fields in Suida

Observation fields should be established within the Suida catchment. The objective is to present to the farmers the effects of good farming practices on the nutrient losses from agriculture. In Estonia an experimental field was visited were this type of demonstration plots were established. In this case samples of soil moisture were taken using suction cups. Similar systems are used in Latvia and were presented during the workshop in Norway. In Latvia however a different system consisting of tipping buckets, operating both as a discharge measurement system and water sampler was used (Fig. 11).The information on discharge and nutrient loss at the level of the demonstration plots also provides important information in connection to scale issues and nutrient losses and as such provides important input to modelling.

Figure 11. Tipping bucket used as discharge measurement structure, Mellupite, Latvia

Evaluation of point source pollution and implementation of demonstration treatment system

Point source pollution can be an important source of nutrient to open water systems and groundwater. In Norway, several ecological waste water treatment plants were visited. A similar system could be used for the cleaning of sewage runoff from the Pizma village in the Suida catchment. (Fig. 12). The treatment plant operates as a three-stage system.

First stage is a settlement tank followed by an intermittent loader by an electric pump. The second stage is a pre-treatment vertical filter without vegetation for oxidation integrated in the first part of the third stage which is a subsurface flow wetland with a filtermedia with a high phosphorus sorption capacity.

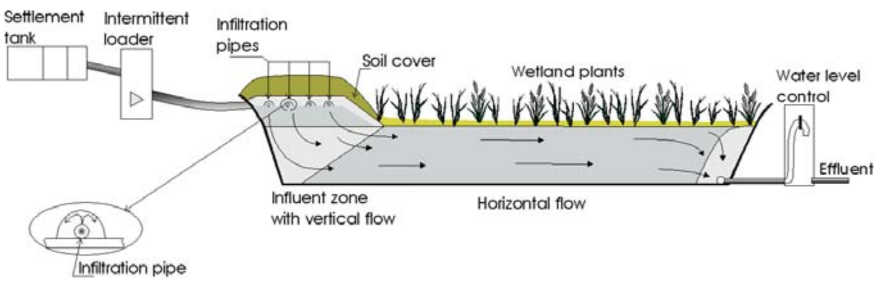

Figure 12. Layout of sewage treatment plant.

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Placed at the end of chapters or at the end of the report (before appendices and summaries)

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Russian summary

Основной целью проекта «Контроль и определение избытка минеральных удобрений в сельском хозяйстве Ленинградской области» являлось введение программы обучения и создание возможностей для этого в Эстонии и Норвегии. Обе страны принимали активное участие в применении надлежащих методов в проектах, имеющих отношение к отходам сельского хозяйства, загрязняющим Балтийское море.

На основании проекта были сделаны следующие выводы:

- Методы контроля водосборной площади в Ленинградской области с преобладающим сельскохозяйственным профилем, должры соответствовать методам, применяемым в Балтийских и Скандинавских странах. Эти же методы должны быть введены в контрольной станции, недавно открытой в Ленинградской области.
- Обмен между специалистами Ленинградской области, Эстонии и Норвегии в деле обслуживания, управления и представления отчетов о результатах контроля, должен продолжаться.
- Система контроля в Ленинградской области должна принимать во внимание системы,используемые другими странами и организовывать их на разных уровнях. Контакты с Эстонией и Норвегией, а также и с Латвией выдвигают предложение об организации подобных систем и в этих странах.
- Обмен опытом, имеющим отношение к методологии лабораторных исследований, необходимо продолжить.
- Точечное загрязнение может превратиться в серьезный источник питательных отходов, как в открытых водоемах, так и в грунтовых водах. Было бы не лишним организовать пробный проект для экологической очистки сточных вод.
- Проект, о котором здесь идёт речь, убедительно доказывает, что в деле улучшения качества воды, необходима тесная связь между программами контроля, расширения служб и местными аграрными объединениями.
- Организация связи в деле контроля и оценки преимущественно сельскохозяйственных отходов в Ленинградской области, в странах Балтики и Скандинавии принесла положительные результаты, обеспечив тем самым право на существование.

Sammendrag

Formålet med prosjektet "Monitoring and assessment of nutrient loads from agriculture in the Leningrad Oblast" var å gjennomføre et samarbeidsprogram for kompetansebygging i Estland og i Norge. Begge land har vært aktivt involvert i implementeringen av harmoniserte metoder i prosjekter relatert til forurensning fra landbruk og næringsstoffbelastning i det Baltiske hav.

Prosjektet ledet til følgende konklusjoner:

- Overvåkingsmetoder i landbruksdominerte nedbørfelt innenfor Leningrad Oblast bør være på linje med overvåkingsmetoder som benyttes i de baltiske og skandinaviske land og disse bør implementeres ved en nylig etablert målestasjon i Leningrad Oblast.
- Utveksling av kunnskap mellom eksperter fra Leningrad Oblast, Estland og Norge knyttet til drift, vedlikehold og rapportering fra overvåkingen bør fortsette.
- Overvåkingssystemer i Leningrad Oblast bør inkluderer ulike arealbrukssystemer og bør etableres på større og mindre skala. Kontakt med Estland og Norge, men også Latvia, er foreslått for å initiere slike systemer.
- Utveksling av erfaringer knyttet til laboratoriemetoder viste seg å være nødvendig og bør fortsette.
- Punktkildeforurensning kan være en viktig kilde til at næringsstoffer entrer åpne vannsystemer og grunnvann. Et pilotprosjekt om økologisk behandling av kloakkvann bør vurderes.
- Nødvendigheten av en nær forbindelse mellom overvåkingsprogram, veiledningstjeneste og brukerorganisasjoner for å oppnå forbedret vannkvalitet, ble tydelig illustrert i prosjektet.
- Etableringen av et nettverk mellom forskere fra Leningrad Oblast, Baltikum og de skandinaviske land innenfor overvåking og vurdering av næringsstofftap fra landbruksdominerte nedbørfelt har gitt lovende resultater og bør fortsette.

Appendices

Participants in project

Project leader; Johannes Deelstra, Bioforsk- Soil and environment, Norway. Other project participants from Bioforsk: Adam Paruch, Heidi Grønsten

Training and capacity building in Estonia, organised by Arvo Iital, Institute of Environmental Engineering, Tallinn University of Technology in close cooperation with Livi Rooma, Agricultural Research Center, Saku and Hennu Nurmekivi, Jäneda Training and Advisory Center, Estonia.

Participants to training and capacity building in Estonia.	
Yulia Razumovskaya, Vitali Dvurechenskiy, Irina Korolenka and Yuri Khomyakov	Reference Center of Rosselhoznadzor (FGU), previously CAS(Central Agrochemical Service, Pushkin)

Participants to training and capacity building in Norway	
Valentina Soboleva Alexander Pertsovich	Reference Center of Rosselhoznadzor (FGU), previously CAS(Central Agrochemical Service, Pushkin)
Yury Malashin	RosHydromet – St. Petersburg
Boris Prokhorov	Vice Head of Committee of Natural Resources – St. Petersburg
Natalia Schagina	HydroMet - Federal Service of Russia, Kaliningrad
Natalia Haluk	Local Implementation Unit (LIU), Kaliningrad
Participants workshop "Monitoring and assessment of nutrient losses from agricultural dominated catchments"	
In addition to the participants from Leningrad Oblast and Kaliningrad, the following people participated in the workshop	
Arvo Iital	Institute of Environmental Engineering, Tallinn University of Technology
Viesturs Jansons	Latvia University of Agriculture, Department of Environmental Engineering and Water Management, Jelgova
Niklas Bergman	Niras AB (formerly Scanagri, Sweden AB)
Katarina Kyllmar	Swedish Univ. of Agricultural Sciences Dept. Soil Sciences Uppsala
Markus Hoffman	Federation of Swedish Farmers – LRF

Sirkka Tattari	**Finnish Environment Institute** **Research Programme for Integrated River Basin Management**
Lillian Øygarden	**Bioforsk – Soil and Environment**
Heidi Grønsten	**Bioforsk – Soil and Environment**
Marianne Bechmann	**Bioforsk – Soil and Environment**
Adam Paruch	**Bioforsk – Soil and Environment**
Gro Hege Ludvigsen	**Bioforsk – Soil and Environment**

Programme Estonia

Date	**Activity**	
14 June	Arrival from St Petersburg, meeting in Hotel Reval Express, Sadama street 1, Tallinn.	
15– 17 June	Training and capacity building focussing on aspects related to farming practices and management and operation of monitoring stations.	
	Farming practices	Operation and management of monitoring stations
Outline of programme	Introduction in the collection of information on farming practice. Aspects to be dealt with;	Introduction in operation and maintenance of monitoring stations. Aspects to be dealt with;
	-overview of farming practices	-maintenance of discharge measurement structure
	-what is the objective of collection of information on farming practices	-operation of datalogger,
	-how often is information on farming practices collected	-visualisation of on-line measurements, changing offset values, downloading and temporary storage of data
	-how is information stored including information on databases	-control of measurement equipment
	-how is information reported and to whom is the information reported	-collection and treatment of water samples
	format of reporting	-management and control of collected data, including correction and entering in database
	-procedures for the collection of additional information on;	-handling of water samples, water sample analysis, analyses results
	soil types including soil texture and more	-calculation routines for nutrient-sediment losses and reporting
	soil nutrient level	
	which analysis methods	
17 June	Departure for St Petersburg	

Programme Norway

Programme Training/capacity building and workshop, Norway

Date	Time	Activity
Monday afternoon		Arrival from St Petersburg
Tuesday Morning		Welcome at Bioforsk
		Visit departments
		Visit laboratories
Tuesday Afternoon		Visit ecological sanitation systems
Wednesday		Visiting monitoring systems
		Visit farmer extension services
		Visit agricultural school
Thursday, Morning session	0900	Start workshop, Welcome by director, department head, research director, presentation of participants.
	0930	The role/objectives of the Norwegian Agricultural Monitoring Programme (JOVA) (Gro H. Ludvigsen)
	0945	Discharge measurement/water sampling in Norway (Johannes D)
	1015	Coffee break
	1030	Experiences/results of the JOVA – programme (Lillian Øygarden)
	1100	Environmental monitoring in the Leningrad Oblast (Russian repr.)
Lunch	1130	Picnic at Skuterud catchment, visit monitoring stations, sedimentation pond, mm.
Afternoon session	1400	Sedimentation ponds; its effects in the landscape (Anne G. B-B)
	1430	The Finnish agricultural monitoring programme. (Sirkka Tattari)
	1500	Coffee/tea break
	1515	Monitoring and modelling agricultural runoff in Sweden (Katarina Kyllmar)
	1545	Point source pollution in catchment runoff (Adam Paruch)
	1645	Animal manure storage, pollution and treatment (Niklas Bergman)
Friday, Morning session	0900	Monitoring and assessment of nutrient losses at different scales, results from Mellupite, Latvia (Viesturs Jansons)
	0930	The Estonian monitoring programme, reporting to Helcom (Arvo Iital)
	1000	Coffee break.
	1015	Abatement measures. The phosphorous index, development and application (Marianne Bechmann)
	1045	Monitoring results, abatement measures and information to farmer organisations; experiences from Sweden (Markus Hoffman)
	1115	Agricultural pollution and the EU Water Framework Directive (Per Stålnacke)
	1145	Conclusion and recommendations
	1215	Lunch

Workshop presentations

Summary of presentations held during the workshop in Ås, Norway 31.August – 1.September 2006 as part of the project ”Monitoring and assessment of nutrient loads in the Leningrad Oblast”

The role and objectives of “JOVA” The Norwegian Agricultural and Environmental Monitoring Programme.
By Gro Hege Ludvigsen, Bioforsk - Norwegian Institute for Agricultural and Environmental Research, Soil and Environment Division.

The JOVA-programme is a national monitoring programme started in 1992 which aims to document the impacts of agricultural production on soil and water quality. The programme registers and reports on the extent of erosion and nutrient losses from different agricultural systems under various agro-climatologically conditions. Special emphasis is put on regions with high agricultural intensity. Nine agricultural catchments (70 – 680 ha) are monitored with regard to erosion and nutrient loss. They represent the main agricultural systems in Norway, from cereal production in the eastern parts of the country, vegetable production in the south, intensive dairy farming in the western parts, to more extensive grass production in the north of the country. Measurements of discharge and water sampling are conducted at monitoring stations. In most of the catchments, discharge is measured using a Crump weir. Composite water samples are collected automatically on a volume proportional basis in all catchments. The total load of nutrients and suspended solids is calculated based on the measured discharge and concentrations of the respective compounds in the composite sample. Water samples are analyzed for the following parameters; pH, suspended solids, suspended inorganic sediments, total-P, dissolved total-P, Phosphate-P, Total-N, nitrate + nitrite and Total-K. In addition water samples are analyzed for different pesticides. Results from 1484 samples from streams and rivers showed detection of pesticides in 78% of samples. The development in total loads is studied over a period of time in order to extract annual variations and trends, and to analyse the effects of mitigation efforts. The collected data can further be used for modelling nutrient and pesticide leaching from agriculture and risk assessment of agricultural practice.

Discharge measurements/water sampling in Norway.
By Johannes Deelstra, Norwegian Institute for agricultural and Environmental Research, Soil and Environment Division.

The Agricultural Environmental Monitoring Programme (JOVA) in Norway monitors and assesses nutrient losses and erosion from 10 small agricultural catchments. The core of the monitoring activities consists of discharge measurement and water sampling, providing data for nutrient load calculation. Different methods can be used to obtain information about discharge, based on a known head-discharge relation for the measurement location. A water sampling strategy has to be able to cope with the dynamics in catchment hydrology, responsible for the nutrient and soil loss generating processes. The losses of P, and to a lesser extend N, are typically event based, and depend on a combination of the prevailing geo-hydrological settings, climatological conditions and agricultural practices. Follow up of monitoring stations is carried out through daily download of collected data and control routines for collected data. The JOVA - programme includes components dealing with modelling nutrient loads and erosion and when necessary additional measurements are carried out to support these activities. To enhance the sustainability of the monitoring programme, the design and implementation is such that it is suitable and attractive for research and educational purposes while the applied measuring methods and procedures are sufficiently advanced to comply with international scientific standards.

The role of monitoring in the Water Frame Directive.
By Lillian Øygarden, Bioforsk - Norwegian Institute for Agricultural and Environmental Research, Soil and Environment Division

The new Water Frame Directive (WFD) gives new challenges for the National Monitoring Programs (NMP) in Norway. Inside EU the water quality should be of good ecological status by 2015. However, Norway has got a postponed deadline until 2021, but will have some selected catchments within 2015. NMPs are based on chemical parameters while WFD include also biological parameters. NMPs must therefore start to adapt biological parameters. Questions which must be considered are: is it possible to reach/fulfil good ecological status in waters in agricultural areas? Even for eutrophic water? What is the natural ecological status for water in agricultural areas? Need of new measures to achieve sufficient reduction? Are the costs of the measures too high? Both costs and effects should be considered. Monitoring can help document both effects and status. Do we need new rules, restrictions, and laws regulations for agricultural activity to fulfil the goals? More cooperation needed with other monitoring programs? Combinations of measures are most important. There must be a public involvement and results must be publically released. It is further necessary that national monitoring cover the most important production systems (crops and tillage methods). Changes will come in structure of national monitoring! Sampling frequency and sampling methods is still not decided. In JOVA we use composite water flow proportional sampling. Other use single sampling frequency weekly, monthly etc. Monitoring the water quality is necessary for documentation of effects of targeted measures. Existing NMPs will be involved! Even if focus is on water quality-measures must include activities in catchments.

Monitoring of surface waters – the Kaliningrad region, Russia.
By Nataliya Schagina, HydroMet - Federal Service of Russia for Hydrometeorology and Environmental Monitoring.

Kaliningrad region is located on the South-eastern coast of the Baltic Sea and is at the same time a state border of the Russian Federation with Poland and Lithuania. On the territory of Kaliningrad region there are 339 water courses with the total length of 5180 km, 150 lakes and ponds with the area of 61 km^2. Kaliningrad region drains to the Baltic Sea. The water area under control is 9.6 km^2 out of which 1.8 km^2 is inland waters, 2.8 km^2 is territorial waters of the Russian Federation (RF) and 5 km^2 is RF Economic Zone. Curonian (1.3 km^2) and Vistula (0.47 km^2) Lagoons are classified as inland marine waters. Basic RF normative documents are regulating organization and implementation of the national monitoring of surface waters. The Kaliningrad centre of hydrometeorology and environmental monitoring is a specially authorized national institution in the area of water monitoring in Kaliningrad region. Depending on objectives the monitoring of inland surface waters in the RF is divided into the following types; operational monitoring, background monitoring and special monitoring. A set of up to 28 hydrological, physical and chemical parameters are observed during the monitoring of water courses; here in 11 rivers and 2 lagoons. Several international activities in the area of environmental pollution monitoring are ongoing. The environmental and chemical monitoring of surface waters is under development like; an increase of number of sampling stations with account of “HOT SPOTS” and stations on trans-boundary water bodies along the border, extension of the list of controlled parameters with the hydro-biological characteristics which are the most outstanding indicators of the water environmental status, introduction of modelling systems and methods of prognostic calculations for forecasting the status of the water course and spreading of pollution. And adaptation of monitoring principles to the requirements of the EU Water Framework Directive in harmony with the Russian legislation and finally, carry out of a joint investigating monitoring on trans-boundary water courses with participation of the EU countries

Monitoring of surface waters in ther Leningrad Oblast, Russia.
By Aleksander Pertsovich, Reference Center of Rosselhoznadzor (FGU)

The main goal of the project is to reduce an impact of agricultural activities on pollution of Baltic Sea. To achieve this, five key actions are focussed on: 1) increase knowledge of workers and farmers on an impact of agriculture on environment through the implement of ecological educational programs and possible modifications of agricultural practises and through study tours to Sweden and Finland. 2) implement a system of agricultural management for industry and farms. 3) develop an effective mechanisms for application of law and norms to agriculture with respect to the environment and human health through possible adjustment of the existing legislation. 4) establish monitoring systems in small catchments, 5) implement recommendation from present project in 2006-2010. Specialists from FGU (previously CAS) carried out periodical observations on four catchments draining to the Baltic Sea. Measurements showed pollution with biogenic elements (nitrogen and phosphorus) originating from the agriculture practises. The investigated catchments were Neima river, Suma river, Suida river and Strelka river. For the whole of Leningrad Oblast a contribution from agriculture totalling 3090 Mkg N and 494 Mkg P is estimated. Estimations based on monitoring results gave an annual N-loss from 3730 - 4790 Mkg and P-loss from 330 - 590 Mkg. This has confirmed that agricultural activities in Leningrad Oblast contribute to the total mass of biogenic components run off to the Baltic Sea. Based on the preliminary estimates, current monitoring should continue and if possible being expanded to include ground water.

Nutrient and pesticide retention in constructed wetland filters treating diffuse agriculture pollution.
By Anne-Grete B. Blankenberg, Bioforsk - Norwegian Institute for Agricultural and Environmental Research, Soil and Environment Division

Agricultural runoff contributes considerably amounts of nutrients and pesticides to rivers and lakes causing water quality problems. Small constructed wetlands (CWs) in first and second order streams are a good supplement to best management practice (BMP) on arable fields, since water purification processes are stimulated. An experimental wetland was established in 2001 located in Lier, 40 km south of Oslo, Norway. The constructed wetland (~1200 m^2) receives water from an agricultural catchment of 0.8 km^2. Water entering the experimental wetland is distributed through a constructed vegetation filter into eight parallel wetland compartments constituted by; a mineral filter (L1), a algae filter (L2), a layered filter (L3), standard wetland (L4), shallow wetland (L5), open channel pared with flagstones (L6), wetland (L7) and barley straw (L8). The Total N - retention in the CW was 17 % in 2003, and 2% in 2004 probably caused by a higher hydraulic load. The organic filters performed better than the mineral filters. The ranking of the filter according to their TN retention was: L5 > L8 = L7 > L4 > L2 > L3 > L6 > L1. The TP retention in the CW was 45 % and 30% in 2003 and 2004, respectively. The ranking of the filter according to their TP retention was: L5 > L1 > L7 > L8 = L4 > L3 > L2 > L6. Only a fraction of the applied pesticides leached from the watershed. Pesticide leaching from the watershed increased with the hydraulic loading rate. The highest concentrations appeared directly after pesticide spraying. The pesticide retention varied from 11 – 42 % in 2003 and 19 - 56 % in 2004. The average pesticide retention for both years varied from 15 - 41 %. The ranking of the filter according to their pesticide retention was: L8, L6 > L2 and L3, L4 > L5, L1.

Monitoring of water quality in small catchments in FINLAND.
By Sirkka Tattari, Research Programme for Integrated River Basin Management Finnish Environment Institute (SYKE).

In Finland, approximately 6% of the total land area is arable land (2.2 mill ha). The objectives of the water quality monitoring in Finland are to monitor the diffuse nutrient losses from agriculture and forestry, to study the effects of hydrology and climate on nutrient leaching and use this data for the testing of water quality models. The present monitoring network was established in 1957 and constitutes of 37 catchments (0.1-122 km^2). The network was established originally for hydrological research (water supply, river regulation, water pollution control etc) and for continuous and accurate observations of runoff from land area of different types of climate, terrain and land use. The water sampling strategy is concentrated on high flow periods (March-May, September-November) and manual sampling takes place once a week in spring, weekly in autumn, a few samples during winter and summer. There is automatic sampling in 6 catchments (ISCO samplers). The analysis program for agricultural and mixed catchments are; el. cond., pH, alkalinity, turbidity, suspended sediments, PO4-P, Tot-P, Tot-N, NO3-N, NH4-N, Temp, Ca, Mg, Na, K, SO4, Cl, org. C. For forested catchments also the following parameters are analyzed: Fe, Mn, F and Al. In the future, more intensive monitoring is needed; more information about actual agricultural and forestry practices, on-line monitoring of water quality variables, the morphology of stream network and geological information as well as more detailed data on the amount and quality of soil and groundwater. Research priorities are detailed testing and application of nutrient leaching models in different river basins, process studies about erosion and nutrient leaching, the influence of climatic factors and land use conditions on water quality.

Monitoring and modelling in small agricultural catchments in Sweden.
By Katarina Kyllmar, Division of Water Quality Management, Swedish University of Agricultural Sciences.

In Sweden monitoring in small agricultural catchments started in 1988. A total of 22 catchments (in 2005) are monitored, where 14 catchments belonged to the regional programme and 8 catchments to the national programme. In the regional monitoring programme water sampling is done in stream outlets, manually every second week. Information concerning crop husbandry is collected irregularly. Additional financial contribution from the EPA for seven of these catchments was obtained to guarantee continuity. In the national programme, flow-proportional water sampling was introduced in 2004, before that water sampling in stream outlets were carried out manually every week. Pesticide monitoring is done in four catchments, with time-proportional sampling during May through November. Groundwater pipes (two locations in each catchment) with water sampling four times a year, analysed for nutrients and pesticides. Information concerning crop husbandry is collected for each field every year. The national monitoring programme of agricultural fields (13 fields in 2005) started in 1972. Water quality in drainage water and in groundwater is measured and annual information concerning crop husbandry is collected. Dynamic simulation of nitrogen leaching on field level with the SOILNDB model is done for several fields. Also calculations of N leaching for fields using coefficients are performed. Each field is given a coefficient based on field information; the average mean leaching for the fields is compared to measured N load in the stream outlet. From application on two monitoring catchments in the south of Sweden it was concluded that the potential effects on N leaching due to changes in agriculture (already implemented or possible) can easily be estimated by using coefficients. This method has large data requirements and time consuming simulations to produce the coefficients, but it is a simple and easy method.

Point source pollution in catchment runoff
By Adam M. Paruch, Norwegian Institute for agricultural and Environmental Research, Soil and Environment Division.

Environmental monitoring of agricultural dominated catchments needs to involve not only diffuse pollution but also point source pollution. This is due to agricultural and domestic wastewater produced on farms and settlements has also various contribution to the total pollution load from catchment areas. Direct discharge of untreated wastewater to ground or water is not allowed therefore, it is obviously that purification is required. However, it is not so evidently, what kind of treatment system can be use. In the rural areas of the Nordic countries, there are many places where the use of conventional centralised sewer systems becomes very expensive due to topography and long distances between the connected facilities. In many cases, the site conditions and new stringent local regulations do not allow traditional onsite septic tank with soil infiltration system. To avoid excessive piping distances, discharge of treated effluent will have to be made to small and vulnerable water environments, where most of the time small individual water supply systems are used. Therefore, there is additional need for robust low maintenance onsite systems with high treatment performance. For these purposes, the solutions could be natural based purification systems represented by constructed wetlands (CWs) and compact filter systems. In general, the systems consist of a septic tank followed by an aerobic biofilter (pre-treatment filter, pre-filter) succeeded by a saturated filter. CWs for Nordic climate conditions have been pioneered in Norway. They are usually vegetated by macrophytes, however during the cold season when the plants are dormant, the use of biofilter preceding the filter bed has been implemented. Compact filters are constructed in similar way as CWs, but they are not planted with wetland vegetation and the filter bed is substantially smaller. These systems produce a stable and high quality effluent throughout the year. Removal of organic matter can reach 97.0%, total nitrogen 40.0%, total phosphorus 99.4% and suspended solids 70.8%. Concentration of faecal indicator bacteria in effluents from the systems meets European swimming water quality and somatic viruses are not detected. No operational problems have been discovered. The systems give a good alternative for large-scale outside systems and compact package treatment plants, offering a solution for some regions where the area is extremely limited or where drinking water supplies could be affected.

Monitoring and assessment of nutrient losses from agricultural dominated catchments - Animal manure storage, pollution and treatment. By Niklas Bergman, Scanagri, Sweden.

Measurements indicated that large animal production farms represent a particularly important source of nutrient losses. To maintain the awareness on these major pollution sources, it is considered useful to document the potential losses from these sources. In addition, a strong focus on the environmental handling of manure at farmlevel is to be prioritised, including the incorporation of manure in nutrient management plan at farm level. The timing of the application of manure is important in realtion to nutrient needs of crops.

Monitoring of the Agricultural run-off in Latvia (1994 – 2005).
By Viesturs Jansons Department of Environmental Engineering and Water Management. Latvia University of Agriculture.

In Latvia, 2.4 million ha is agricultural land (6.4 million ha total land area) out of which 1.6 million ha is drained. The monitoring network in Latvia constitutes of three non-point source pollution monitoring stations (catchments). Bērze (368 ha) was established in 1968/1994 and has intensive farming, cereals and sugar beets with 80-90 % arable land of total area. Vienziemīte (592 ha) was established 1948 /1994, it has low input agriculture, agr. land 79 %, arable land 4-5 %. Mellupīte (960 ha) was established in 1995, average intensity with 60-70% arable land. Three non-point source pollution points (small catchments); Auce (53 ha, intensive farming, cereals), Skriveri (890 ha, average intensity of farming) and Bauska (750 ha, intensive farming, cereals, sugar beats). In addition there is three point source pollution monitoring points for large animal farms (pigs). Shallow ground water monitoring has been carried out since 2005. Runoff measurements are done with V–shape Crump weirs, triangular weirs for drainage fields and a tipping bucket system on small drainage plots. Soil, plant, nutrient and water relationships could be studied at the plot level (15 plots in Mellupite catchment), and nutrient leaching from soil with a different application of mineral or organic fertilisers for various crops might be examined in detail. Nutrient losses from arable land might be measured at a field level established in Berze, Mellupīte and Vienziemite catchments. Field scale run-off represents are integrated effect of farming practice, crop rotation, application of fertilisers etc. on the water quality. The integrated influence on nutrient run-off of variations in farming practices, erosion, soil and topography within the small catchment might be studied in a better way than in the field scale. In that scale emission rates (loads) that can contribute to the nutrient enrichment of surface water ecosystem can be examined.

The Estonian monitoring programme reporting to HELCOM and EUROSTAT.

By Arvo Iital, Institute of Environmental Engineering, Tallinn University of Technology.

In connection with the reporting to Eurostat, an estimation of the wastewater generation by source categories in 2004 was performed, both point and non-point sources were included. The pollution load from the following different source categories were calculated; non-point source pollution from agricultural land, atmospheric load, load from clear cutting areas, urban stormwater load, load from wetlands and forests. Non-point source pollution from agricultural land are calculated from an area specific load using data from two automatic agricultural monitoring stations and also from other rivers having higher share of agricultural land. The non-point source pollution from agricultural land covers different land cover types - based on the Corine Land Cover map of Estonia and the state statistics. The calculated agricultural load include loading from the scattered dwellings not connected to the sewage water systems. The share of human induced non-point source load to inland water bodies is 67% of TN and 52% of TP load. The share of agriculture from human induced load was found to be 93% of TN and 77% of TP. The natural and human induced area specific non-point load is 5.6 kg N/ha/a and 0.15 kg P/ha/a, respectively. Load from agricultural areas needs more precise evaluation. Automatic stations that cover different regions with different land-use intensity are necessary, using automatic discharge measurement and automatic sampling.

Abatement measures. The phosphorous index, development and application.

By Marianne Bechmann, Bioforsk - Norwegian Institute for Agricultural and Environmental Research, Soil and Environment Division

Simple risk assessment tools for agricultural phosphorus (P) losses, like the P index, have been developed in the U.S.A. and in some European countries. The phosphorus (P) Index, a risk assessment tool, is a simple approach used to rank the potential for P loss from agricultural fields. The P Index identifies areas where sources of P coincide with high risk of P transfer. Factors included in the P Index, developed for Pennsylvania, U.S.A. has been justified in relation to Norwegian conditions and relevant changes is made. For Norway, the P index approach comprises the risk related to both the source of P (soil P status, amount of fertilizer and manure as well as method of application, plant P release by freezing and P balance) and the risk related to transport of P (erosion, flooding, surface runoff, contributing distance, modified connectivity, soil profile, subsurface drainage). Management practices in the Index are adjusted to reflect the effect of time and method of P application on P loss, as well as erosion control measures relevant to agricultural management in Norway rather than Pennsylvania. We have applied the Norwegian P index to a small agricultural catchment, the Skuterud catchment (450 ha), in southeastern Norway and evaluated the availability and applicability of input data at field scale. Results from the validation showed that the Norwegian P index were well correlated (R^2 = 0.66) to the monitored P transfer and were able to detect fields and subcatchments with the highest monitored concentrations. Results also showed that the source factor was most important for the identification of high risk areas in Skuterud catchment. For the various variables included in the source factor, it was found that the soil P status described 66% of the variation in the source factor. Among the transport variables, it was found that both erosion risk and contributing distance had an important influence on the transport factor. Despite many identified uncertainties in the quantification of the various input-variables, the P index proved to be able to detect the areas with the highest monitored concentrations.

Monitoring results, abatement measures and information to farmer organisations; experiences from Sweden.

By Markus Hoffman, The Federation of Swedish Farmers – LRF

N and P losses from agriculture are a hot item on the environmental agenda in Sweden. The Swedish discussion is mainly focused on coastal conditions and the Baltic Sea rather than on groundwater and freshwater. Repeated algae blooming in the Baltic Sea maintains this opinion. The Swedish farmers used to deny these problems but are now aware and interested; this process has taken 15-30 years. There are many measures, but in principal there are only three ways of implementation; i) legislation, ii) economic incentives (taxes or subsidies) and iii) training and education. Which way are the most efficient? Each measure has its own most suitable way of implementation. Each country has its own mix of the three ways. Some have much legislation (Denmark) and some have a lot of different EU-subsidies (Finland). In recent years we have tried to explore the potential in training and education and invested 150 million SEK in a knowledge campaign. We have gained important experience from 22000 environmental farm visits during the last 5 years: 1- It is important to make repeated visits to change farmers' behaviour. Single visits are almost pointless. 2- The environmental advisor can not only talk about benefits for the environment but also point out positive effects on the farm economy. 3 - It is important to show the environmental progress to media and thereby make the farmers proud of their improvements. 4 - The farmer wants to see ecological effects of his/hers commitment. Reduced and N and P concentrations are not an ecological effect. This is a substantial challenge for scientists and monitoring experts.

Agricultural pollution – trend analysis
By Per Stålnacke, NIVA - Norwegian Institute for Water Research.

The presentation focused on time-trend analysis of nutrients in rivers and streams. Three examples were given; The Baltic Sea rivers 'story', the forest nitrogen saturation 'story' in Sweden and large-scale 'experiments' in Eastern Europe. The latter due to the dramatic land-use and emission changes since the early 1990's. Surprisingly few downward trends in Eastern Europen rivers has been observed. It was also shown that natural variation in nutrient losses/load (as the Baltic and nitrogen saturation cases) may impede the detection of existing trends. The basic conceptual/methodological statistical idea is: separation of slow and rapid variation, rapid variation and seasonal variation are natural fluctuations and gradual changes are due to human activities. Two basic methods for detection of environmental change are commonly used in the reporting of trends– 1)Significance tests for monotone trends (seasonal Mann-Kendall tests with adjustment for spurious trends in meteorological or hydrological variable and flow-adjustment (C/Q relationships) and test the residuals for trends and 2) Meteorological or hydrological normalization of environmental quality data (flow-normalisation of riverine loads (HARP Guidelines), e.g., by semi-parametric regression and 'roughness penalty approach'). It was concluded that time series data and assessment studies are crucial not only for scientific understanding and model validation but that it is also essential that we know how long it can take to detect the response of a river system to changes in agriculture and implemented measures, because such information is needed to allow environmental authorities and decision and policy makers to establish realistic goals (like in the implementation of the WFD). In addition, it was stressed that observed data is the only way to calibrate and validate models.

Agricultural extension in Norway

By Einar Strand and Stine Marie Vandsemb, Romerike Agricultural Extension Service, Norway.

The Norwegian Agricultural Extension Groups are a cooperative society, farmer owned and farmer led. The Norwegian Agricultural Extension Service has 83 groups all over Norway and gives crop production advisory service. The main idea is – local knowledge developed under local conditions. It has 28 500 farmers/members/owners and 250 advisors and assistants. They advise farmers in environmental related questions. Gives information on meetings, written information materials/website, has field trials (e.g. reduced tillage). They offer telephone contact and farm visits, offers individual advising, information of hydro-technical improvements and information of state grants to farmers' related to environmental issues (Regional Programme for Environment; plan with locally adapted measures).

Soil mapping at the Norwegian Forest and Landscape Institute

By Arnold Arnoldussen, Norwegian Forest and Landscape Institute.

The Norwegian Forest and Landscape Institute was established in 2006 as a merger from Norwegian Forest Research Institute, Norwegian Institute for land Inventory and Norwegian Genetic Resource Centre. The new national institute, associated with the Ministry of Agriculture and Food, will collect data and carry out research on forest, soils, mountains and landscapes. The institute will also disseminate information to the authorities, industry, and the public to contribute to the sustainable management and development of land resources. Organized soil mapping in Norway was started after the algae catastrophe 1988 – 1989 (North Sea agreement), with a mapping program in the watersheds feeding to North Sea and Skagerrak. The main objective was reduction of erosion and only agricultural areas are mapped. The soil database covers 4900 km^2 (by 2006), i.e. 50 % of Norwegian agricultural area. The scale is 1:15.000 and 0.4 ha is minimum mapping unit. Soil augering is used to determine the profile development, texture, organic matter, drainage and stoniness. The national soil classification system is based on WRB. Today field work is done by using a portable PC. Information on land use, orthophoto and DTM are then available. Location and orientation is done using GPS.

Advantages using PC in the field are: improvement in data quality, reduced costs and less susceptible for bad weather conditions. Disadvantages: technically advanced and backup is needed in case of technical problems. The soil database contains information on the characteristics (both physical and chemical) from each soil type. The soil geographical database gives information about the geographical distribution of soil types. Models are needed to produce thematic information – erosion risk and land capability. All maps are available in digital form and are available via internet.