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REPORT

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Abstract

The main project task has been further development of the current water monitoring system in Lithuania. Neris River catchment has been the pilot study area. The work have included laboratory and field work on water chemistry, benthic macroinvertebrates and phytoplankton. Water management has been a preferential task, including water quality criteria. Further, a pollution load model, TEOTIL, has been developed for Lithuanian conditions.

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1. Overvåking, elver, innsjøer	1. Monitoring, rivers, lakes.
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Project manager

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Head of research department

Preface

The project "Development of an efficient water quality monitoring system for the Neris River" was initiated by the Joint Research Centre (JRC) in Vilnius, the Norwegian Pollution Control Authorities (SFT) in Oslo, and the Norwegian Institute for Water Research (NIVA) in Oslo. The project is financed by SFT, and is a joint project between JRC and NIVA. Vilnius Regional Department Laboratory (VRDL) has also participated in the project.

The project has covered main aspects of monitoring, such as field work, chemical and biological laboratory analyses and water management, including water quality criteria and pollution load modelling. The project was planned as a five-year project. This report covers the work of the first four years. According to priority made by JRC water resources management was given the highest priority during the last two years.

Mr Tor S. Traaen

Norwegian project leader

Mr Bronislavas Giedraitis

Lithuanian project leader

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1. Introduction

1.1 Background and project establishment

According to White Paper no. 80 (1991-92), the Baltic States were among the main co-operative countries for Norway with regard to environmental assistance in countries in Eastern and Central Europe.

This project is based on the outcome of NIVA's and SFT's discussions with the Joint Research Centre and the Ministry of Environment in Vilnius, Lithuania, 22-24 January1995. The discussions covered a wide range of possible co-operative projects ranging from Pollution Assessment, Pollution Monitoring, Water Management Plans, Pollution Abatement Plans, Sewage and Industrial Effluent Water Treatment and Drinking Water Supply.

NIVA's broad offer of services was narrowed by the fact that several research and feasibility studies had already been carried out, or were running, in Lithuania. Several foreign consulting firms and institutions were assisting, such as: University of Montana and US EPA (USA), KI, Krüger Consult, Rambøll & Hannemann and COWI Consult (Denmark), and K-Konsult, ÅF-IPK and ANOX (Sweden). However, previous assistance from abroad had only to a minor extent resulted in training of local personnel, implementation of new systems, methodologies and technologies.

A main issue, put forward by Mr. Daubaras, at the Joint Research Centre concerning water management, was that there was a missing link between the collection of environmental data and the use of the data for water management purposes.

The outcome of the discussions was that NIVA should assist the Joint Research Centre in establishing an efficient "Water Quality Monitoring System for Nemunas River". The pilot project should focus on the river Neris, which is a main tributary to Nemunas. Neris flows through Vilnius.

The project should cover:

- localisation of monitoring stations;
- evaluation of :
    - the sampling frequency;
    - the parameters monitored,
    - the needs for automatic monitoring stations; and
    - the analytical equipment;
- data management and processing (i.e. data base and models);
- quantification of the degree of over-loading of the main pollutants;
- reporting routines; and
- assistance in implementing the new system.

The responsibility for the present monitoring programme in Lithuania is divided between 8 regional institutes, each with its own laboratory. It was agreed that the co-operative project should be carried out in one of the regions. NIVA's activities should not only cover a theoretical description of a new monitoring system, but should also include assistance during practical implementation of the new system, and adjustments whenever necessary. When the system is optimised and well functioning in the first region, it is planned to implement the system in the rest of the Nemuna's river system, and possibly in other regions of Lithuania.

The joint study team has consisted of experts from NIVA, JRC and the Vilnius Regional Laboratory.

The names of the team members are listed in Table 1.1.

***Table 1.1** Lithuanian and Norwegian team members.*

Issue	NIVA	JRC
Project leader, chemical water quality	Mr Tor Traaen	Mr Bronislavas Giedraitis
Water botany	Mr Pål Brettum	Ms Vida Mackeviciene
Water zoology	*Mr Thorleif Baekken*	Mr Bronius Augustnavicius Ms Daina Akiniene
Chemist, lab. equipment, analytical methodologies	Mr Håvard Hovind	Ms Aurelija Ceponiene
Data treatment, Modelling	Mr Torulf Tjomsland	Mr Boleslovas Binkauskas Ms Rita Tijunaite
Water management	Mr Stig A. Borgvang	Mr Edmundas Zablodskis Mr Balys Binkauskas
Regional laboratory		Ms Stase Siviene
Quality assurance/ advisor	Mr Dag Berge	Mr Arturas Daubaras *Mr Antanas Didziapetris*

1.2 The current water monitoring system in Lithuania

The main goal of the Lithuanian Surface Water Monitoring programme is to establish a quantitative assessment of long-term and large-scale changes in the environment, primarily given as an effect of human activities, as well as information about short-term variation in relation to e.g. flood forecasting and hydro-power production.

The main cause of surface and ground water contamination in Lithuania is insufficient treatment of municipal and industrial wastewaters, as well as pollution from diffuse sources. In 1997, approximately 233 million m^3 of wastewater were discharged into surface water bodies; 49% of the wastewater were treated to comply with the Lithuanian requirements for wastewater discharges, 34% were insufficiently treated and 17% were discharged untreated.

The Lithuanian monitoring system is based on hydrochemical, hydrological and meteorological networks. These networks are run by the Joint Research Centre (JRC) and the Lithuanian Hydro-meteorological Service, which both are part of the Environmental Ministry.

About 80-90% of the Lithuanian surface area is covered by the 85 hydrological gauging stations, which should enable assessments of general trends in water balance and the transboundary water flow. The hydrochemical network focuses on:

- Rivers;
- Lakes and Ponds; and
- The Baltic Sea and Kursiu Lagoon.

The river water quality monitoring is one of the longest operating state environmental observation systems in Lithuania. Some small river catchments, almost undisturbed by human activities, have been chosen in different geographical regions for observations of natural background values. The highest number of monitoring river sites is in the areas with industrial and farming activities.

The water quality is monitored in 47 rivers, at 100 sites, in an approximately 5000 km long network of rivers, with the aim to determining 70 physical, chemical and biological parameters (see Figure 1.1). Water pollution observation sites are mainly chosen downstream urban industrial and domestic sewage

discharge points, and at sites chosen for assessing the impact of intensive agriculture. Although the water quality is in general measured at the mouth of major rivers, it is also measured in transboundary rivers (at the borders).

From an environmental point of view, Lithuania is divided into 8 regional departments that are affiliated to the Environmental Ministry. The regional departments are located in:
Vilnius, Kaunas, Klaipeda, Panevezys, Siauliai, Alytus, Marijampole and Utena (see figure 1.2).

The departments have state laboratories of analytical control and cover measurements on every station belonging to the network. The range of analyses includes the most important chemical parameters of water quality such as BOD, COD, nutrients, anions and cations. The frequency of water sampling in a *basic programme* is once a month, i.e. 12 times a year.

The *specific programme,* run by JRC, has sampling frequencies from 2 to 4 times per year. It covers the analyses of toxic and organic substances such as phenols, pesticides, mineral oil, heavy metals and biological parameters, Coli bacteria, phytoplankton and benthos.

Internal and external quality control guidelines for state and department laboratories were developed in 1987. The internal quality control is performed every three months.

The laboratories are responsible for the operation and realisation of the monitoring network. The analysed data are sent to JRC every 3 months. They are stored in a central database. These data are used for preparation of the annual report and other specific purposes.

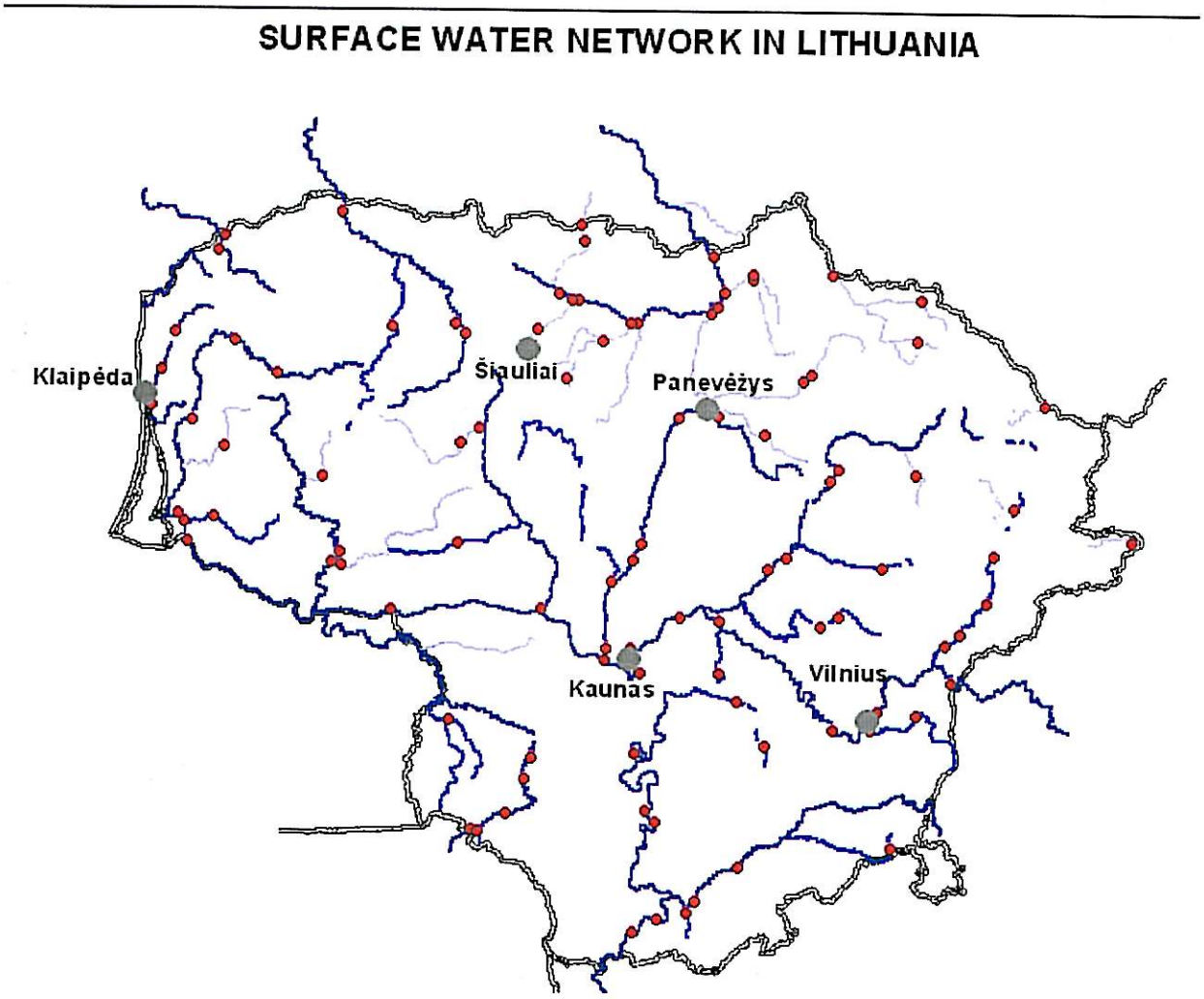

Figure 1.1 The surface water monitoring network in Lithuania.

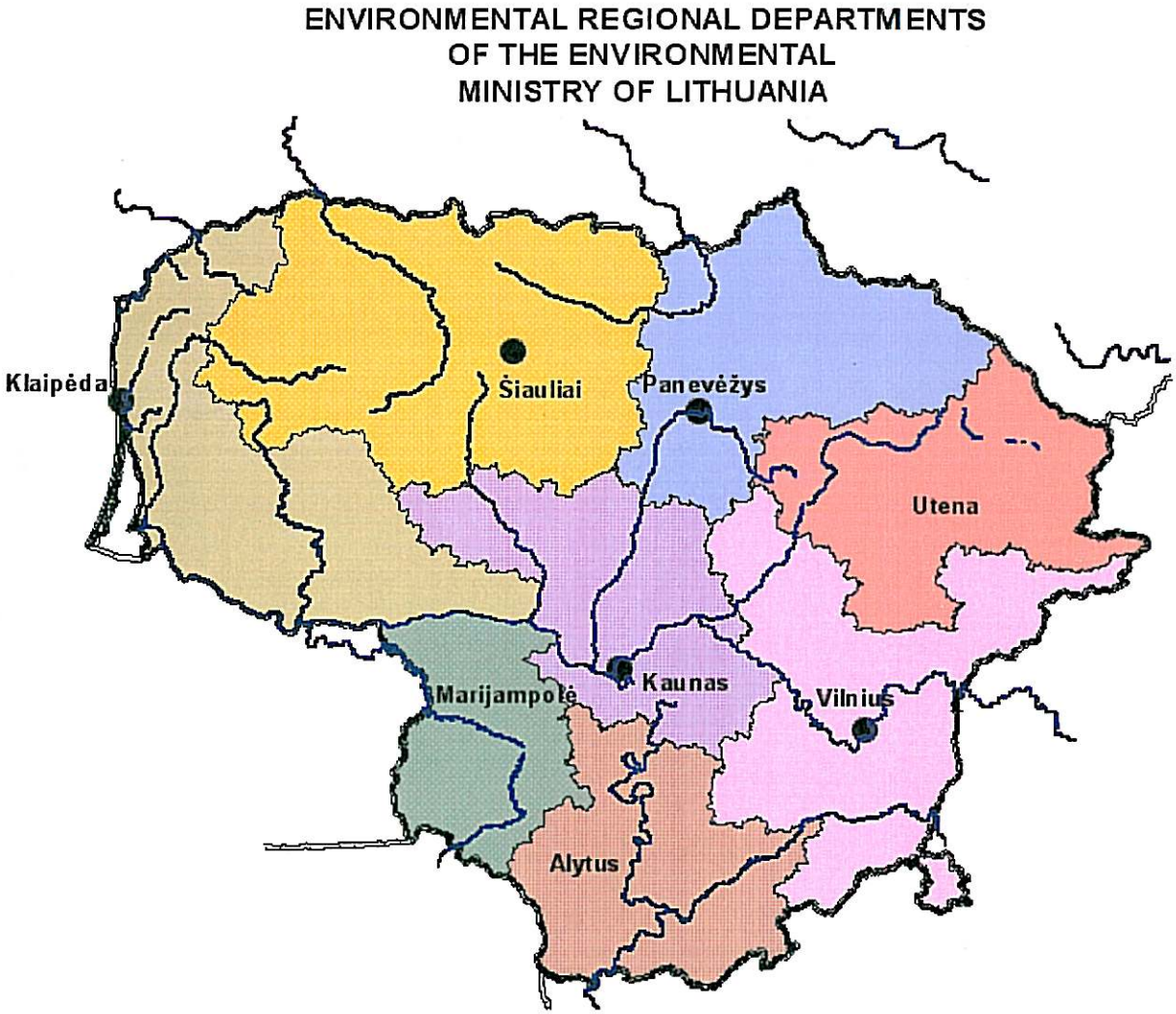

Figure 1.2 The 8 environmental regional departments in Lithuania.

1.3 Current water classification system in Lithuania

The main system for surface water quality classification in Lithuania is based on BOD_7, inorganic nitrogen (NO_3-N + NH_4-N), phosphate phosphorus (PO_4-P) and total Coliform bacteria. Class borders for the parameters and an example of surface water quality in Lithuania in 1997 are shown in Figure 1.3.

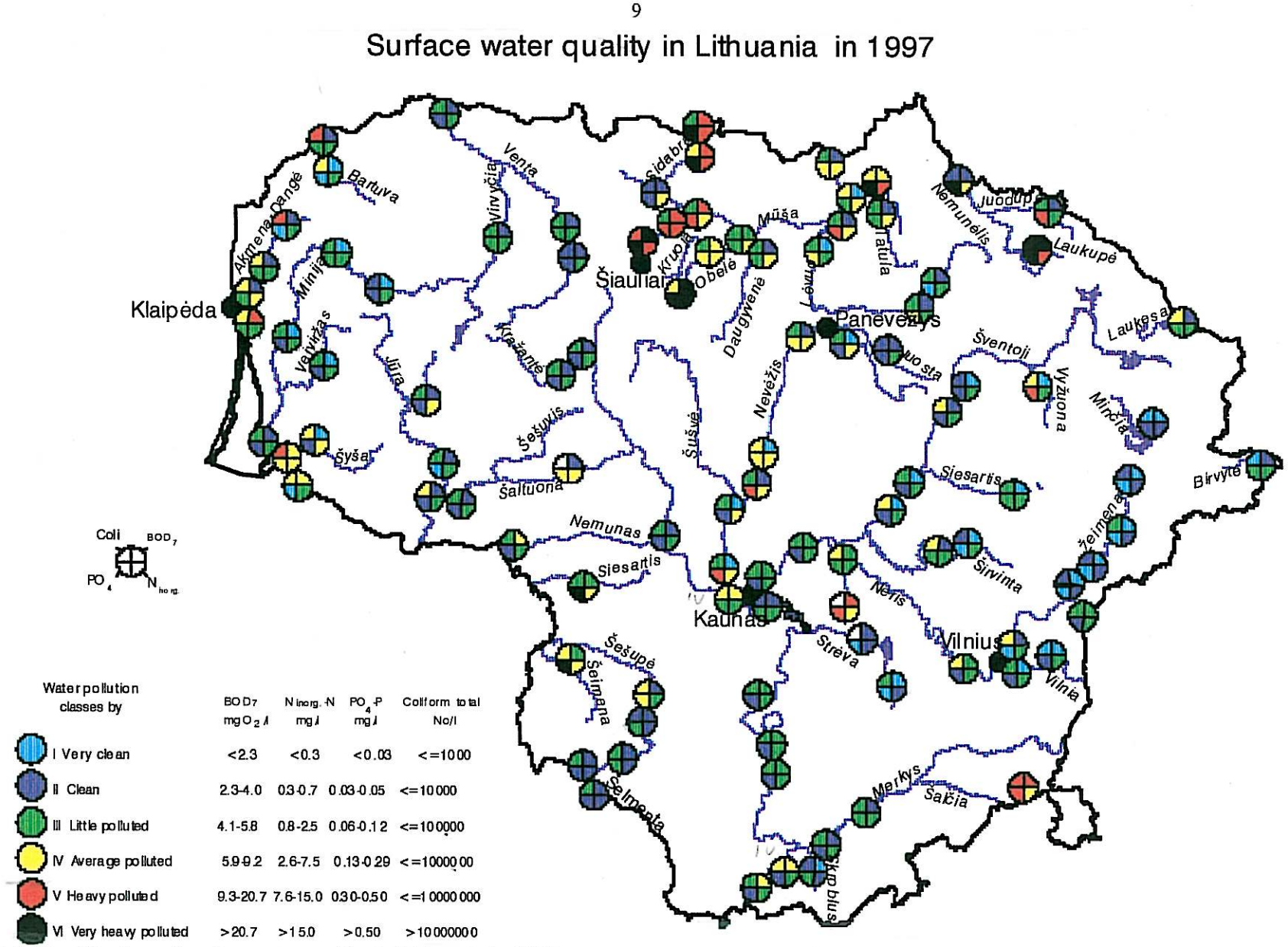

Figure 1.3 Classification of surface water quality in Lithuania in 1997.

1.4 Norwegian water classification system[1]

The main purpose of the Norwegian water quality classification system is to give different people in the central, regional and local administrations, consulting engineers and scientific researchers a uniform and objective tool for evaluation of environmental quality status and trends in Norwegian watercourses.

The system should assist in the development of goals for environmental quality, and "translates" environmental observations from biological and chemical parameters, and concentrations to concepts useful for decision-makers and of interest for the public.

System structure and limitations

Table 1.4.1 shows the classification of environmental *quality status* and *suitability* related to adequate usage of the watercourse.

Table 1.4.1. *Concepts used in the classification system.*

	Quality status		**Suitability**
Basis:	Based on measured concentrations		Adequate usage associated with a given water quality
Classes:	**Nutrients, org. matter etc.:** I = Very good II = Good III = Fair IV = Bad V = Very bad	**Micro pollutants:** I = Slightly polluted II = Moderately polluted III = Markedly polluted IV = Severely polluted V = Extremely polluted	**Four classes:** 1= Highly suitable 2= Suitable 3= Less suitable 4= Unsuitable

Classification of quality status is based on measured concentrations which have two components; a natural component which stems from natural processes in the catchment area, and a component which stems from human influence, *i.a.* acid rain, effluents from industry and sewage, and agricultural runoff. The latter is defined as 'pollution'. This is illustrated in figure 1.4.1.

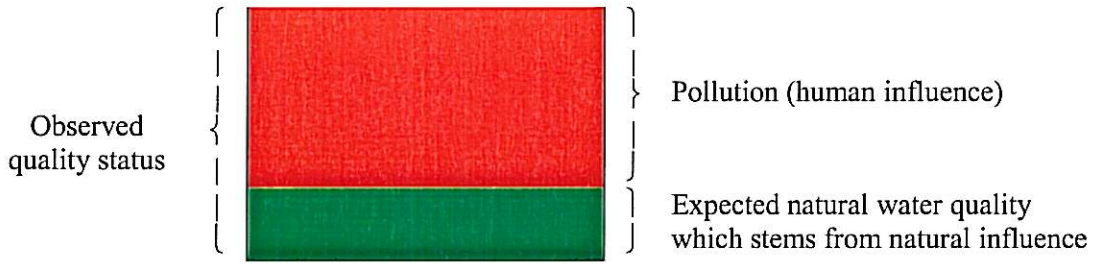

Figure 1.4.1. A measured quality status can be divided into an expected natural water quality and contributions from human activities.

The human influence on the water quality will vary substantially, and it is important to estimate the natural water quality when the goals for the water quality are set. As an example, figure 1.4.2 shows the expected natural water quality and the observed quality status for a shallow lake in the southeastern part of Norway.

[1] *This section is based on* SFT-guideline 97:04, ISBN 82-7655-368-0 and documents drafted by Mr Jon-Lasse Bratli (NIVA).

Table 1.4.2. *A typical shallow lake in the southeastern part of Norway with most of its catchment consisting of marine clay.*

	Quality class				
Effect categories:	**I**	**II**	**III**	**IV**	**V**
Nutrients					
Organic matter					
Acidifying components					
Micro-pollutants					
Particles					
Faecal bacteria					

Expected natural water quality

Observed quality status, when it is not identical to the expected natural water quality

The difference between the observed quality and the expected natural quality represents the pollution, and a goal for future quality should be between these two. A class II goal for particles in this lake is therefore meaningless.

The classification of suitability is based on the pollution control and health authorities evaluation of what is appropriate quality for different usage of the water i.e. for drinking water, bathing, fishing and irrigation.

Methods and data requirements

As shown in Table 1.4.3, there are 6 different effect-categories or pollution types in the system. Each of these effect categories has a number of parameters to describe the pollution types. Parameters in italic are so-called key parameters. The sampling frequency and calculation methods to be used to get the classification value are also provided. Each of the effect categories should be estimated. A general pollution class should not be elaborated, but each of the effect-categories should be treated separately. Some parameters, which are commonly studied, but not classified in this system, are included in the table in brackets.

Table 1.4.3. Requirements for classification of each of the effect categories.

Effect categories:	Ecosystem -type	Parameters	Sampling frequency	Calculation method
Nutrients	Lakes	*Total phosphorus* *Chlorophyll a* *Secchi depth* Primary production Total nitrogen (Orthophosphate)¤ (Phytoplankton) (Zooplankton)	At least monthly. Mixed sample, May-October. Deep-profile (3-5 samples) late-summer and late-winter	Arithmetic mean.
	Rivers	*Total phosphorus* Total nitrogen (Periphyton) (benthic fauna)	At least monthly.	Arithmetic or time-weighted mean.
Organic matter	Lakes	*TOC* *Colour* *Oxygen* *Secchi depth* COD Fe Mn	Deep-profile (3-5 samples) in spring, late summer, fall and late winter.	Arithmetic mean. Oxygen: lowest value Fe and Mn: highest values
	Rivers	*TOC* COD (Periphyton) (Benthic fauna)	At least monthly[#]	Arithmetic or time-weighted mean.
Acidifying components	Lakes and rivers	*Alkalinity* *pH* (Benthic fauna)	Spring, summer, fall and winter in lakes. Monthly in rivers.	Lowest value.
Micro pollutants (heavy metals)	Lakes and rivers	Dependent on problematic component(s)	Spring, summer, fall and winter in lakes. Monthly in rivers	Highest value
Particles	Lakes and rivers	*Turbidity* *Suspended matter* *Secchi depth (in lakes)*	At least monthly.	Arithmetic or time-weighted mean.
Faecal bacteria	Lakes and rivers	*Thermotolerant Coliform bacteria*	At least monthly.* Deep-profile (3-5 samples)	Highest 90-percentile.

[#] More frequent sampling in small rivers.

* If drinking or bathing interests (bathing season) prevail, weekly sampling may be necessary (ref. regulations for drinking water and bathing water).

¤ Measured in smaller rivers and in deep-profile in lakes.

Classification of environmental quality

The basis for the division of parameter values into quality classes is a combination of statistical information about the distribution of the substances in Norwegian watercourses, and knowledge about the substances' effects on the ecology in the water environment.

Table 1.4.4 shows the classification of the water *quality status*. The key parameters are listed in Italics.

Table 1.4.4. *Classification of the water quality status for nutrients, organic matter, acidifying components, particles and faecal bacteria.*

Effect categories:	Parameters	Quality class				
		I "Very good"	II "Good"	III "Fair"	IV "Bad"	V "Very bad"
Nutrients	*Total phosphorus*, µg P/l	<7	7-11	11-20	20-50	>50
	Chlorophyll a, µg/l	<2	2-4	4-8	8-20	>20
	Secchi, m	>6	4-6	2-4	1-2	<1
	Prim.prod., g C/m^2 y	<25	25-50	50-90	90-150	>150
	Total nitrogen, µg/l	<300	300-400	400-600	600-1200	>1200
Organic Matter	*TOC*, mg C/l	<2,5	2,5-3,5	3,5-6,5	6,5-15	>15
	Colour, mg Pt/l	<15	15-25	25-40	40-80	>80
	Oxygen, mg O_2/l	>9	6,4-9	4-6,4	2-4	<2
	Oxygen, %	>80	50-80	30-50	15-30	<15
	Secchi, m	>6	4-6	2-4	1-2	<1
	COD_{Mn}, mg O/l	<2,5	2,5-3,5	3,5-6,5	6,5-15	>15
	Iron, µg Fe/l	<50	50-100	100-300	300-600	>600
	Manganese, µg Mn/l	<20	20-50	50-100	100-150	>150
Acidifying Components	*Alkalinity*, mmol/l	>0,2	0,05-0,2	0,01-0,05	<0,01	0,00
	pH	>6,5	6,0-6,5	5,5-6,0	5,0-5,5	<5,0
Particles	*Turbidity*, FTU	<0,5	0,5-1	1-2	2-5	>5
	Susp. matter, mg/l	<1,5	1,5-3	3-5	5-10	>10
	Secchi, m	>6	4-6	2-4	1-2	<1
Faecal bacteria	*Thermotol. coli. bact.*, num./100 ml	<5	5-50	50-200	200-1000	>1000

2. Scope of work

2.1 Short summary of the main project issues

The Monitoring Programme development is based on the experience gained from the ongoing monitoring programmes both in Lithuania and in Norway. Particular attention has been paid to experience gained from the Norwegian National Pollution Monitoring Programme. This programme has been run for 15 years. The scope of work includes the following items:

- Choice of region- watercourse stretch and monitoring points
- Establishment of the study team
- Pollution types and sources - Water use
- Sampling frequency
- Analytical parameters
- Intercomparison- Quality control of analysis
- Joint field and laboratory work
- Sampling and transportation of samples
- Data equipment
- Data processing, including models for pollution load and water quality.
- Pollution abatement planning - Water management
- Presentation of the results
- Evaluation of the programme after some years of monitoring
- Implementation of the monitoring system in other parts of Lithuania

2.2 Choice of region, water course stretch and monitoring points

Out of the 8 regions, the Vilnius region was chosen, for practical reasons, as a pilot region. For the river monitoring study the river Neris, from the border with Belorussia to downstream Jonava, was chosen. This catchment has served as a model catchment. The sampling stations were the same as in the ongoing Lithuanian Monitoring Programme (Figure 2.1), i.e.:

1. At the border with Belorussia
2. Upstream Vilnius
3. Downstream Vilnius
4. Upstream Jonava
5. Downstream Jonava

For the purpose of exchanging experience with respect to methodology, the eutrophic Bebruko Lake in the Neris catchment was used for joint fieldwork.

The Nemunas catchment is 97928 km^2, of which 46700 km^2 are in Lithuania, 45450 km^2 in Belorussia, 2520 km^2 in Poland, 3170 km^2 in Russia and 88 km^2 in Latvia. The Neris catchment is 24942 km^2, of which 13850 km^2 are in Lithuania, 11005 km^2 in Belorussia and 84 km^2 in Latvia. The average water flow in Neris is approximately 75m^3/s at the border with Belorussia and 200 m^3/s at the confluence with Nemunas.

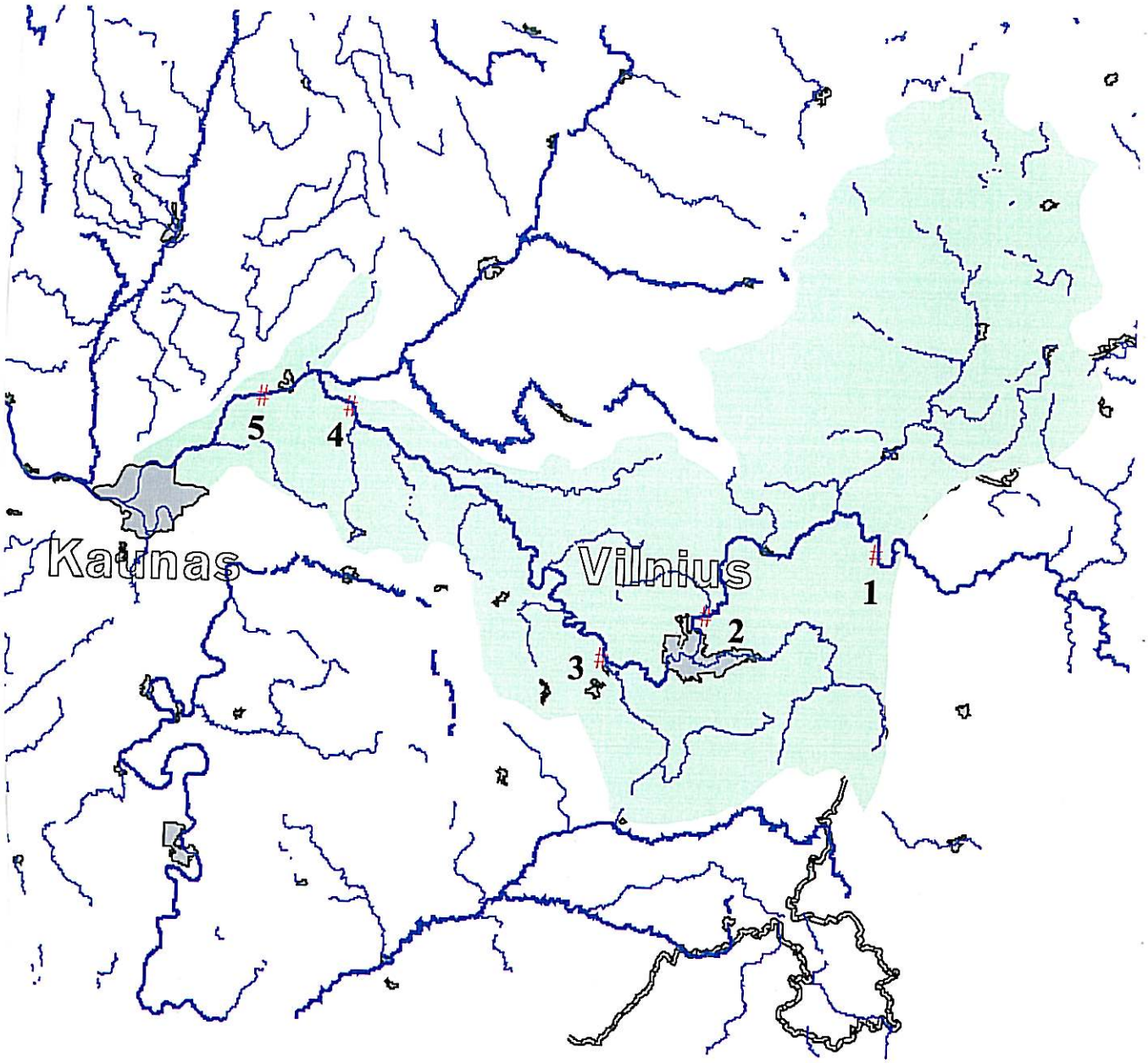

Figure 2.1. Monitoring stations in Neris River.

2.3 Pollution types and sources - Water use

Baseline information about the pollution types and sources, which are affecting the river, is essential to be able to design an effective monitoring programme. It is also important to gather information on the main water use interests confined to the chosen watercourse stretch.

A monitoring programme should not only register the environmental situation as such, but also be an 'active part' of the water management, and identify and quantify the need for pollution abatement measures. When measures have been implemented, the monitoring programme should register the improvements in the river, as a control of the effectiveness of the measures taken.
Table 2.1 below gives a general overview of the main pollution types influencing the Neris River. A detailed collection of such data is best carried out through a separate programme. Examples of collection, structuring and use of such data are presented in detail in section 5.

Table 2.1. *Main pollution sources in the Neris River catchment.*

Monitoring station	**Pollution sources**	**Discharges/losses**
1. Border to Belorussia	Hydropower	Losses of erosion products (particle pollution)
	Agriculture	Losses of nutrients and organic matter (erosion and manure)
2. Upstream Vilnius	Agriculture, forest	Diffuse run-off containing nutrients
3. Downstream Vilnius	Domestic sewage, pulp and paper factory, various small industrial plants	Non treated or poorly treated effluents containing nutrients, bacteria, heavy metals and organic matter.
4. Upstream Jonava	Agriculture and scattered dwellings	Losses of nutrients and organic matter
5. Downstream Jonava	Fertiliser factory, domestic sewage	Effluents containing nutrients and organic matter

Water user interests include the populations' different utilisation of the water bodies, such as drinking water supply, swimming, irrigation, fishing and boat transport. These user categories have requirements as regards the water quality. The monitoring programme should also enable an assessment of to what extent these standards are achieved.

3. Water chemistry

3.1 General issues

Water samples are in most cases collected manually at equal time intervals. Automatic monitoring stations restrict the number of parameters that can be monitored, but are useful in places where events of specific hazardous discharges are likely to occur. Occasional discharges of unknown substances are not likely to be detected by parameters that are available for continuous measurements. Hence, continuous monitoring of specific substances is more appropriate for industrial effluents where the potential hazardous substances are known, and where measures can be taken before the effluent reaches the river. Automatic stations should only be established when specific needs have been identified. Semi-automatic (portable) water samplers and a system for storing samples for later analyses if needed, may be an alternative to automatic measurements at sites where hazardous discharges are likely to happen. In general, adequate equipment and staff for the laboratory should have first priority, rather than automatic stations.

3.2 Water monitoring

3.2.1 Water sampling and parameters

Water sampling was performed manually by the Vilnius Regional Laboratory. Particular attention was paid to ensure that sampling was done at sites where the waters were well mixed. Downstream Vilnius, in the vicinity of the outlet from the main sewage treatment plant, 3 separate samples were taken across the river.

The Lithuanian water sampling system, including manual sampling by regional laboratories, ensures a rapid and safe transportation of water samples to the respective laboratories. In general, the analytical parameters measured will vary from station to station, depending on issues such as the actual pollution problems, the need for documentation of the water quality and the analytical facilities available. The most actual parameters were already part of the ongoing monitoring programme in the River Neris. Conductivity and turbidity were added to the programme. The project supplied one conductivity meter for the JRC laboratory and one for the Vilnius regional laboratory. One turbidimeter was given the VRC laboratory.

The following parameters were monitored during the joint monitoring programme:
pH
Conductivity
COD_{KMnO4}
TOC (only NIVA)
Turbidity (JRC and NIVA)
Ammonia
Nitrate/nitrite
Total Nitrogen
Total Phosphorus
Phosphate (PO_4-P)
Chloride
Sulphate
Calcium
Magnesium
Bicarbonate
Sodium
Potassium

3.2.2 Monitoring results

Monitoring results for Neris River from 1995-1997 of tot-P, tot-N, BOD and water flow are shown in figure 3.1. The results show high values of BOD_7 and nutrients in River Neris. However, the increase in BOD_7 from above the city of Vilnius to below the city was less in 1997 than earlier years. This is probably due to the start-up of the biological treatment of the Vilnius sewage treatment plant in May 1996. The increase in total P and N concentrations are also somewhat less in 1997 than earlier. From below Vilnius to above Jonava there is a marked increase in total P concentrations, while the concentration of total N decreased in 1995 and 1996, but increased in 1997. The concentration of total P decreases from above Jonava to below, probably mainly due to the dilution effect of the tributary river Sventoji. The data shows no obvious effect of the discharges from the nitrogen fertiliser factory in Jonava. The concentrations of total N are, however, highly variable from one year to another.

3.2.3 Additional lake-related parameters

Based on Norwegian experiences, it was suggested to include three additional parameters in the monitoring programme: chlorophyll "a", turbidity and Secchi depth. Chlorophyll "a " was determined by methanol extraction of filters and measured as absorbance at wavelength 665 nm, corrected for turbidity at wavelength 750 nm.

To date, only one series of data including the new parameters for lake monitoring, is available. The data of May/June 1998 from 6 lakes are shown in table 3.1. Table 3.1 also shows the water quality classification of these parameters according to Norwegian quality criteria (see section 1.4). Such classification should be based on the average values of the relevant parameters of 4 to 6 samples during the summer season. It is included only to illustrate the system.

In figure 3.2 the parameters are plottet against each other for correlation purposes. As expected, there is a relatively good correlation between turbidity and Secchi depth. There is also good correlation between turbidity and total phosphorus, but surprisingly not between total phosphorus and chlorophyll, or chlorophyll and turbidity. This indicates that a substantial part of total phosphorus is connected to particles other than phytoplankton (probably erosion particles). This picture may be altered when additional data becomes available. Apart from 2 outlayers, there seems to be a relatively good correlation between chlorophyll and Secchi depth. This indicates that phytoplankton affects the Secchi depth values more than the other particles that create most of the turbidity.

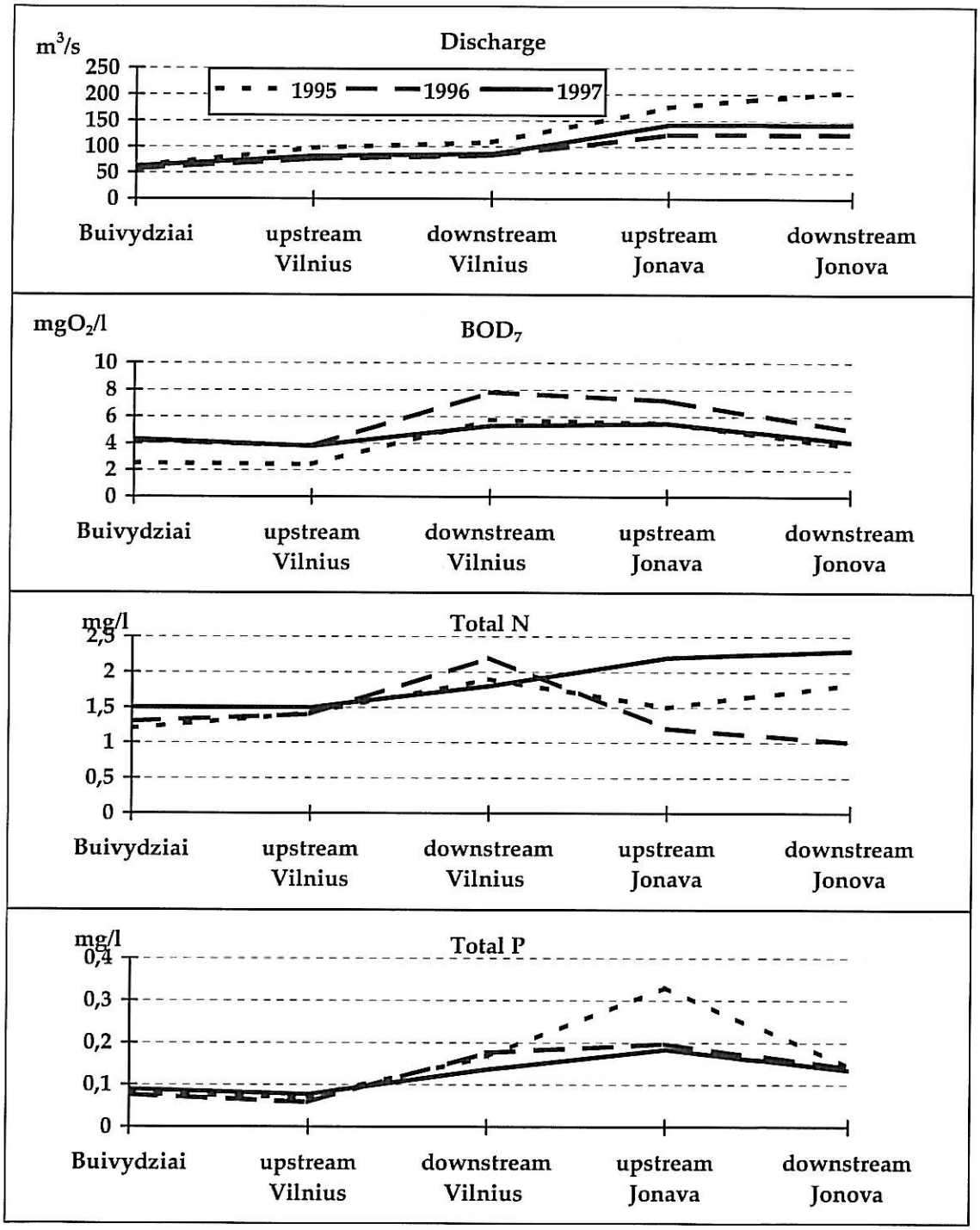

Figure 3.1 Monitoring results from Neris River in 1995-1997.

Table 3.1 *Monitoring data from 6 lakes, and classification of water quality according to the Norwegian water quality system*

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Date	Station	Chlorophyll a		Secchi disk		Total phosphorus		Turbidity	
		µg/l	Class	m	Class	mg/l	Class	NTU	Class
1998 05 07	**lake Dusia**								
	south part	9,30				0,029		0,57	
	east part	5,0				0,040		1,24	
	centre part	9,15				0,014		0,56	
	west part	2,63				0,026		1,05	
	north part	4,90				0,042		0,90	
	Average	**6,20**	**III**			**0,030**	**IV**	**0,86**	**II**
1998 05 19	**lake Tauragnas**								
	west part	0,75		4,5		0,023		1,70	
	north part	1,53		4,2		0,023		0,74	
	south part	1,04		4,0		0,029		0,82	
	Average	**1,11**	**I**	**4,2**	**II**	**0,025**	**IV**	**1,09**	**III**
1998 05 26	**lake Lukstas**								
	west part	5,93		2,2		0,091		(11,03)	
	centre part	4,43		2,1		0,055		2,91	
	east part	5,58		2,2		0,054		3,66	
	Average	**5,31**	**III**	**2,2**	**III**	**0,067**	**V**	**3,29**	**IV**
1998 05 26	**lake Plateliai**								
	west part	5,80		6,0		0,014		0,32	
	centre part	4,64		6,0		0,014		0,31	
	Average	**5,22**	**III**	**6,0**	**II**	**0,014**	**III**	**0,32**	**I**
1998 06 03	**lake Rubikiai**								
	north part	7,12		2,7		0,017		0,77	
	centre part	5,32		2,8		0,017		1,20	
	south part	5,05		2,7		0,023		1,52	
	Average	**5,83**	**III**	**2,7**	**III**	**0,019**	**III**	**1,16**	**III**
1998 06 11	**lake Sventas**								
	south part	2,05		3,6		0,027		0,29	
	centre part	1,45		3,5		0,021		0,29	
	north part	1,87		3,5		0,025		0,29	
	Average	**1,79**	**I**	**3,5**	**III**	**0,024**	**IV**	**0,29**	**I**

Water Quality classes: I: very good, II: good, III: fair, IV: bad, V: very bad

Parameter	Quality class				
	I "Very good"	**II "Good"**	**III "Fair"**	**IV "Bad"**	**V "Very bad"**
Total phosphorus, µg/l	<7	7 - 11	11 - 20	20 – 50	>50
Chlorophyll a, µg/l	<2	2 – 4	4 - 8	8 – 20	>20
Secchi dept, m	>6	4 – 6	2 – 4	1 – 2	<1
Turbidity, FTU	<0,5	0,5 – 1	1 – 2	2 – 5	>5

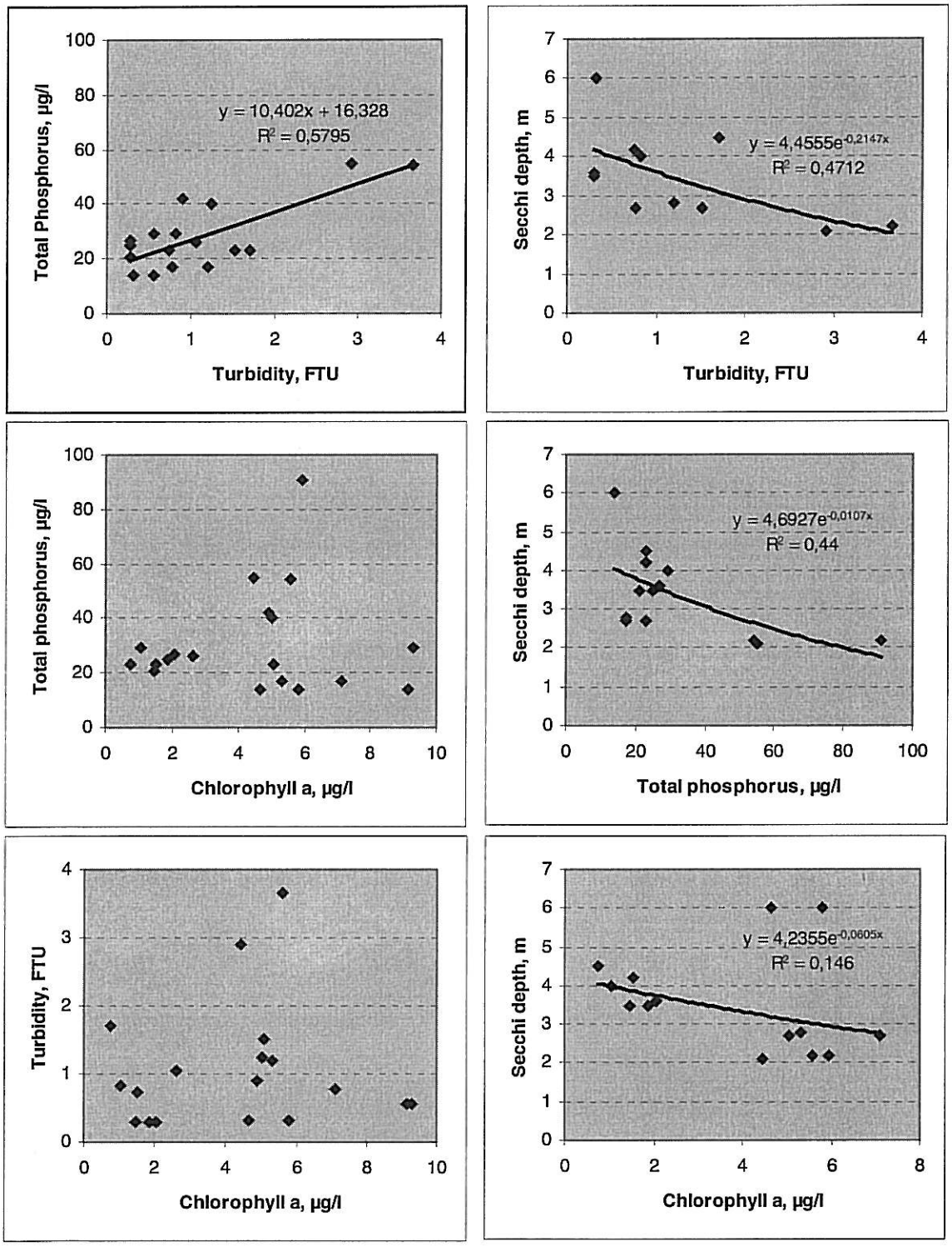


Figure 3.2. Correlation between lake monitoring parameters from 6 lakes in May/June 1998.

3.3 Intercomparison and quality control

3.3.1 Internal quality control procedures

The aim of internal quality control is to ensure that the laboratories are able to maintain a high level of quality in routine analyses. Internal quality control procedures for JRC and Vilnius regional laboratories were established in 1995. Until then, the Russian methodical guideline "Control systems of measurement results precision" was applied.

The internal quality control includes procedures for analysing nutrients, BOD, COD, major ions and suspended solids. The laboratories carry out the internal control programme "Quality", developed by the Water Quality Institute, VKI, in Denmark. The programme includes:

- One blank per run.
- One duplicate for precision test (at least for every 20 routine samples).
- Two standard samples for calibration check and one control sample (at least one for every 20 routine samples) for accuracy and bias check in each run.
- One spiked sample for recovery-check in the presence of a sample matrix.

3.3.2 Intercomparison- Methods and results

In February and March 1997, a double set of samples were taken from the river Neris and sent to the Vilnius Region Department Laboratory (VRLD) and the Norwegian Institute for Water Research (NIVA) for analysis. Acceptable comparability was achieved for all of the samples of pH, chloride, calcium, potassium and chemical oxygen demand, and acceptable comparability for most of the samples for nitrate + nitrite, total nitrogen, total phosphorous and magnesium.

For conductivity, alkalinity, sulfate, phosphate, ammonium, silica and sodium, the differences were too high. For most cases, the difference may be explained by the different methods used. However, for some variables an acceptable explanation for the observed differences between the laboratories are to be found.

In 1998 a second intercomparison, involving 3 laboratories (JRC, VRDL and NIVA) was performed.

In March and May 1998, water samples were collected at five stations in the river Neris for chemical analysis. At each station the sample was split into three equal sub-samples, one set of samples was brought to the Joint Research Centre (JRC), on set to Vilnius regional Department Laboratory (VRDL), and one set was mailed to the Norwegian Institute for Water Research (NIVA).

The sampling stations were as follows (see Figure 3.1):

Near Buivydziai
Upstream Vilnius
Downstream Vilnius, middle
Upstream Jonava
Downstream Jonava

The comparability between the laboratories are illustrated by correlation diagrammes, the results of one laboratory are plotted against the results of the other laboratory, as shown in figures A3.1 – A3.16 in Annex 3. The 45 degree line in the figures represents the ideal case were the analytical results of the two laboratories are indentical.

The water samples were delivered to the Lithuanian laboratories the day of sampling, and analysed during the following days. To NIVA, the samples were transported by air, however, because of

various transport problems, the delivery of the samples was delayed. Thus the samples taken 24. March arrived at NIVA 4. April, and the samples taken 19. May arrived at NIVA 25. May.

The analytical results produced by the three laboratories are compared in this report, and the measured values are presented in Annex 3.

pH

pH was determined at all three laboratories by electrometric measurement, VRDL and NIVA applied a combined glass and silver/silver-chloride electrode, while JRC used a glass electrode and a reference electrode. The laboratories performed the determination at room temperature, and all three laboratories applied automatic temperature compensation. The temperature in the solution may affect the pH value measured considerably, e.g. at 25 °C the neutrality point is 7.00, whereas at 0 ° this neutrality point moves to 7.5 and at 60 °C to pH 6.5.

The results from NIVA (both in the March and May samples) and VRDL (March samples) clearly indicate that the pH value is increasing down the river. The pH values reported from JRC are varying downstream. There is also observed a clear increase in pH from March to May, however, the increase is rather different at the three laboratories. Thus the average increase at JRC is 0.63 pH units, at VRDL 0.90 and at NIVA 0.43 pH units. This demonstrates that the comparability between the three laboratories is rather poor for this variable.

Figure A3.1 illustrates that, on average, the pH results from VRDL are 0.28 pH units lower than the NIVA values for the March samples while, for the May samples, the VRDL values are 0.19 units higher than the NIVA results. Comparing the JRC and NIVA data, on average, the JRC results are 0.07 and 0.29 units higher than NIVA's. As all three laboratories applied automatic temperature compensation during the pH measurement, the differences between the laboratories cannot be explained by temperature effects.

As NIVA received the samples some days after the sampling, a possible storage effect may have affected the measured pH values from this laboratory. Especially the May samples may have been affected by the high temperature, which was about 30 °C at the sampling site. However, the samples were analysed at the same time at the two Lithuanian laboratories, which means that the difference was not caused by storage effects.

As the differences in the pH values are varying both between the laboratories and between series of samples, there may be contributions from several sources of errors causing the observed differences. It is likely that the main explanation for the differences between the laboratories may be caused by differences in the calibration routines of the instruments. A proper internal quality control routine is also necessary to ensure good comparability between the day to day measurements.

Conductivity

The laboratories determined conductivity by electrometric measurements, applying instruments equipped with automatic temperature compensation. The temperature correction is definitely necessary for this measurement, as the conductivity is increasing by 2 % per degree at temperature range of 20 – 30 °C.

The conductivity value increases downstream the river, which is clearly documented by the results from all three laboratories, and for both set of samples. The results from JRC and VRDL for station 4 in May are atypical in this respect. A similar trend is also observed for some other analytical variables.

Figure A3.2 illustrates that there is close to constant difference between the results of the laboratories. The differences between the results from NIVA, VRDL and JRC respectively are, on average, 9.1 and

8.6 % in March, and 8.8 and 3.8% in May. This may be caused by wrong temperature correction. If the temperature compensation system is not controlled properly, this may lead to day to day variations in the measured values.

A good routine for internal quality control is therefore very important, to ensure that the adjustment of the "zero point" of the instrument is not affected, and also that the cell constant is correct at the different days of analysis.

Considerable variations between the results of the laboratories were also observed in the series of samples analysed at different times in 1997.

Alkalinity

The laboratories determined alkalinity by titrimetric methods, but the methods used were relatively different. NIVA titrated the samples with 0.01 mol/l hydrochloric acid to pH = 4.5 according to the ISO Standard 9963-1:1994. The results are usually reported in mmol/l. These numbers are therefore multiplied by 61 to transform the results to mg/l HCO_3^-. JRC and VRDL titrated the samples with sodium tetraborate, using a mixture of methyl red and methylene blue as indicator, which changes colour at pH = 3.

The use of different titrant and different indicator may lead to systematically different results for alkalinity, as alkalinity varies significantly with different end-point pH used. However, the results, illustrated in the Figure A3.3, show that JRC and NIVA obtained results with good comparability, while the results from VRDL are significantly lower than the other laboratories' results. The difference is approximately the same for the March and May samples.

It is very important to use a control solution, which should be checked against international intercomparison solutions, as there is no certified materials for this variable, to ensure that the results are comparable from series to series of samples, and also comparable to international Standards.

Nitrate-nitrogen

There are some differences between the methods used by the laboratories. JRC and VRDL used sulfanilic acid as diazotation agent, while NIVA used sulfanilamide. As coupling agent, all three laboratories used the same reagent, namely N-(1-naphthyl)-ethylene diamine. The determination step was performed manually with a filter photometer at JRC and VRDL, using wavelength 510 nm, while NIVA used an automated photometric method measuring the colour development at wavelength 540 nm. The detection limit with the automated method is about 1 µg/l N, and thus the precision at low concentrations is probably better than with the manual method.

The results for the March samples are systematically higher at NIVA than JRC by approximately 40 %. This difference, which is clearly illustrated in the Figur A3.4 B, is probably caused by the different methods used. JRC and VRDL filtrated the samples before analysis. NIVA did not filtrate the samples, but the samples were stored in such a way that the particulate matter was allowed to settle before analysis. The turbidity values measured at NIVA indicate that particles will not make any significant problems for the photometric methods

The concentration of nitrate decreased strongly from March to May, however, in both periods the concentration increased downstreams. The results obtained by JRC and VRDL for the sample from station 4 in May are therefore probably too low.

Ammonium-nitrogen

The method used in Lithauen is the ISO method using sodium dichloroisocyanurate (trione) and sodium salicylate solution for the colour development, and measurement of the absorbance at 670 nm. This method is performed manually. NIVA is using an automatd photometric method using sodium hypochlorite solution, and measurement at 630 nm. The precision of the automated method is probably far better than the manual method at the low concentration range to be analysed in these samples.

The results for ammonium are presented in the Figure A3.5, which clearly shows that there is no comparability between NIVA and the two other laboratories. The comparability between JRC and VRDL are acceptable. For ammonium there are several effects that may affect the results. Contamination is a severe problem at low concentrations, and this problem has to be controlled at the laboratory and for the sample bottles.

Another important factor in summer time is the temperature, in May it was very warm during sampling and mailing the samples to NIVA. This may affect the biological activity in the samples, which in turn may affect the ammonium concentration in the sample. The best way to prevent such problems is to preserve the subsamples for ammonium determination with sulfuric acid immediately after sampling.

Nitrite-nitrogen

This variable has been compared for JRC and VRDL in the samples from May, and the comparability is good. This variable has to be determined as fast as possible after the sampling, and are not suited for several days transport.

Total nitrogen

The samples were digested with alkaline solution of peroxodisufate in autoclave (pressure cooker), and then determined as the sum of nitrate and nitrite. This principle was followed by all three laboratories.

The results are illustrated in Figure A3.7. The comparability between the laboratories is varying from one series of samples to another (e.g. JRC and NIVA in Figure A3.7 B) and between the laboratories. All laboratories found that the nitrogen concentration is increasing downstreams, but NIVA has 34 % higher result on average for the March samples than JRC, unfortunately VRDL did not report results for these samples. In May NIVA reported 18 % lower results on average. For the May samples VRDL also reported higher results than NIVA, however, the comparability between JRC and VRDL are acceptable (less than 10 %).

The turbidity measured by NIVA demonstrates that the content of particulate matter is probably twice as high in March compared to May. If the digestion is not effective enough, this may lead to lower results. NIVA used an autoclave for the digestion process, while JRC and VRDL used a kitchen pressure boiler. The temperature should not be very different in these to systems, however, there is no documentation of the pressure (and thus the temperature) in the kitchen boiler. NIVA digested the total sample. If the samples had been filtered before digestion, the results would have been much lower.

Total phosphorus

Acid digestion with peroxodisufate in pressure cooker or autoclave was used for the pretreatment of the samples. The determination was performed with the molybdenum blue method, ascorbic acid is used as reduction agent at all three laboratories. NIVA used an automated photometric method for the determination step, and measured the absorbance at 880 nm. VRDL and JRC used manual determination with filter photometer at 670 nm. This wavelength is more susceptible to possible interferences, e.g. from silica and other compounds.

The phosphorous concentration is increasing from station 1 to 3 (after Vilnius) where it has its maximum. The same pattern is observed at all three laboratories, except for the May series of samples at VRDL where the results are varying a lot from station to station. It is not likely to believe that the concentration should vary as much as these numbers indicate.

Except for one result, the comparability between VRDL and NIVA is reasonable, compared to JRC the results of NIVA is lower (17 % on average). The correlation plot between JRC and VRDL shows more random spread of the results.

Phosphate-phosphorus

Both NIVA and VRDL laboratories use the molybdenum blue method for the determination of this variable, and as mentioned under total phosphorous there are some differences in the routine of determination. As the concentrations reported for some of the samples are rather close to the detection limit of the manual method, the uncertainty is greater than for the automated method where the detection limit is 0.5 µg/l P.

There is a nearly constant difference between the results from VRDL and NIVA for the March samples, NIVA reported on average 22 µg/l higher results than VRDL. The May results are more spread out, indicating that random effects may contribute to the results. As the data from March indicate that there is a maximum in the concentration at the station after Vilnius, just as for total phosphorus, it is quite likely that the variations in phosphate concentration from one station to another reported by VRDL is caused by random effects.

A study of the internal quality control results may contribute to the explanation of which sources of error may be dominating, provided that the control solution is comparable to the natural samples.

Chemical oxygen demand, COD-Mn

The chemical oxygen demand is determined by a redox titration of excess of permanganate after the digestion of the samples on a water bath. The comparability of the results from the three laboratories are acceptable, except for some very few results.

Chloride

The comparability of the results for this variable is illustrated in Figure A3.11. It is very great difference between the method used by NIVA and the two other laboratories. NIVA used ion chromatography with suppressor column, which has a detection limit of 0,2 mg/l. JRC and VRDL used manual titration with mercury thiocyanate solution with a detection limit of 5 mg/l. The measured concentrations are about the twice of this concentration, however, the uncertainty is rather great as demonstrated by Figure 11 A.

The synthetic solutions normally used in intercomparisons, and also for internal quality control samples, are not affected by the same problems as we find in natural samples. Therefore we often observe good results in such intercomparisons, while the picture in Figure A3.11 is dominating when natural samples are compared. However, the comparability between the two lithuanian laboratories is good, as illustrated in figure A3.11 C, and is due to the fact that these two laboratories are using the same method. The interferences affecting the two different methods will affect the results produced by the two methods in quite different ways.

Sulfate

If the picture was rather bad when comparability of chloride was concerned, the picture is still worse when we look at Figure A3.12 where the sulfate results are plotted. The results of NIVA are higher than the VRDL results, while the situation is on the contrary compared to the results from JRC. Comparing JRC and VRDL, just as in Figure A3.12 C, the picture is still worse. The concentration is according to the NIVA numbers increasing down the stream, while the trend is more variable results at the two other laboratories.

The VRDL and JRC laboratories used a manual, turbidimetric (photometric) titration method with bariumchloride - thorine for the determination of sulfate. The detection limit of this method was 2 mg/l. NIVA used ion chromatography, where the detection limit is 0.2 mg/l. This method is far more precise than the manual method. Therefore it is possible to observe the small change in the sulfate concentration downstream. The photometric method is affected by the presence of particulate matter in the samples, while the particles are removed before the analysis.

Calcium

The results for calcium are presented in Figure A3.13, and show reasonably good comparability between the three laboratories. There is one exception, for station number four in the May series of data VRDL and JRC have lower results than at the other stations, these two results are probably too low as other series of data show that the calcium concentration is increasing downstream.

At JRC and VRDL calcium was determined by complexometric titration with EDTA, and using Eriochrome Black T as indicator. The detection limit for this method is about 1 mg/l, however, the concentrations of the samples analysed are much higher and should not make any problems in this monitoring. NIVA used an instrumental method, ICP, for the determination of this metal.

Magnesium

In Figure A3.14 the results for magnesium are illustrated, and it is quite clear that the comparability between the laboratories is far worse than for calcium. There are great systematic differences between the results reported by the laboratories, and this may be explained by the methods used.

NIVA used an instrumental method, ICP, for the direct determination of magnesium in the samples. JRC and VRDL applied an indirect method based on complexometric titration. The hardness (the sum of calcium and magnesium) was determined, and then the calcium value was determined separately and subtracted from the hardness. The uncertainty of this technique is much worse than a direct determination of the element.

Sodium and potassium

The sodium and potassium results are presented in Figure A3.15 and A3.16, respectively, and the comparability between the laboratories is rather varying. Thus the comparability between JRC and VRDL is reasonably good, while the results from VRDL are about 50 % higher for sodium. The difference is, on average, less than 20 % for potassium.

All three laboratories are using an emission technique, however, there are rather great differences between them. NIVA used ICP which have a high temperature plasma, and the results are showing an increasing concentration of the element in the samples downstream. VRDL and JRC used flame photometry, and the high concentration of dissolved compounds may affect the flame photometric method more than the ICP method. The possible effect may be different at JRC and VRDL as the two laboratories used quite different instruments.

Conclusions

Three laboratories were involved in the intercomparison in 1998. The experience this year is much the same as last year. For some analytical variables the comparability is acceptable, while for others it is not. There are differences between NIVA and the two Lithuanian laboratories, and also between the two Lithuanian laboratories. Some of these differences have so far not been explained satisfactory, and there should be made attempts to find these explanations as soon as possible. In some cases it may be that the conclusion is to use more modern instrumental methods for trend analysis purposes, i.e. ion chromatography and atomic absorption.

An internal quality control program has been described at the laboratories, and it must be stressed that it is very important that this control program is followed every time the analyses are performed. It is also important that there are clearly defined action limits for analytical discrepancies, which imply immediate actions if they are exceeded.

4. Water biology

Water biology is a very important part of a monitoring system. The biology reflects the joint effects of physical and chemical aquatic environments, not only at the time of sampling, but for some time prior to the sampling.

Benthic macroinvertebrates represent the most common group of organisms used for monitoring water quality in rivers. Phytoplankton is the group most commonly used for monitoring lakes. To assess the biological monitoring, JRC and NIVA carried out joint field work in Neris River (macroinvertebrates) and in the Bebruko Lake (Phytoplankton).

4.1 Joint benthic macroinvertebrate studies in the Neris River.

4.1.1 Methods

Benthic invertebrates were sampled on June 1-2 1996 in rapids at five locations in the River Neris; namely at Buivydziai, upstream and downstream Vilnius and Jonava, and at one locality in the tributary Sventoji (Ukmerge). The latter locality is assumed to be an unpolluted reference locality.

The fauna was sampled using a standard method: Kick sampling for 3 times 1 minute, using a handnet with a mesh size of 0,25 mm. Only riffle areas in the rivers were sampled.

The following indexes have been used for assessment of the environmental quality of the rivers in relation to their biology:

BMWP (Biological Monitoring Working Party). A selection of macroinvertebrate families are ranged on a scale of index values 1-10 according to their tolerances of pollution. The community tolerance level is the sum of index values for each family (Armitage et al 1983). High values indicate good water quality.

ASPT (Avereage Score Per Taxon). This is the community BMWP index devided by the number of score families of the community: ASTP=sumBMWP/no. families (Armitage et al 1983).

Danish Fauna Index. The presens/absence of key/indicator groups (species or higher taxa) are registrated. In combination with a set of "diversity" groups", the registered keygroups ends up in a index value (1-4) indicating a more (high value)or less (low value) polluted river (Andersen et al 1984).

EPT-species. The number of species of the macroinvertebrate taxa Ephemereoptera, Plecoptera and Trichoptera.

Biotic index of JRC resembles the Danish Fauna Index, however, high values of Biotic index indicate good water quality.

4.1.2 Results

The benthic macroinvertebrate fauna at the sampling site in the reference river was dominated by blackfly larvae (Simuliidae), having more than 60% of the number of individuals (see Figure 4.1 and Table A4.1 in Annex 1). However, chironomids as well as mayflies were often found.

Among the mayflies, Ephemerella and Baetis were the dominating genus. At site St1, the number of individuals was higher; however, the distribution among the groups was similar to the reference site. The diversity in the EPT-group (Ephemeroptera, Plecoptera, Trichoptera, see Table A4.2 in Annex1)

was higher than at the reference site with 9 species. A quite similar distribution of groups was observed at site St2, as well as a similar number of EPT species. At this site, stoneflies were found, indicating that the water is less polluted. However, the number of stoneflies observed in the samples was very small and their absence or presence in the samples may be accidental.

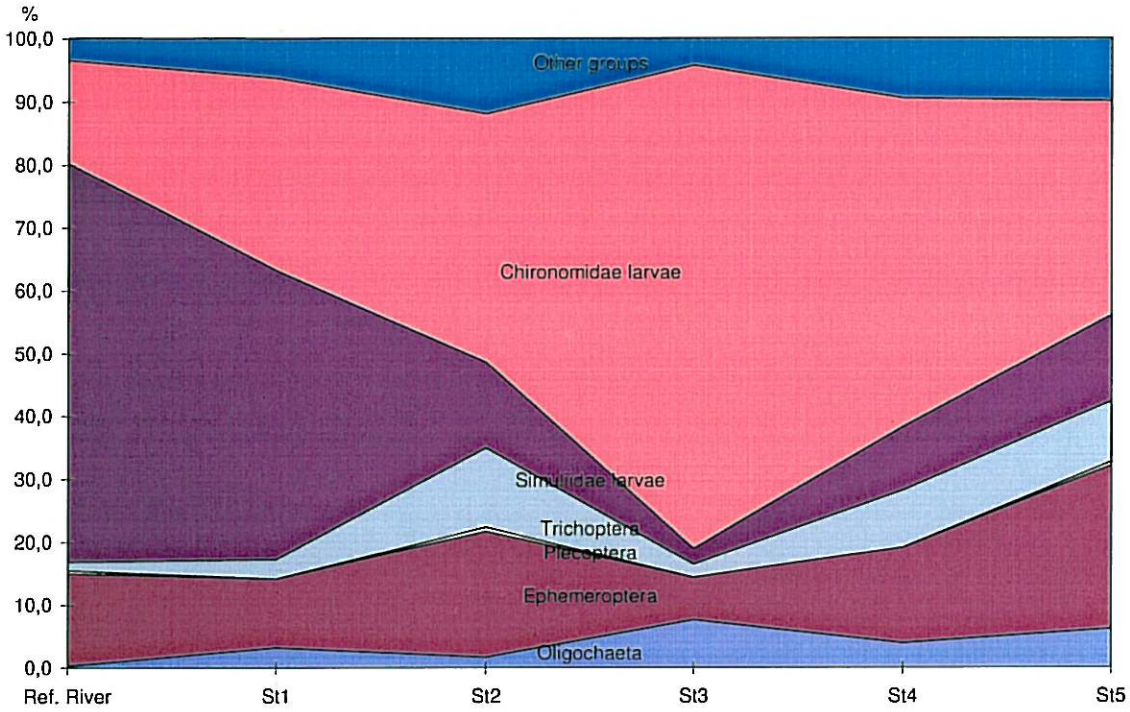


Figure 4.1. Percentage distribution of main macroinvertebrate groups at five localities in the River Neris (St1-St5) and one locality in the reference river (Sventoji).

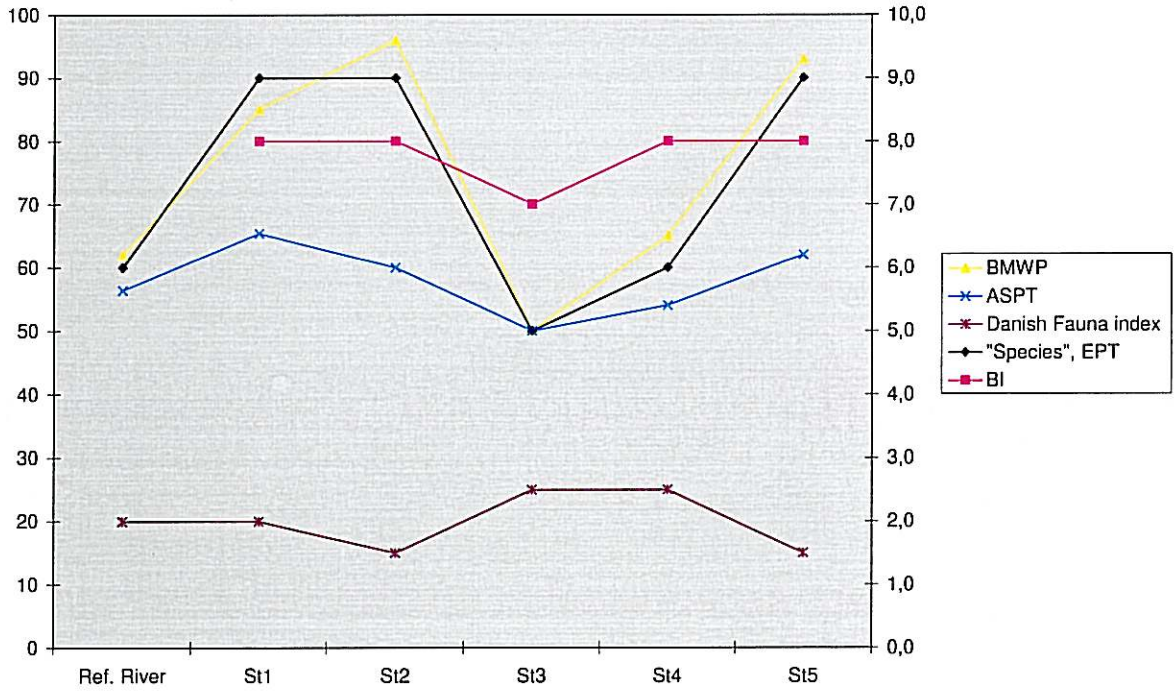


Figure 4.2 . Different macroinvertebrate indexes based on the material from the Neris river. The numbers are index values. BMWP on the left axis. Other indexes on the right axis.

At site St3, the chironomides increased their dominance from 50% at St2 to about 80% at St3. The number of EPT decreased from 9 to 5, indicating more polluted water at St3. At St4, the situation was similar. However, the proportion of mayflies and caddisflies increased as the number of chironomides decreased. A small increase in the number of EPT was observed, from 5 to 6 species. At St5, the relative increase in the number of mayflies continued; and one species of stoneflies was observed. The EPT number increased to 9 .

The EPT is a very simple way to assess the ecological quality of the river. Many different indexes have been developed using macroinvertebrates, to assess the ecological quality or water quality of streams and rivers. Some of these are compared in figure 4.2 and table A4.3 in Annex1. It shows that the indexes are correlated. The Biotic Index, as calculated by the JRC, also shows a similar result even though the sampling method used by NIVA and JRC differed to some extent.

Literature

Andersen, M.M., Riget, F.F. & Sparholt, H 1984. A modification of the Trent Index for use in Denmark.- *Wat.Res.***18**: 145-151.

Armitage, P.D., Moss, D., Wright, J.F. & Furse, M.T. 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. - *Wat.Res.* **17**:333-347.

4.2 Joint phytoplankton studies in Bebruko Lake.

4.2.1 Methods

The project supplied JRC with an inverted microscope, which was used for analysis of quantitative phytoplankton samples. The method is less time-consuming and gives a more accurate analysis of the phytoplankton composition and volumes of the single species, the main groups and the total volume of phytoplankton than the methods used previously.

The inverted microscope method requires sedimentation in a special "sedimentation chamber" of a sub-sample with known volume, taken from the water sample collected in the investigated lake.

Utermöhl (1958) first described the method and his principles are still in use with some modifications. The following steps from the counting results of number of specimen of each species in the sub-sample, through measurements and calculations of mean specific volume of each species, to the final calculation of phytoplankton volume per litre or m^3 of water in the investigated lake, are described in Rott (1981). Descriptions of the methods used for quantitative phytoplankton analyses are gathered in Olrik et al. (1998).

In connection with the excursion to Lake Bebruko 3 September 1996, a quantitative phytoplankton sample was collected for analytical examination. It was fixed in the field with acidified Lugol's solution.

The sample was divided into two sub-samples, one for analysis at the Biological Department at the Joint Research Centre and one for analysis at NIVA

4.2.2 Results

The results from the analyses performed by JRC and NIVA are shown in Figure 4.3 and Table A4.4 and A4.5 in Annex 2. They show a reasonable good accordance, both in the taxonomical determination of the most important species, the calculations of specific volume and the volume of each species, and the total volume of phytoplankton in the sample.

Some minor disagreements in the volumes calculated are mostly a result of a little different specific volume used for the analyses. The estimation of the specific volumes for each species at JRC is based on measurements of a number of specimen per species, while NIVA has used more approximated values for the specific volumes, based on experience from previous analyses.

The phytoplankton composition was dominated by species in the group Chlorophyceae (green algae), totalling approximately 70 % of the total volume of phytoplankton. The dominating species, *Oocystis lacustris*, is considered to be an indicator species of eutrophic waters. Most of the registered species in the sample are usually found in nutrient-rich waters. With a calculated total volume of 3000-4000 mm^3/m^3, the water masses of Lake Bebruko must be characterised as eutrophic.

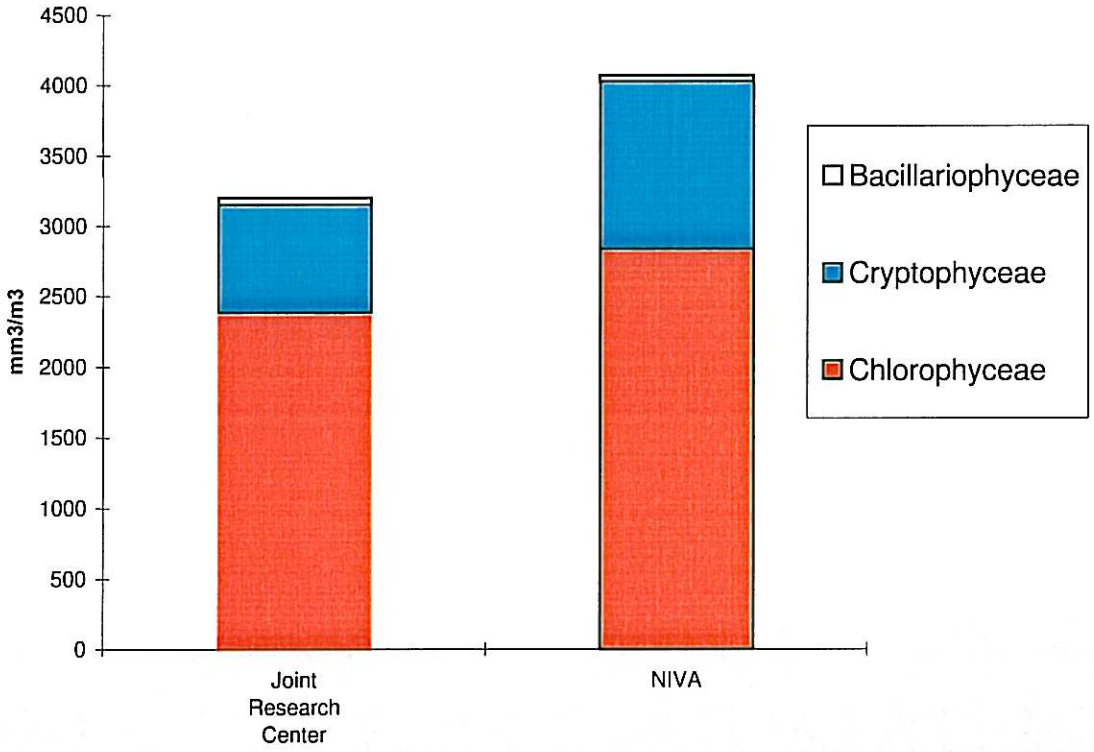


Figure 4.3 Calculated volumes of the main groups of phytoplankton in the sample from Bebruko Lake 3 September 1996. The Joint Research Centre and NIVA made the calculations separately.

Literature

Olrik, K.,Blomqvist, P., Brettum, P., Cronberg, G., and Eloranta, P. 1998. Methods for Quntitative Assessment of Phytoplankton in Freshwaters, part I. *Report 4860, Naturvårdsverket*, 86 pp.

Rott, E. 1981. Some results from phytoplankton counting intercalibrations. *Schweiz. Z. Hydrol.* **43**, 34-62.

Utermöhl, H. 1958. Zur Vervollkommnung der quantitativen Phytoplanktonmethodik. *Mitt. Int. Verein. Limnol.* **9**, 1-38.

5. Water management

5.1 Water management principles and procedures

Overall Action Plan

- Development of methods for an Abatement Strategy
- Development of an overall Action Plan for all polluting activities in the Neris River Catchment
- Co-ordination of measures to be taken within each county/municipality

The methods should include elements such as:

1. user interests
2. definition of water quality goals
3. prioritisation of user interests with regard to polluting substances
4. dose/response models
5. calculation of reductions required in order to reach the goals set
6. criteria for prioritisation of measures
7. evaluation of necessary means to implement the measures chosen

Industry

- Prioritisation of industrial sectors with regard to abatement, taking current water quality and user interests into account
- Assess existing technology/processes
- Suggest new technology (BAT)/processes
- Cost/effectiveness analysis

Waste Water Treatment

- Develop an overall Master Plan for WWT (Waste Water Treatment) in the whole catchment area, taking account of:
    - Sites-locations
    - Connection
    - Sewerage
    - Type of treatment
- Evaluate the necessary degree of treatment needed at WWTPs, taking user interests into account, with the aim of improving the existing water quality to achieve set goals.
- Cost/effectiveness analysis

Agriculture

- Develop a complete picture of agricultural activities in the Neris River Catchment
- Identify a list of appropriate measures
- Carry out cost/effectiveness analysis

Waste Deposits

- Develop an overview of existing waste deposit sites
- develop a plan for new waste deposit sites in the Neris River Catchment, taking account of the co-ordination within each county-municipality

Atmospheric Deposition

- Estimate the atmospheric deposition of identified, main pollutants
- Develop a monitoring network for atmospheric deposition

5.2 Identification of problems in the Neris river catchment and setting of water quality goals

The main environmental problems are:

- The substantial quantities of untreated sewage from urban areas (about 3040 000 tonnes per year), deposition of air transported polluting substances and surface run-off into surface waters;
- The fact that about 382 million m^3 of water from the river Neris are being transferred every year to be used as fresh water supply for the city of Minsk (capital of Belorussia). That accounts for about 64% of annual run-off in the Neris river during a dry year in that area. In the vicinity of Vilnius, this loss of the Neris river run-off accounts for about 15% of the yearly run-off;
- Eutrophication as a result of human activities and subsequent nutrient discharges/losses into water bodies (especial in summer time).

The protection of surface water bodies is one of the priorities of the National Environmental Strategy of Lithuania. According to the Lithuanian Development Strategy, the surface water quality should satisfy the requirements for fish farming, fishing and recreation (see map of user interests, Figure 5.1). From an economic point of view and referring to some special energy and transport development programmes, it is suggested to use a part of the Neris river, i.e. from Jonava (where a large fertiliser plant is located) to its mouth (which is at the second largest city in Lithuania city, namely Kaunas), for navigation purposes. There are development projects in which it is suggested to build a hydropower plant above Vilnius (near Turniskes) and to renovate some other smaller hydropower plants in order to increase the supply of energy.

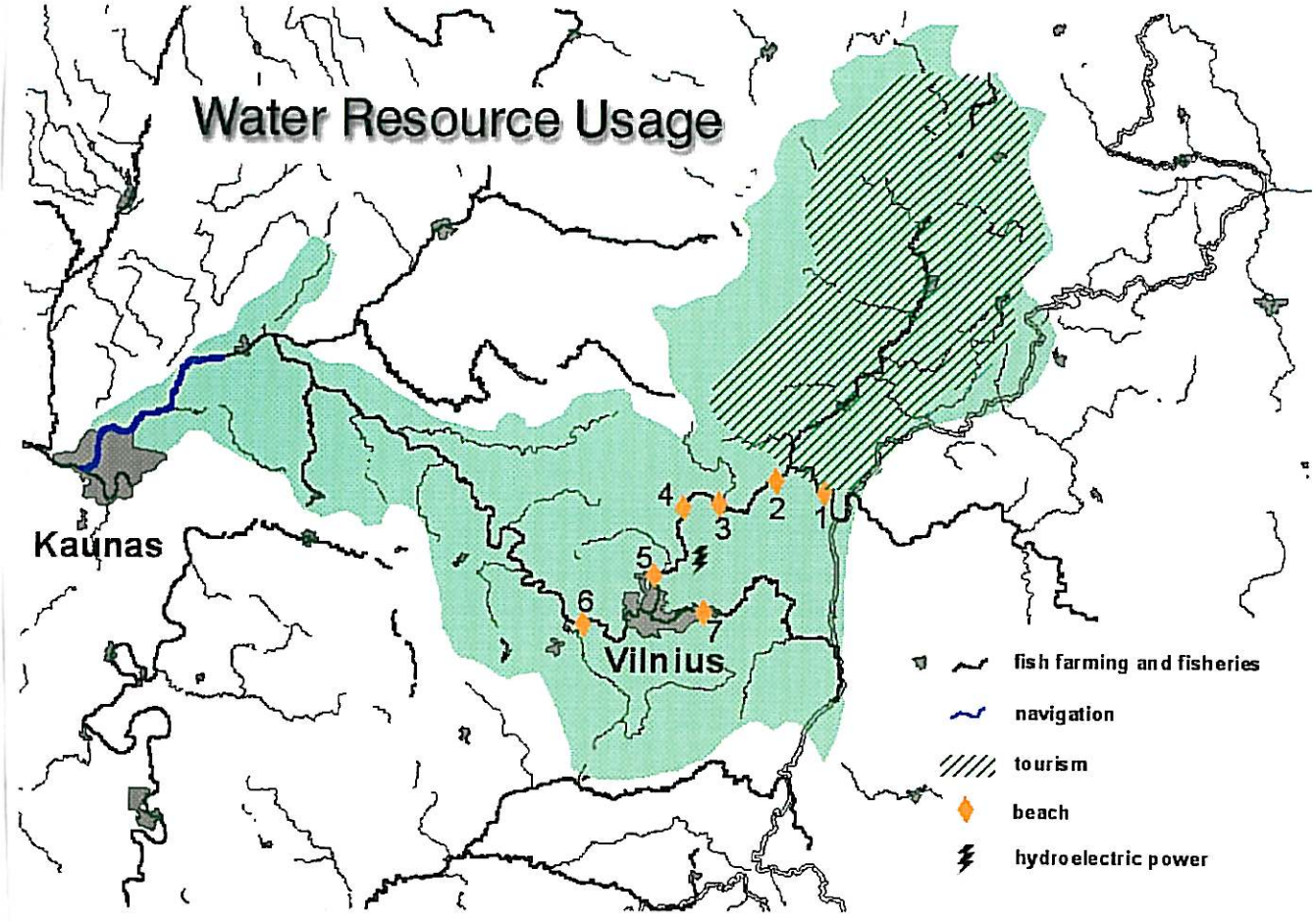


Figure 5.1. Main user interests in the Neris River catchment.

5.3 Data collection, data base and data storage procedures

According to Lithuanian law, all water uses of more than 10 m^3 water/24 hour must be accounted for by means of an annual report to regional environmental protection departments, according to an agreed reporting form. There are 8 regional environmental protection departments in Lithuania, namely: Vilnius, Kaunas, Klaipeda, Panevezys, Siauliai, Alytus, Marijampole and Utena. The main part of the Neris catchment area belongs to the Vilnius regional department, but smaller parts belong to the Kaunas and Utena regional departments. All data are collected within regions or regional departments, independantly of river catchments. However, the location of the discharge points and water intakes are registered.

The data structure of the water related statistics is presented in Figure 5.2. Annual data is collected in regional departments and submitted to the Joint Research Centre, Division of Information System. After the data is checked and any inconsistencies corrected, the data is presented in annual reports and used for studies of the environment.

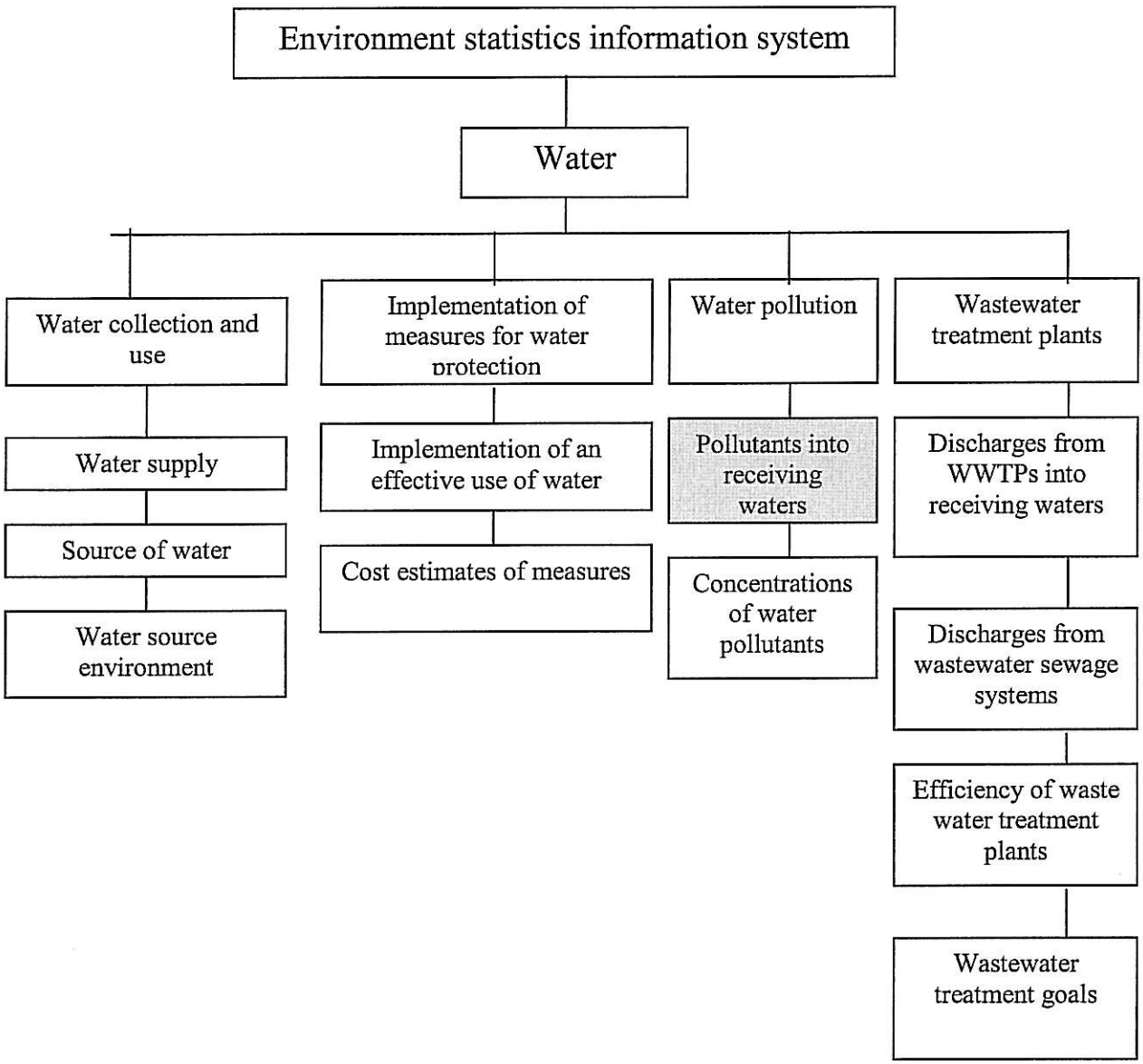


Figure 5.2 Structure of the Lithuanian water database.

The WATER database consists of a considerable number of files. However, it is possible to group the files. An overview of the main groups is given in Table 5.1.

***Table 5.1**: Main groups of files in the database.*

Lithuanian groups of file names	File group topics
dirb_vit.dbf	Wastewater treatment plants in the current sewage systems
dirbo.dbf	Reporting requirements
dirbo_vi.dbf	Wastewater treatment plants' performances
em_salt.dbf	Sources for water collection
f_klaid.dbf	Comments on errors in data
gamtspr.dbf	Implementation of measures for obtaining an effective use of water, and of measures for water protection
gspr_les.dbf	Cost-effectiveness of measures
gspr_st.dbf	Activities of enterprises
isl_i_kt.dbf	Quantification of wastewater discharges into sewerage
isl_i_pr.dbf	Wastewater discharge into receiving waters
l_klaid.dbf	Comments on input errors
lab_darb.dbf	Data about laboratories
paeme.dbf	List of water intakes
paj_mat.dbf	Units for capacity measurements
perdave.dbf	Water supply
priimt.dbf	Recipients of wastewater
p_up_bas.dbf	Main river catchments
rac_pr_r.dbf	Criteria for obtaining an effective use of water and an effective implementation of measures for water protection purposes
rangovas.dbf	Contractors
sutaupo.dbf	Restrictions for water consumption
tersmedz.dbf	Classification list of pollutants
tm_i_kt.dbf	Polluting substances into sewerage
tm_i_pr.dbf *	Water pollution into receiving waters
tm_vi_kt.dbf	Sewage treatment efficiency
val_ir_i.dbf	Wastewater discharges into receiving waters
val_ir_p.dbf	Wastewater treatment goals
val_ir_t.dbf	Treatment goals, efficiency and capacity of WWTPs
vand_hor.dbf	Classification list of watercourses
vh_naud.dbf	Amount of water from watercourses
vi_efekt.dbf	Classification of the effectiveness of WWTPs
v_n_rus.dbf	Quality of water and wastewater

5.4 Modelling of the pollution load and the water quality

5.4.1 TEOTIL Model: calculation of phosphorus- and nitrogen load in the Neris River catchment

Introduction

The TEOTIL model calculates yearly loads of total phosphorus and total nitrogen. The river catchment is divided into sub-catchments. The model calculates the loads for each sub-catchment, as well as accumulated loads from transport downstream the river system. The calculations are carried out by using data on water flow, discharges of nutrients from municipal wastewater and industry, losses of sewage from scattered population and different uses of land areas. The results are presented as total nutrient loads and loads per source category.

The model may also be used to calculate loads and water quality in areas without observations. It is possible to quantify the contributions of the different types of sources and to localise the most important sources of pollution. This is useful in abatement strategies made to improve the water quality.

The model may be used to find yearly trends and to study measures taken to improve the water quality. The model may simulate the downstream effect of existing or potential new point sources under different hydrological conditions. Great differences between observations and calculated loads can indicate unaccounted pollution sources in the catchment.

In the current project, the TEOTIL model was adapted to the Lithuanian part of the Neris catchment.

Main types of data required for the TEOTIL model

Sub-catchments

The Neris catchment was divided into **16** sub-catchments. For each of the sub-catchments information about pollution sources was registered.

Sources

In the current version of TEOTIL adapted to Lithuanian conditions, the diffuse pollution sources are divided into agriculture, forest, wetlands and municipal sites. There is ongoing work to obtain data which will enable more detailed estimations of the losses of pollutants from diffuse pollution sources (e.g. development of area runoff coefficients).

Natural background
Natural background losses of nutrient (Lb) from each sub-catchment are quantified according to :

$$Lb = q * Cb * A$$

where
q= specific water flow , Cb = Mean concentration from the specific source and
A = drainage area

Areas with natural background losses are e.g. forests, wetlands, rivers and lakes and bare rocks. In the model, all non-cultivated areas are defined as natural background areas. Losses from forest are the most important sources.

The mean concentration for a part of the catchment, Cb, is estimated from observations in areas with similar conditions, by calibration with observed values.

Agriculture
For each type of agricultural area, the losses from each sub-catchment (La) are calculated according to the formula:

$$La = q * Ca * A$$

where
Ca is the mean concentration of losses from the specific source.

The mean concentration for a part of the catchment , Ca, is estimated from observations in areas with similar conditions, by calibration with observed values.

Population
Data about nutrient discharges from municipal wastewater plants, including industrial discharges into public sewage, are sampled from the treatment plant and entered into the water database.

The nutrient losses from scattered population (Lsp) are calculated as follows:

$$Lsp = Nsp * Lperson * (1 - retention)$$

where
Nsp is the proportion of scattered population,
Lperson is a coefficient that represents the mean nutrient production from each person, and
retention is the part of the losses retained in the soil.

Industry/point sources not connected to public sewage
The nutrient load from industrial plants not connected to public sewerage is obtained by measurements or stipulated by calculations for each sources.

5.4.2 TEOTIL adapted to Lithuanian conditions

The TEOTIL model has been adapted to data from the Neris catchment, but the system was designed to cover the main 16 sub-catchments in Lithuania. Most of the existing data is linked to administrative regions and is not related to these sub-catchments. It is necessary to continue to work to improve the handling of existing data, as well as to collect new types of data. This may concern types of land area, uncertain localisation of about 1500 enterprises and lacking data about scattered population.

Some problems have been encountered in order to adapt TEOTIL for use in Lithuania. This is because there are different 'data collection traditions' in Lithuania and Norway. However, Lithuanian version of TEOTIL has been developed.

The main purpose of this user instructions is to give a stepwise guidance in the data collection procedure in order to get all necessary data. The model needs a considerable amount of input data. However, it may also be run in cases where some data is lacking. In this version of **TEOTIL,** the water environmental statistics data are linked to the data from river cadastres (Figure 5.2).

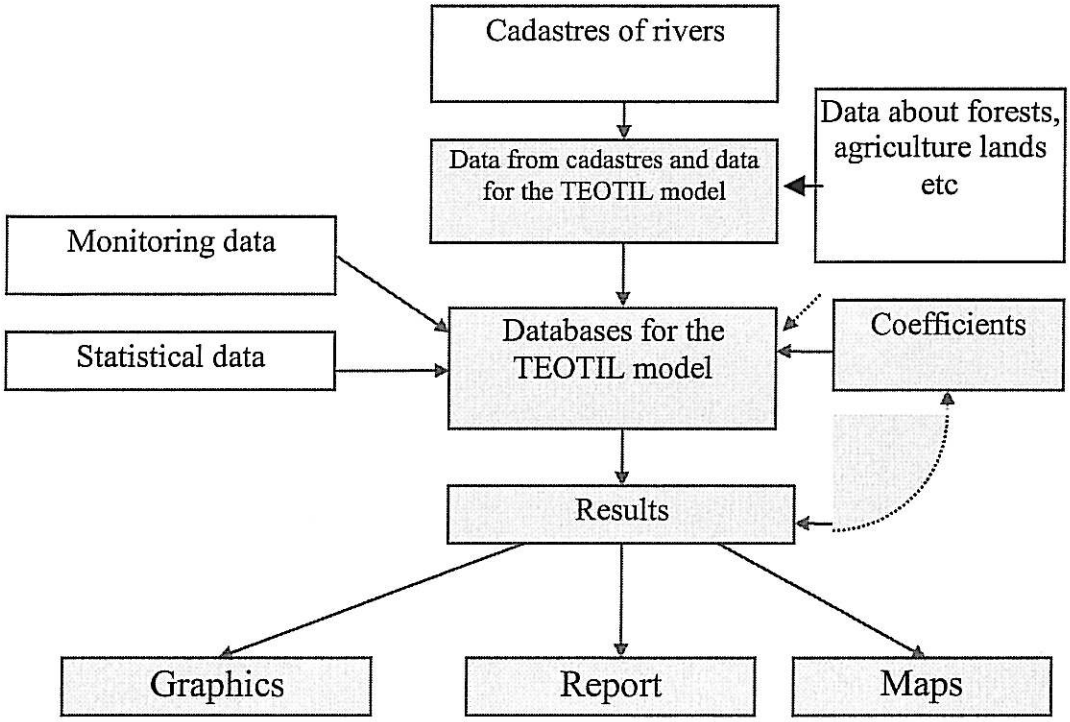


Figure 5.3. Scheme of the Lithuanian adapted TEOTIL model.

The first step is to check and improve the quality of the statistical data, see Figures 5.3 and 5.4. They show the code of the point sources, their co-ordinates, the location of the discharge points into the rivers, data about adverse effects of the discharges and possibilities to improve the conditions in the rivers. The regional departments must carry out a quality control of the data before sending them to the Information system Division.

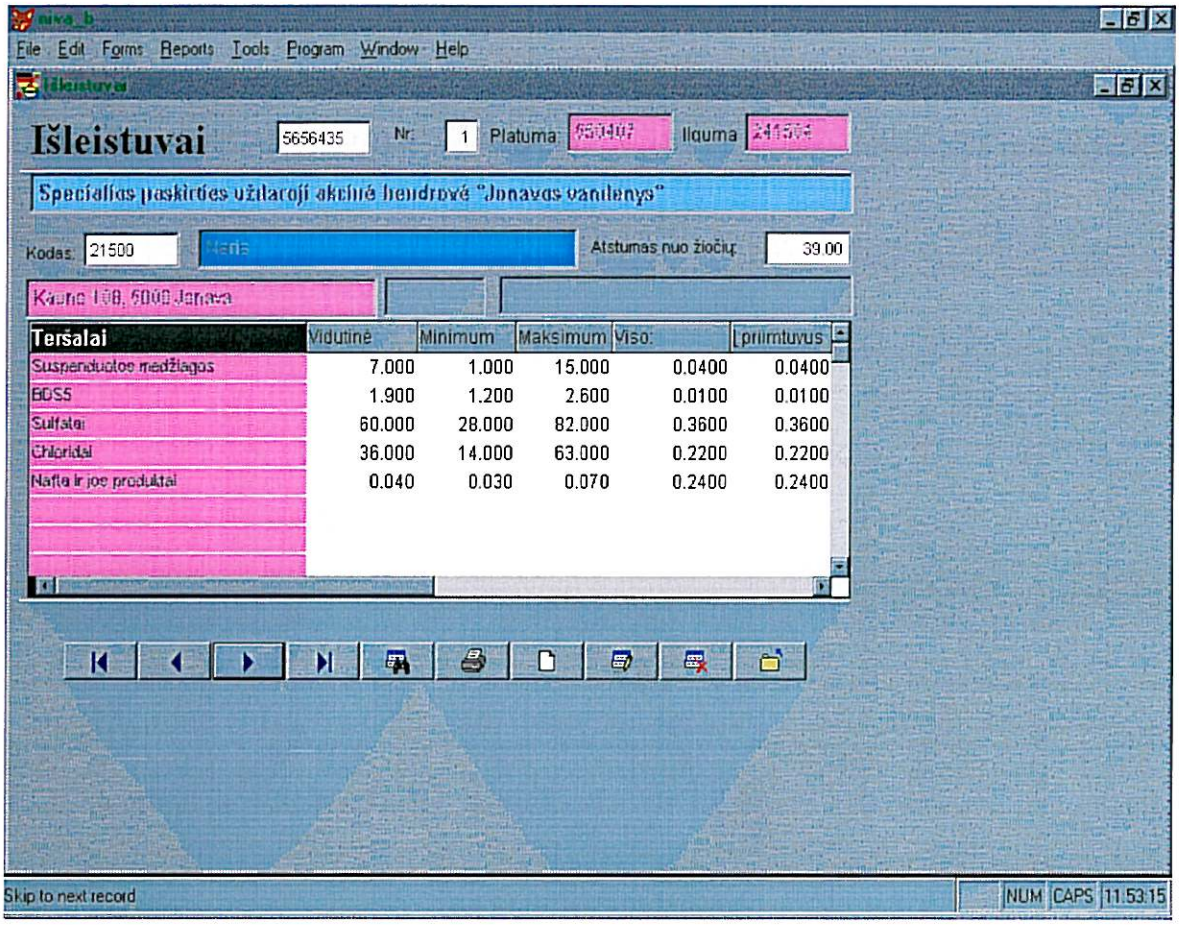


Figure 5.4. Window to be used for improving statistical data.

The second step consists of selecting the rivers, see Figure 5.5.

Neries baseinas (Teotil project)

Upe	Kodas	baseino plotas	Intako baseinas	1	2	3	Upės ilgis
Dubysa	17700	79908.4	2068.6	167.5	0.0	0.0	145.6
Dysna	37701	0.0	0.0	100.0	0.0	0.0	197.2
Jecava	35600	11362.3	1225.3	85.7	0.0	0.0	136.7
Juodoji Ančia	31001	36114.0	1906.0	476.1	0.0	0.0	141.5
Jūra	11600	91597.6	3986.2	81.2	0.0	0.0	177.2
Katra	31200	32983.0	2010.0	534.7	0.0	0.0	108.6
Levuo	36700	3764.8	1587.7	171.0	0.0	0.0	148.1
Merkys	29300	42062.3	4415.7	417.8	0.0	0.0	203.0
Minja	10100	0.0	2978.4	3.2	0.0	0.0	212.9
Mituva	16900	81091.6	776.5	124.0	0.0	0.0	102.2
Mūša-Lielupė	34900	0.0	0.0	0.0	0.0	0.0	284.0
Nemunas	10000	0.0	98219.4	0.0	0.0	0.0	937.4
Nemunėlis	35800	9366.4	4048.2	120.5	0.0	0.0	190.6
Neris	21500	71254.7	24933.0	207.7	0.0	0.0	509.5
Nevėžis	18800	77463.8	6141.1	199.2	0.0	0.0	209.6
Suseja	36100	2232.5	1218.5	120.5	83.0	0.0	110.2
Svislotis	31301	30930.0	1751.0	541.1	0.0	0.0	115.2
Usa	32700	1437.0	1316.0	912.0	0.0	0.0	103.8
Venta	33400	0.0	0.0	0.0	0.0	0.0	350.2
Virvyčia	33901	3387.4	1144.1	224.0	0.0	0.0	131.1
Zelva	31401	27604.0	1937.0	588.9	0.0	0.0	146.8

Figure 5.5. List of rivers in Lithuania longer than 100 km.

When the river is selected, information should be collected about the main stream of the river, for further use, see Figure 5.6

Neries baseinas (Teotil project)

Upkod	Pavad	Intak	Laikas	Vieta
21500	Neris	int2	98/09/18 20:17	DATA\REZ\TEOTIL8.dbf
21600	Šventoji	int3	98/08/19 11:52	DATA\REZ\TEOTIL7.dbf
21701	Širvinta	int4	98/08/19 10:07	DATA\REZ\TEOTIL5.dbf
25700	Švogina-Žeimena	int3	98/08/19 10:09	DATA\REZ\TEOTIL6.dbf

Figure 5.6 List of the Neris river's tributaries.

It is possible to include the main tributaries in the Neris river catchment. The next step is to collect the data about human activities in the river catchments. In Figure 5.7, input data about land coverage should be included, and any additional information

Neries baseinas (Teotil projektas)

Tekst	Arimai	Medis	Namai	Pelke	Savart	Nuotekis	Pastaba
Malkosnė	73.0	25.0	2.0			9.00	memo
Musinis	56.0	38.0	6.0			9.00	memo
Širvinta	51.0	42.0	3.0	4.0		9.00	memo
Kriokšlys	55.0	40.0	2.0	3.0		9.00	memo
Geležė	63.0	25.0	6.0	6.0		9.00	memo
Žuvintė	55.0	42.0	3.0			9.00	memo
Žimaja	62.0	35.0	3.0			9.00	memo
Armona	83.0	15.0	2.0			9.00	memo
Galba	56.0	40.0	4.0			9.00	memo
Gniuža	33.0	65.0	2.0			9.00	memo
Storė	80.0		20.0			9.00	memo
Ukmergėlė	57.0	5.0	38.0			9.00	memo
Ukmergės v.m.p.						9.00	memo
Moliupis	72.0	28.0	10.0			9.00	memo
Dukstyna	71.0	27.0	2.0			9.00	memo
Duoburis	88.0	10.0	2.0			9.00	memo
Galaupė	84.0	15.0	1.0			9.00	memo
Panuotekis	68.0	31.0	1.0			9.00	memo
Mūšia	84.0	14.0	2.0			9.00	memo
Siesartis - Malkėstas	59.0	36.0	3.0	2.0		9.00	memo
Sakiena	64.0	35.0	1.0			9.00	memo

Figure 5.7. Input of data about human activities in the Neris River catchment

Before the database for the TEOTIL model it is developed, some preliminary factors may be included, see Figure 5.8.

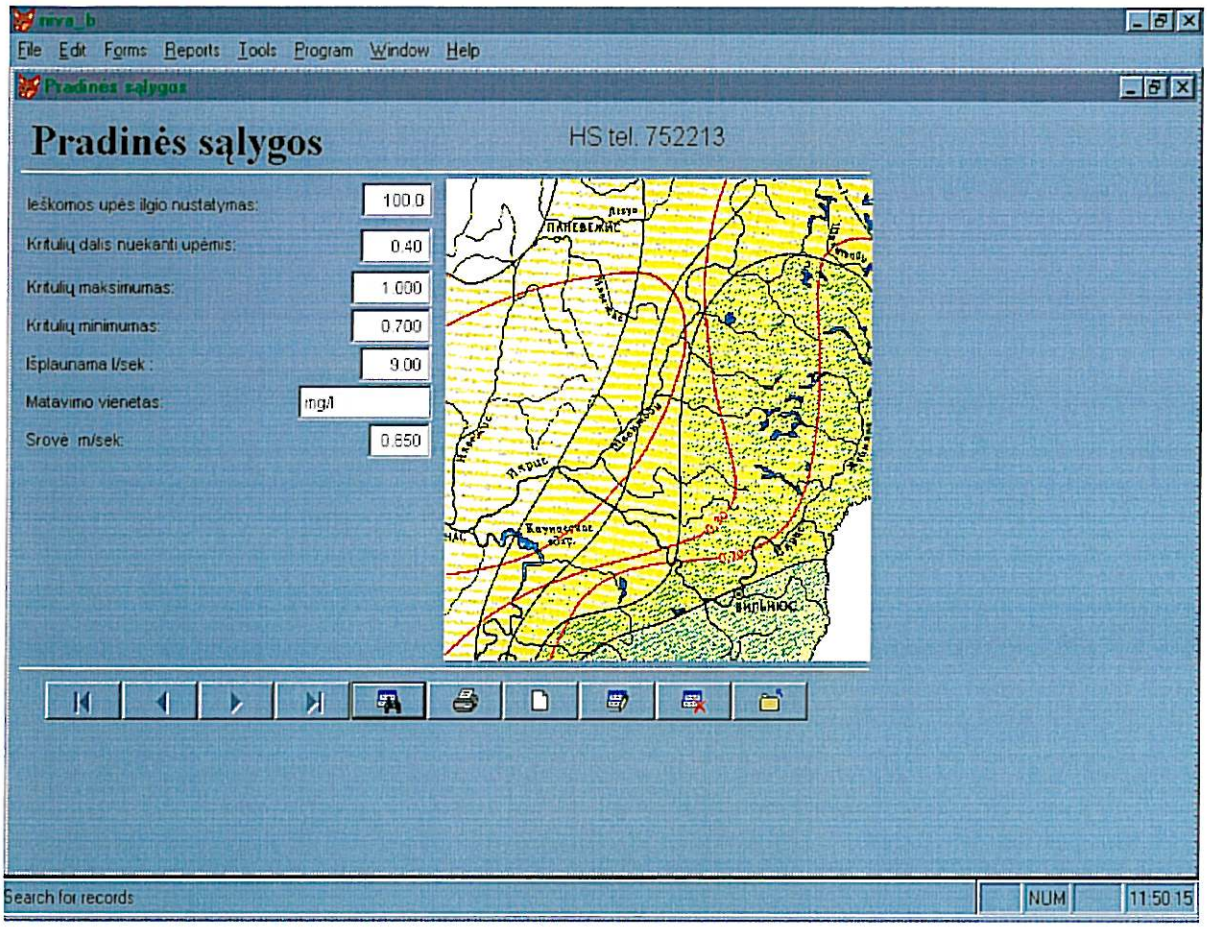


Figure 5.8. Window for input of preliminary factors in the TEOTIL model.

Figure 5.9 provides saving procedures for the input data.

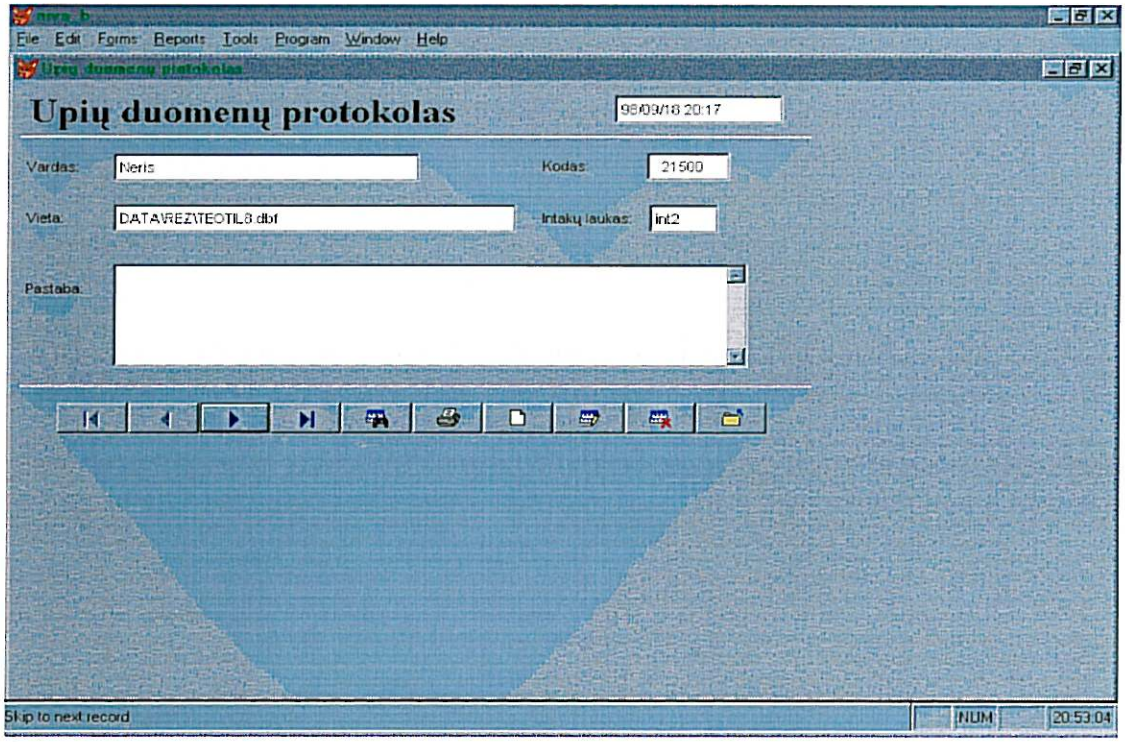


Figure 5.9. Data saving procedures.

The next step is to select, from the code list, the hazardous substances for consideration, see Figure 5.10. Figures 5.6 and 5.10 are then combined to obtain information about a specific river and the relevant hazardous substances.

Medziagos
BDS5
ChDS
NH4 ir amonio druskos
SPAM (detergentai)
Bendra geležis
Bendras azotas
Bendras chromas
Bendras fosforas
Chloridai
Cinkas
Fenoliai
Fosfatai
Gyvsidabris
Kadmis
Manganas
Nafta ir jos produktai
Nikelis
Nitratai
Nitritai
Riebalai
Sulfatai

Figure 5.10. List of hazardous substances in the Lithuanian environmental statistics about water.

In the new database, information about the quantities of hazardous substances from the different types of land is required. It is possible to select new or revise the former database (see Figure 5.11).

Upės pavadinimas	Teršalas	Tvarkymo laikas:
Neris	Bendras azotas	98/08/19 10:09
Švogina-Žeimena	Bendras azotas	98/08/18 10:31
Neris	Bendras chromas	98/08/19 11:02
Neris	Bendras fosforas	98/08/19 11:10
Širvinta	Bendras azotas	98/08/19 11:58

Figure 5.11. List of rivers and hazardous substances for selection

The next step is to revise the factors, see Figure 5.12, and prepare the model for each site.

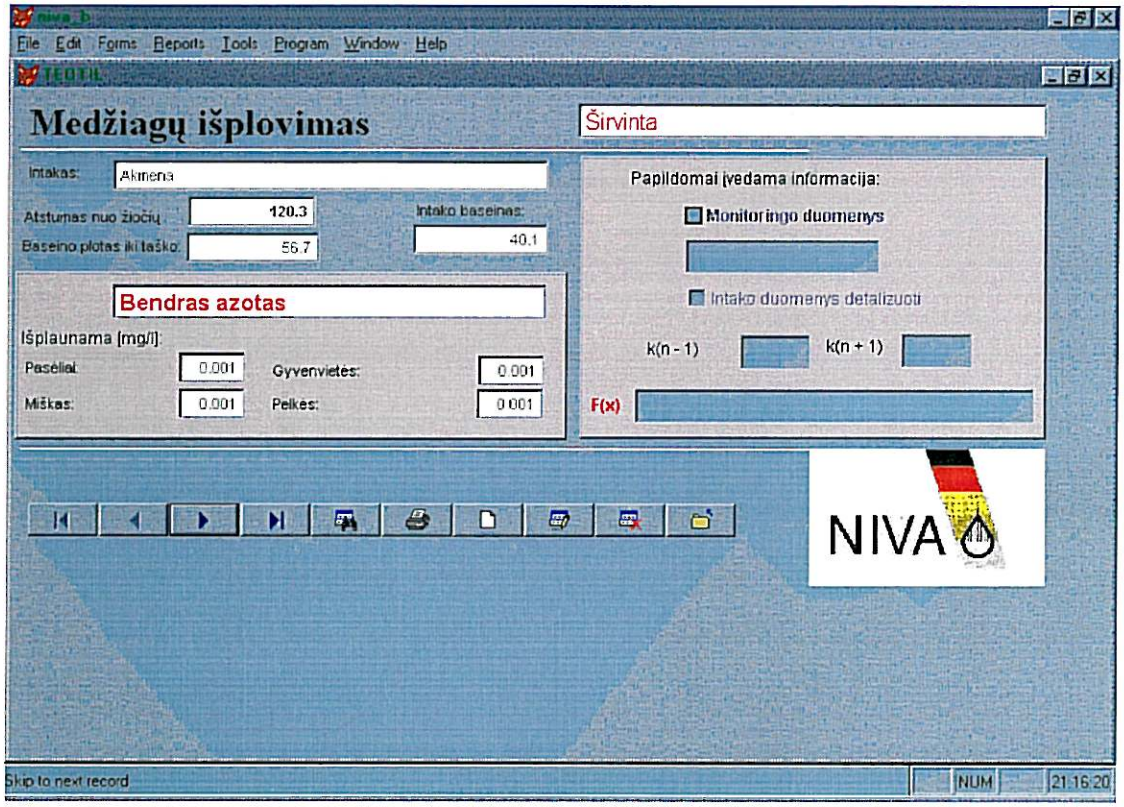


Figure 5.12. Window for revision of factors and for preparing TEOTIL.

The right side of the window provides the possibility to control the data processing in selected points. It is possible to use them for e.g. simulation of water treatment.

Figure 5.13 represents the final step, where it is possible input factors about e.g. precipitation, preliminary conditions before the model is run.

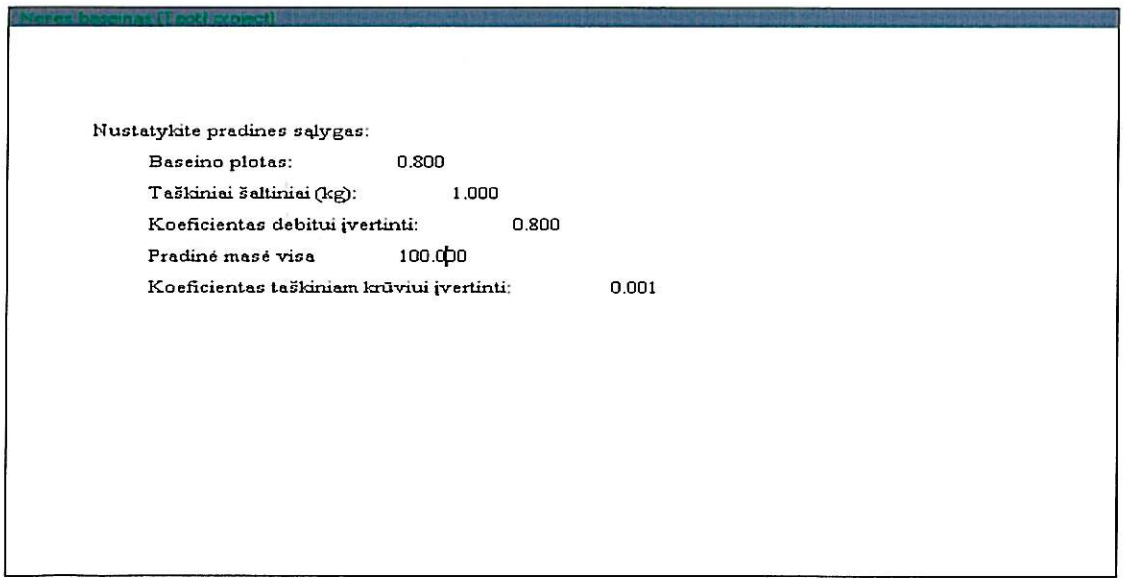


Figure 5.13. Final inputs of factors before running the model.

6. Conclusions and recommendations

Monitoring

1. The river-monitoring network in Lithuania gives a good monitoring coverage for the whole country, and could serve as an example for other countries (e.g. Norway).

2. The current monthly sampling and analyses of main parameters are considered adequate. However, it is recommended:
   - to include turbidity as a routine parameter for the particle content in the water.;
   - in slow-flowing rivers like the Neris river, where planktonic algal blooms may occur, to analyse the concentration of chlorophyll "a" as part of the basic monitoring programme;
   - to determine hygienic water quality, analysis of the content of termotolerant coliforme bacteria should be applied rather than total coliforme bacteria;
   - to take samples at least monthly during the growing season (May – October) for the purpose of lake monitoring. Chlorophyll "a", Secchi depth, qualitative and quantitative phytoplankton analyses and main nutrients (total nitrogen, nitrate/nitrite, ammonia, total phosphorus, phosphate and silicate) are the most important routine monitoring parameters to be included;

Laboratories

3. Priority should be given to upgrade the chemical laboratories. It is recommended to seek financing of an atomic absorption spectrophotometer and an ionic chromatograph.

4. The relevant laboratories have already an internal quality control programme. It is very important that this control programme is followed each time analyses are carried out. It is also important that there are clearly defined action limits, which imply immediate actions if they are exceeded.

5. In order to reduce analytical variances due to discrepancies between laboratories, it is recommended to consider having only one single, high quality laboratory to carry out all the chemical analyses used for long-term monitoring (trend analyses). Norwegian experiences show that pooled data from several laboratories may be less adequate to detect long-term trends.

General Water Management

6. It is recommended to continue the bilateral project between Lithuania and Norway in order to:
   - develop quantitative water quality criteria (classification) for different types of pollutants, such as nutrients, organic substances, toxic substances, particles and termotolerant coliforme bacteria (in addition to the current system of defining general water quality criteria). It is also recommended to develop quality classification for main user interests, such as raw water for drinking water, irrigation, bathing and recreation, and fishing.
   - develop further the software for adapting the pollution load – water quality model TEOTIL. There is still work left regarding data collection and determination of pollution load coefficient for diffuse sources before reliable model outputs can be expected. Data from the current monitoring network will probably give adequate information to estimate load coefficients for diffuse sources.

The implementation of the above mentioned elements will contribute to a better basis and improved procedures as regards Water management.

ANNEX 1

***Table A4.1**: Main groups of benthic macroinvertebrates at five localities in the River Neris and at one locality in the reference river (Sventoji) on 2 July 1996. Number of individuals in a 3 times 1-minute kick sample when using a hand net with a mesh size of 250 µm for sampling.*

Site code	Ref. River	St1	St2	St3	St4	St5
Oligochaeta	8	240	40	408	68	188
Hirudinea	0	0	80	48	4	0
Gastropoda	8	0	80	0	0	40
Lamellibranchiata	0	80	32	8	32	104
Hydracarina	32	120	56	8	20	44
Hemiptera	0	80	16	16	12	24
Ephemeroptera	440	840	496	368	268	792
Plecoptera	16	0	16	0	0	20
Coleoptera larvae	8	0	16	0	4	12
C. imago	0	0	0	0	0	4
Trichoptera	40	240	312	112	160	292
Simuliidae larvae	1904	3520	336	136	176	420
S. pupae	16	120	0	0	0	4
Chironomidae larvae	488	2344	976	4160	920	1040
C. pupae	32	16	8	152	84	44
Other dipterans	16	64	8	0	12	28
Sum	3008	7664	2472	5416	1760	3056

***Table A4.2** . Mayflies, stoneflies and caddiflies in the Neris River 2 July 1996. Number of individuals in a 3 times 1 minute kick sample, when using a hand net with a mesh size of 250 µm for sampling.*

Site code	Ref.river	St1	St2	St3	St4	St5
Ephemeroptera (Mayflies)						
Baetidae	80	232	56	176	20	192
Heptagenia spp.	0	104	176	0	64	172
Ephemerella spp.	320	344	152	96	36	168
Ephemera sp.	40	8	0	0	0	32
Caenis spp.	0	152	88	80	148	228
Potamantus sp.	0	0	24	16	0	0
Plecoptera (Stoneflies)						
Capnia sp.						
Leuctra sp.	8	0	16	0	0	20
Trichoptera (Caddisflies)						
Rhyacophila nubila	8	0	0	0	0	0
Hydropsyche siltalai						
Hydropsyche sp.	32	144	160	112	140	160
Brachycentrus subnubilus	0	64	136	0	20	4
Leptoceridae indet	0	16	0	0	0	0
Psychomyia pusilla	0	16	16	0	0	128

Table A4.3. Some macroinverebrate water quality indexes for the River Neris and the reference river Sventoiji.

St.code Indexes	Ref.river	St1	St2	St3	St4	St5
BMWP	62	85	96	50	65	93
ASPT	5,6	6,5	6,0	5,0	5,4	6,2
Danish Fauna index	2	2	1,5	2,5	2,5	1,5
"Species", EPT	6	9	9	5	6	9
Danish Fauna index	II	II	I/II	II/III	II/III	I/II
Made at JRC:						
Biotic index (BI)		8	8	7	8	8
WaterQual.Class		II-III	II-III	III	II-III	II-III

ANNEX 2

Table A4.4 *Phytoplankton determinations by Joint Reseach Centre.*

Group/species	Specific volume used μm^3	Calculated volume mm^3/m^3
Chlorophyceae (green algae)		
Ankyra sp.	107.5 (cell)	27
Coelastrum microporum Nägeli	3180.0 (col)	23
Oocystis lacustris Chodat	2616.6 (col)	1671
Oocystis parva W. & G.S.West	925.1 (col)	60
Pandorina morum (O.F.Müller) Bory	3055.0 (col)	44
Pediastrum boryanum (Turpin) Meneghini	8341.4 (col)	544
Scenedesmus quadricauda (Turpin) Brebisson	497.7 (col)	14
Cryptophyceae		
Cryptomonas erosa Ehrenberg	1517.1 (cell)	770
Bacillariophyceae (diatoms)		
Cocconeis pediculus Ehrenberg	4781.3 (cell)	24
Stephanodiscus hantzschii Grunow	3723.2 (cell)	23
Euglenophyceae		
Trachelomonas hispida (Perty) Stein em.Defl.	5362.3 (cell)	38
Total volume		3242

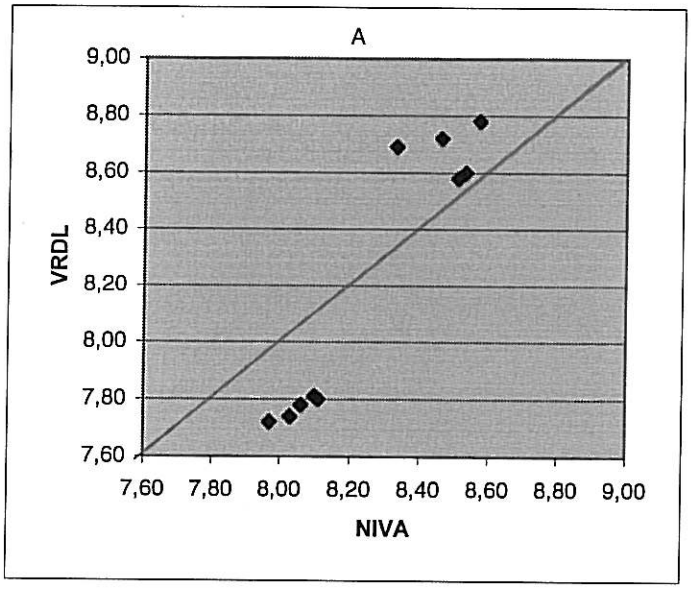
Table A4.5 *Phytoplankton determinations by NIVA.*

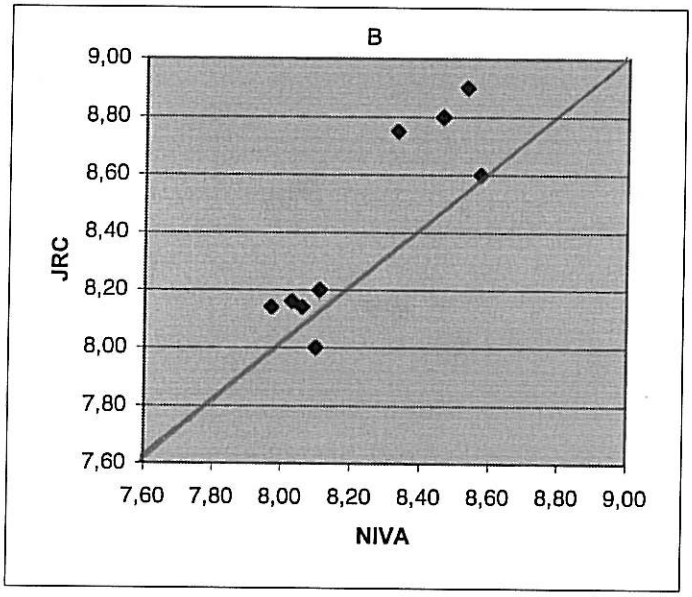
Group/species	Specific volume used μm^3	Calculated volume mm^3/m^3
Chlorophyceae (green algae)		
Ankyra judayi (G.M.Smith) Fott	70 (cell)	21.9
Coelastrum microporum Nägeli	3650 (col)	7.3"
Cosmarium margaritiferum Meneghin	16000 (cell)	25.6
Cosmarium subcostatum Nordstedt	1500 (cell)	0.6
Indet. cocc.green algae (Chlorella sp.?)	200 (col)	2.4
Oocystis cf.lacustris Chodat	3000 (col)	2289.6
Oocystis parva W. & G.S.West	890 (col)	153.7
Pandorina morum (O.F.Müller) Bory	2875 (col)	137.1
Pediastrum boryanum (Turpin) Meneghini	7150 (col)	189.1
Quadrigula pfitzeri (Schröder) G.M.Smith	500 (col)	1.3
Scenedesmus opoliensis P.Richter	500 (col)	1.3
Scenedesmus quadricauda (Turpin) Brebisson	600 (col)	1.5
Selenastrum capricornutum Printz	30 (cell)	0.4
Staurastrum paradoxum Meyen	4150 (cell)	6.4
Tetraëdron minimum (A.Braun) Hansgirg	250 (cell)	0.7
Chrysophyceae (golden algae)		
Large chrysomonads (d >7 µm)	325 (cell)	4.3
Ochromonas sp. (d=3.5-4 µm)	27 (cell)	0.8
Small chrysomonads (d < 7 µm)	65 (cell)	2.8
Cryptophyceae		
Cryptomonas erosa Ehrenberg	1500 (cell)	1005.7
Cryptomonas erosa v.reflexa Marsson (C.reflexa ?)	1900 (cell)	176.2
Cryptomonas marssonii Skuja	1200 (cell)	6.4
Bacillariophyceae (diatoms)		
Nitzschia sp.	350 (cell)	42.7
Euglenophyceae		
Trachelomonas hispida (Perty) Stein em.Defl.	6000 (cell)	1.2
"µ-algae" (small indet.cells with d=2-4 µm)	10 (cell)	16.9
Total volume		4095.9

ANNEX 3

Figures and tables showing results from intercomparison of chemical analyses.

Figure A3.1. pH





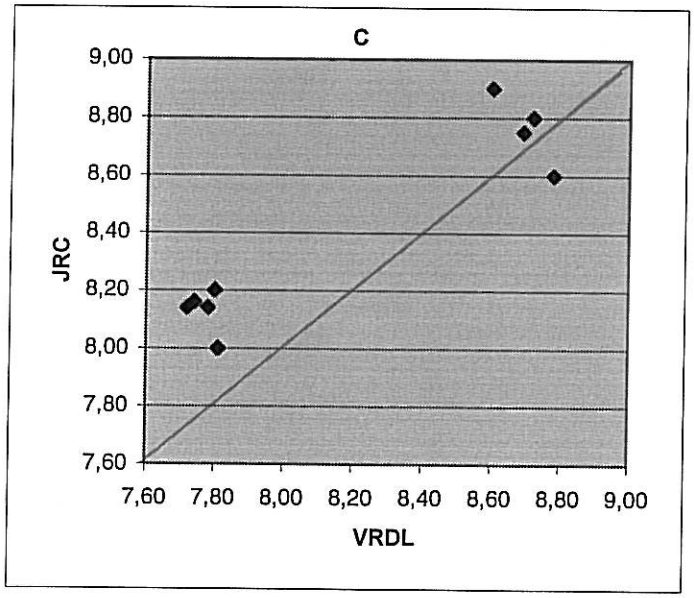
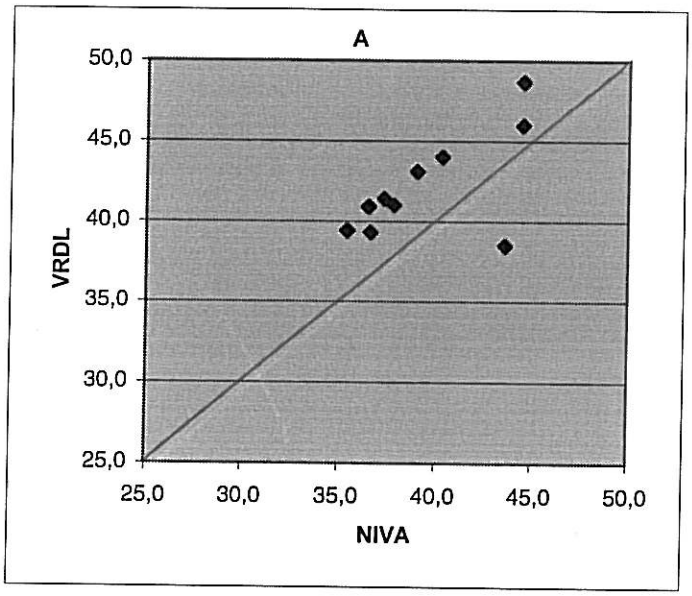
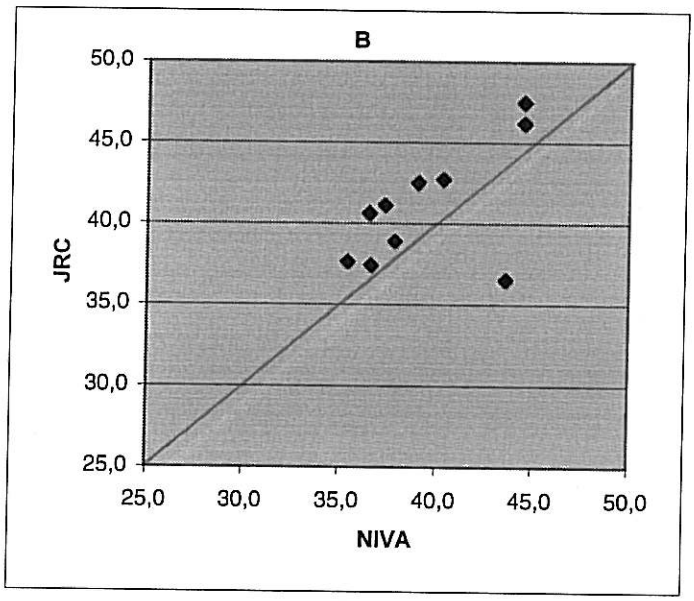


Figure A3.2. Conductivity, mS/m at 25 °C





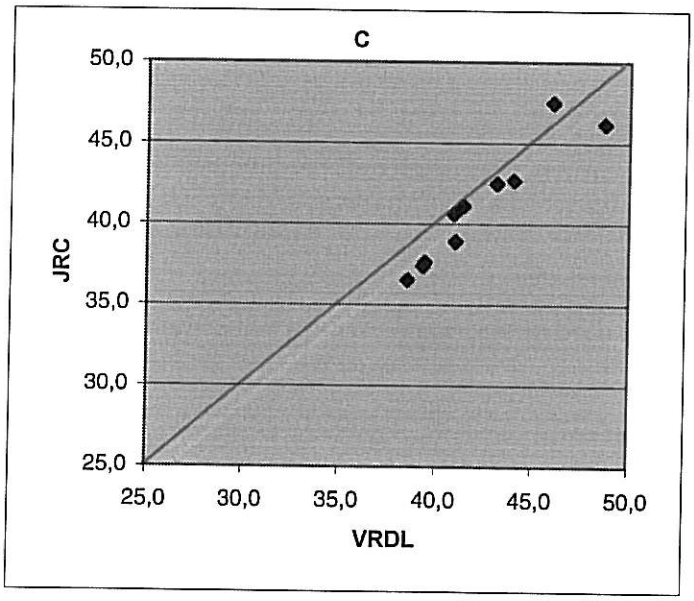
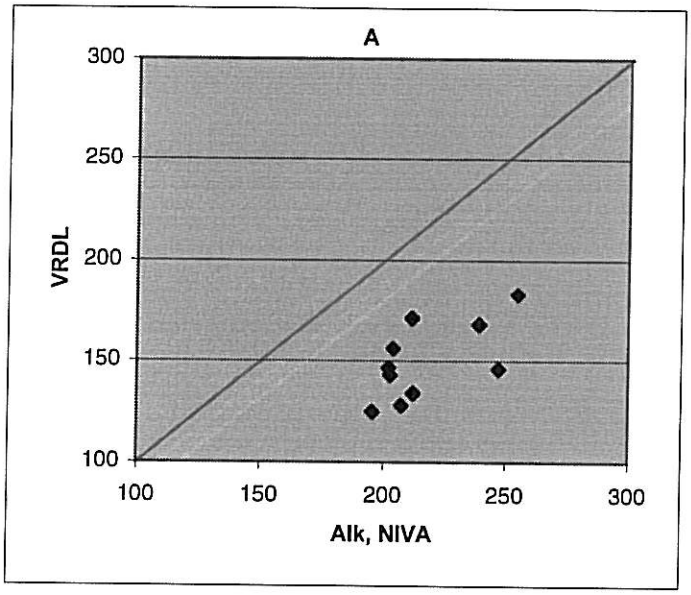
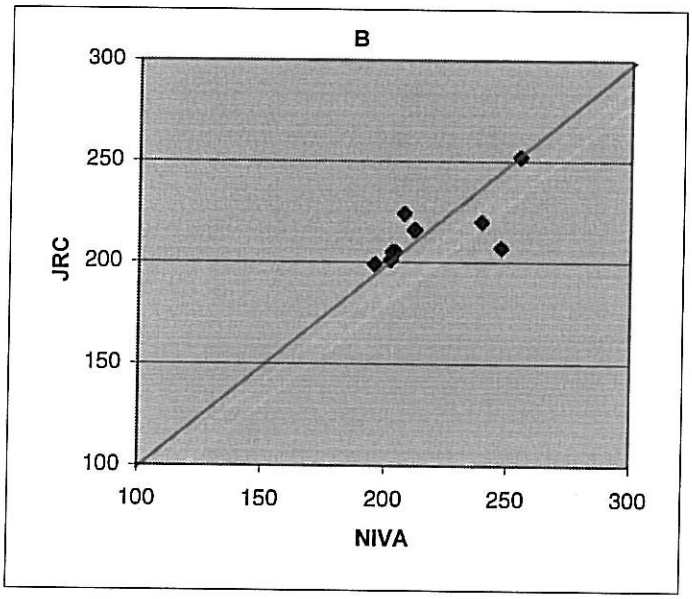


Figure A3.3. Alkalinity, mg/l HCO_3





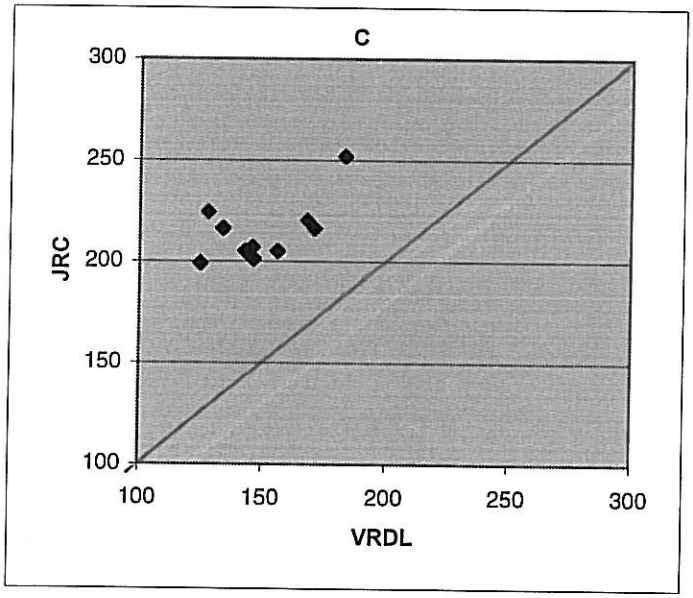
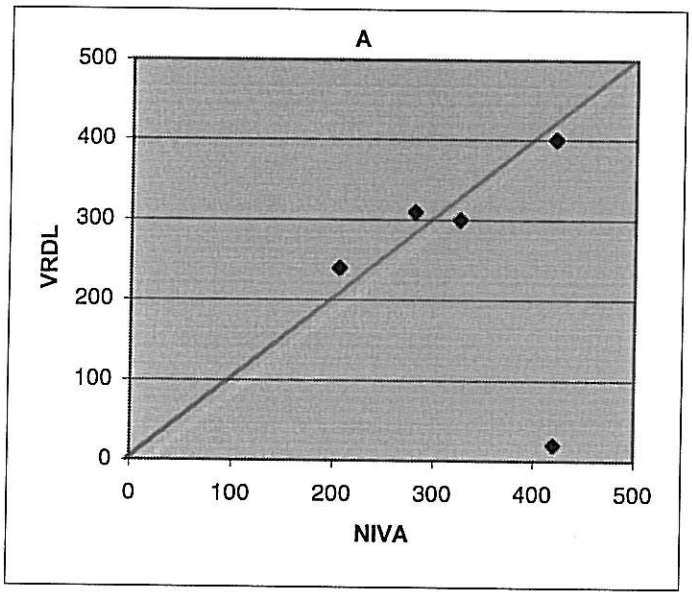
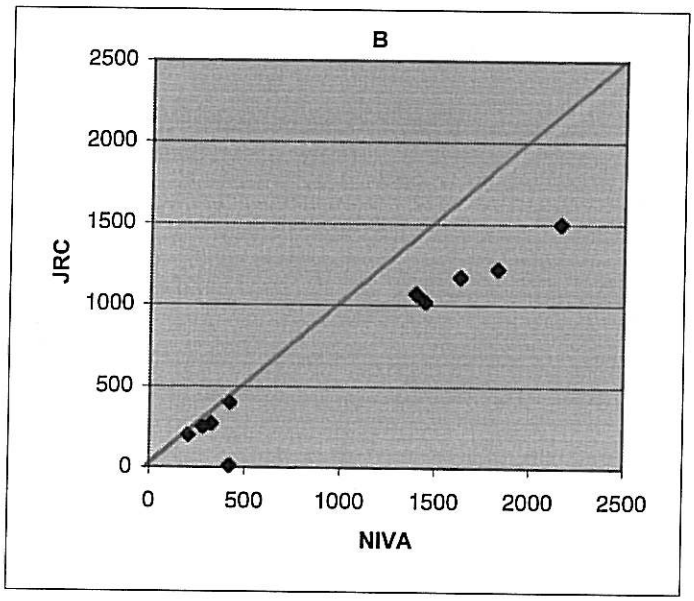


Figure A3.4. Nitrate-nitrogen, µg/l





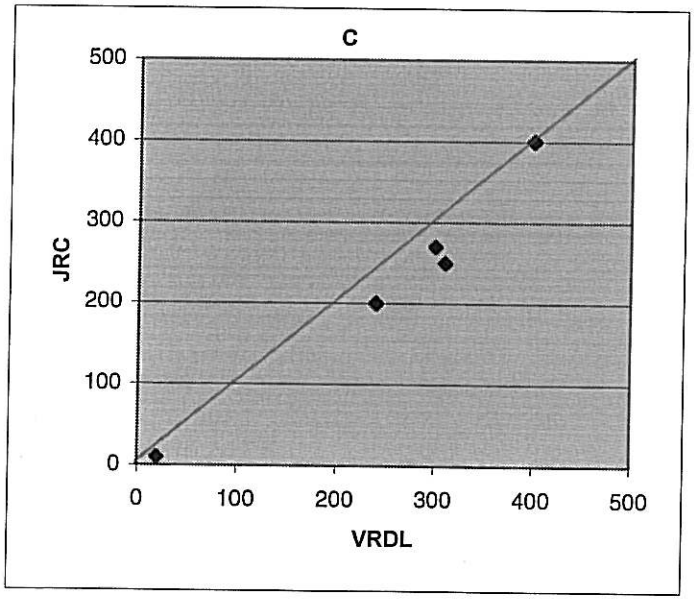
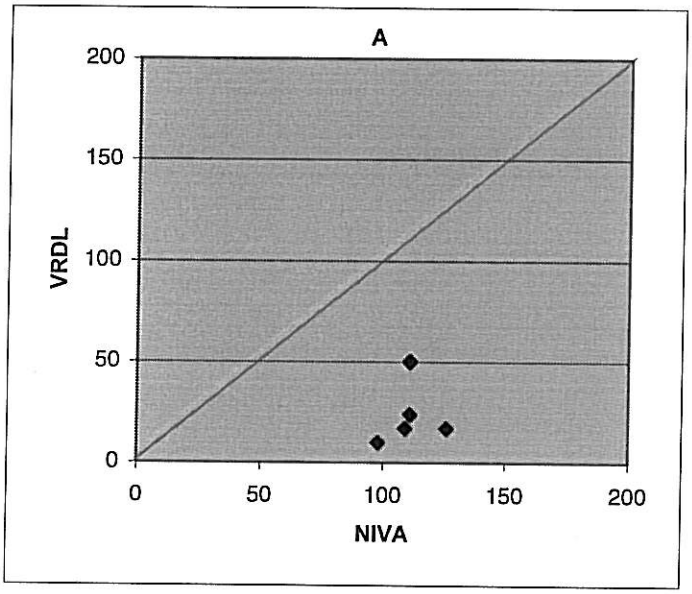
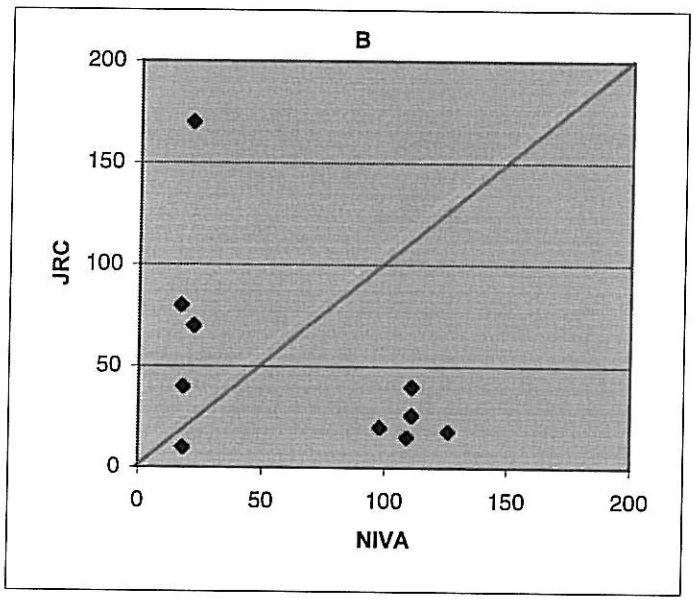
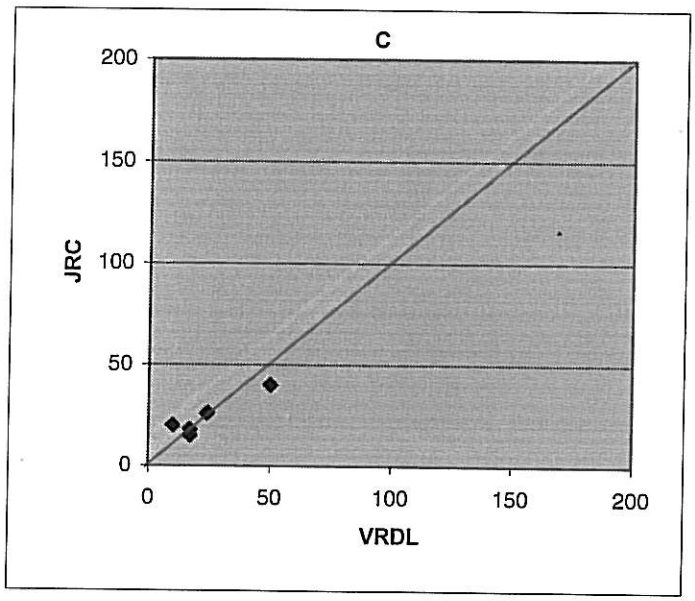


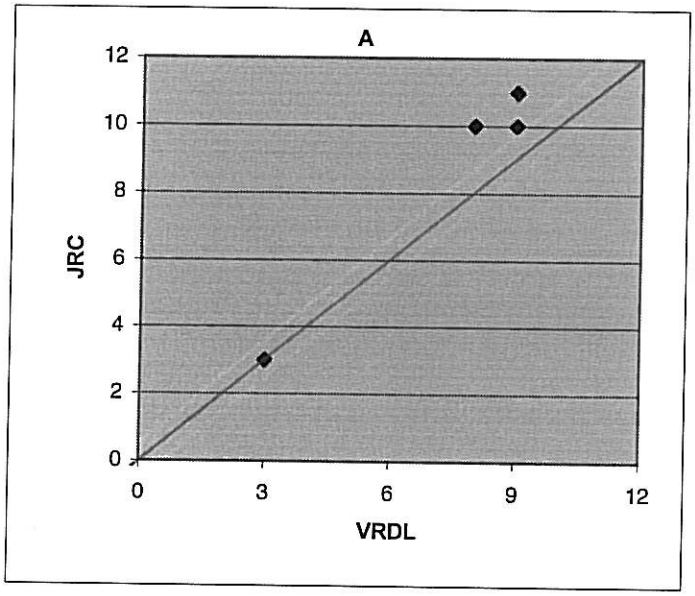
Figure A3.5. Ammonium-nitrogen, µg/l



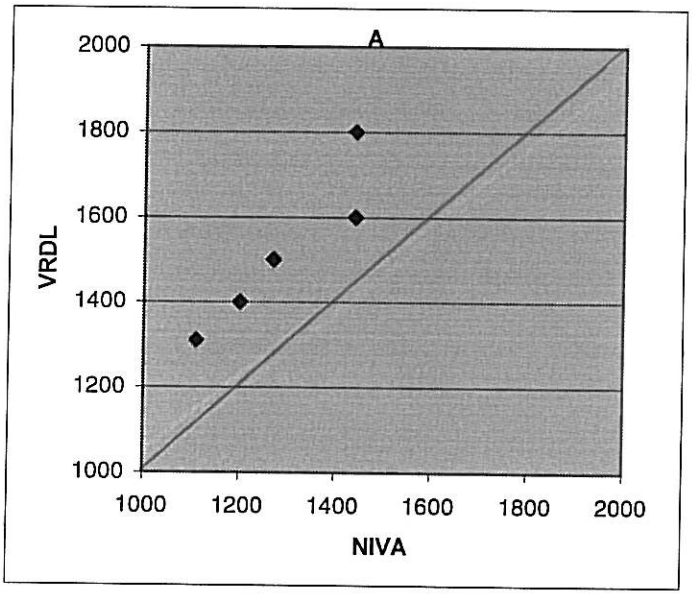


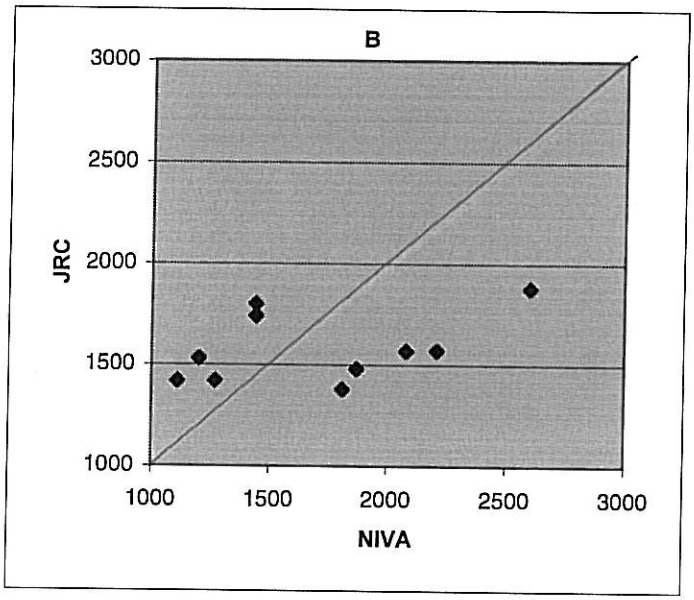


FigureA3. 6. Nitrite-nitrogen, µg/l



FigureA3. 7. Total nitrogen, µg/l





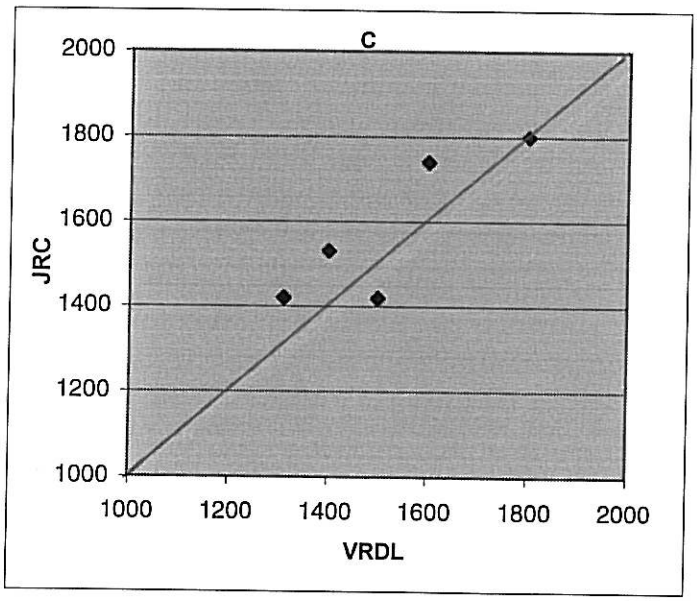
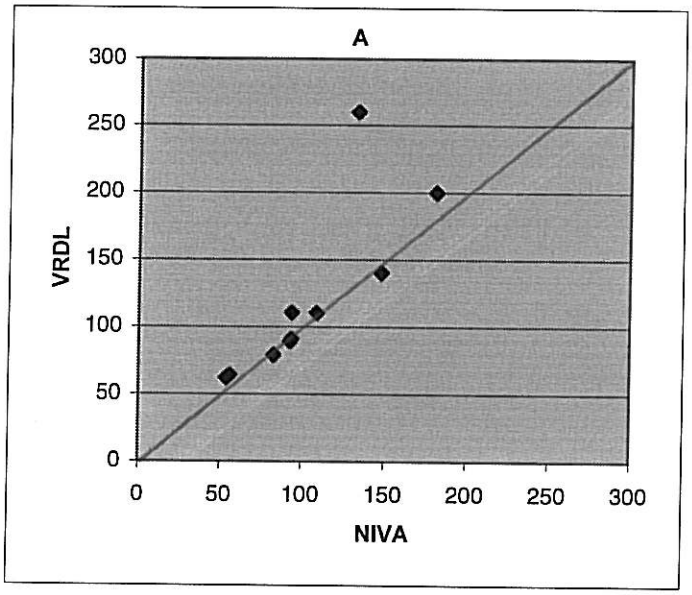
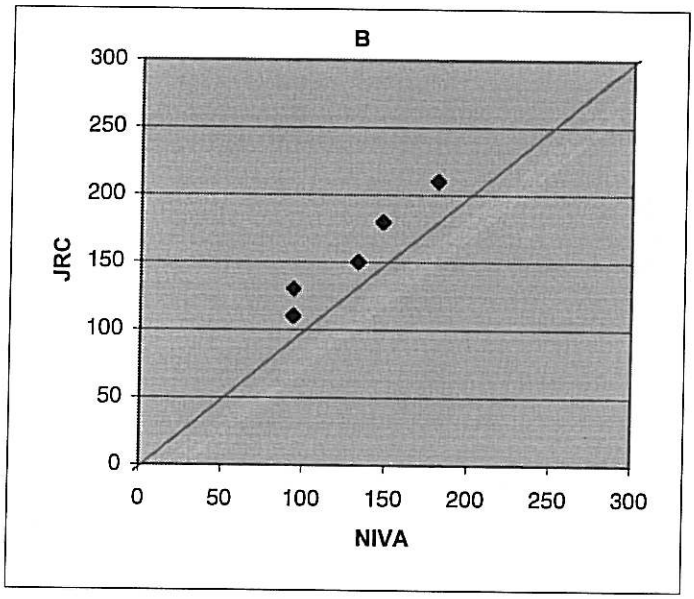


Figure A3.8. Total phosphorous, µg/l





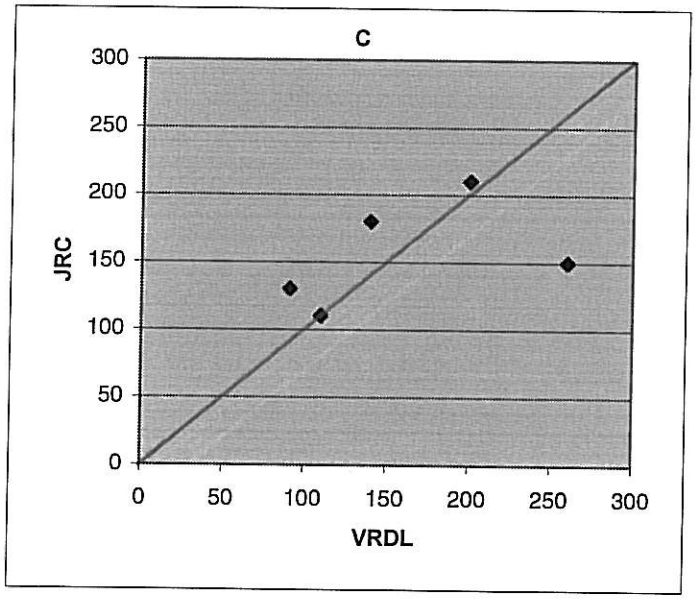


Figure A3.9. Phosphate-phosphorous, µg/l

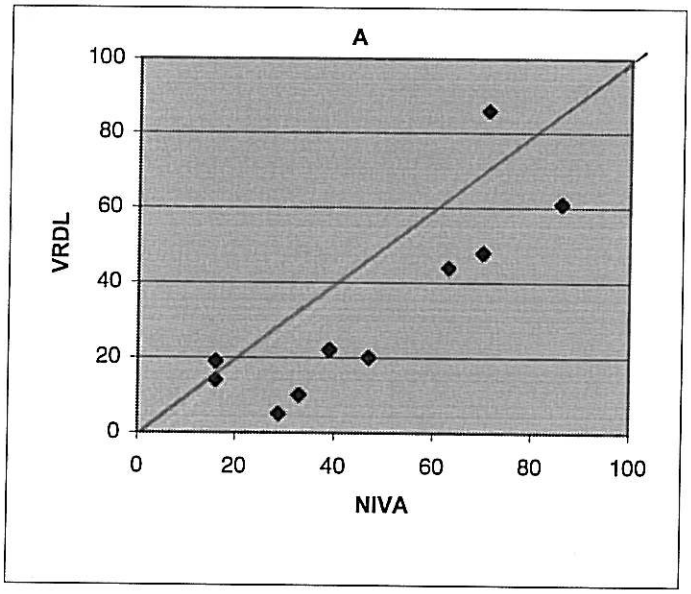
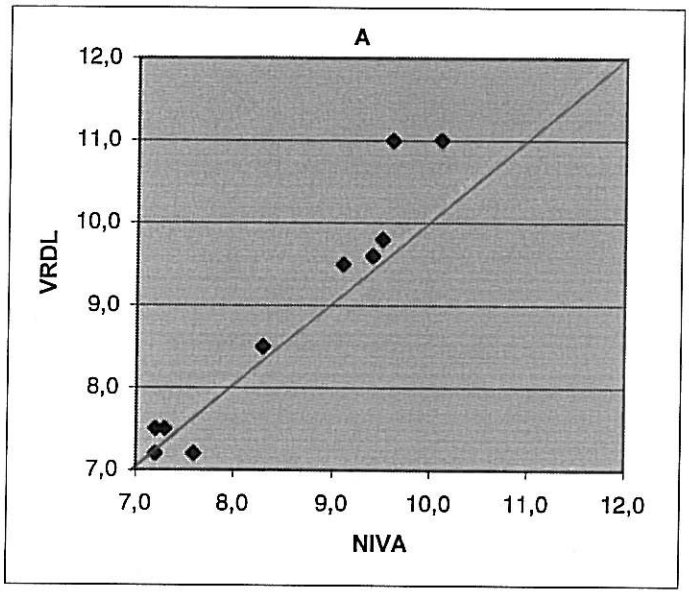
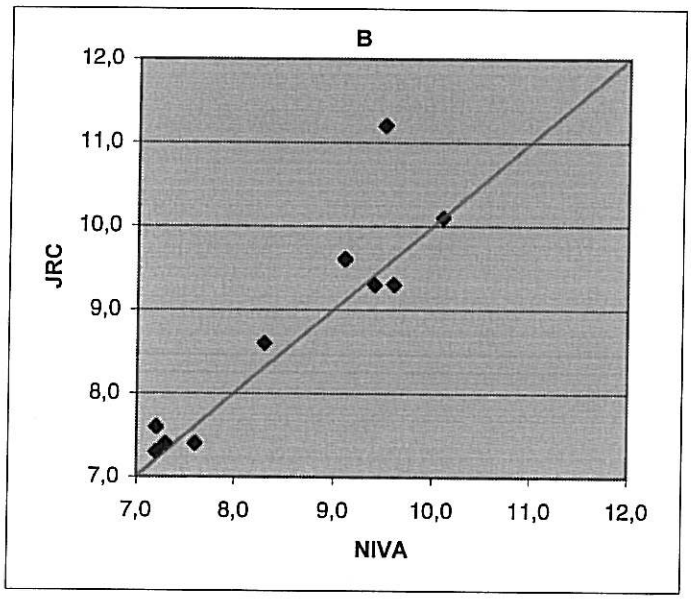


Figure A3.10. Chemical oxygen demand, COD-Mn, mg/l





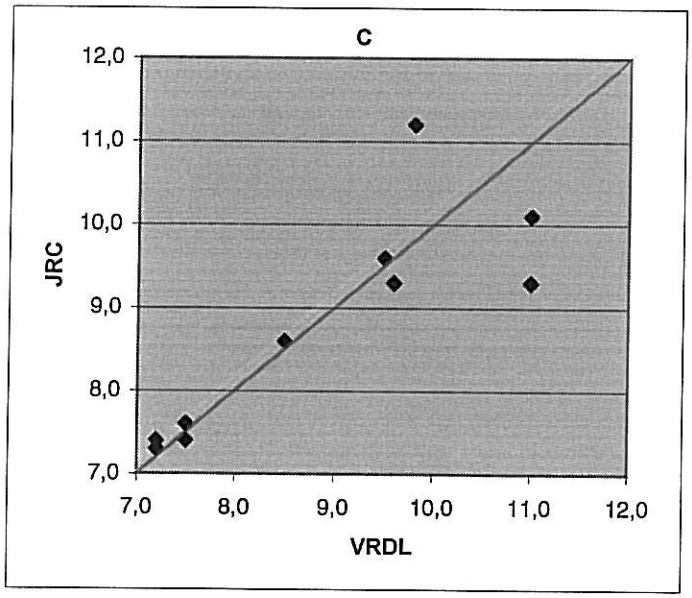
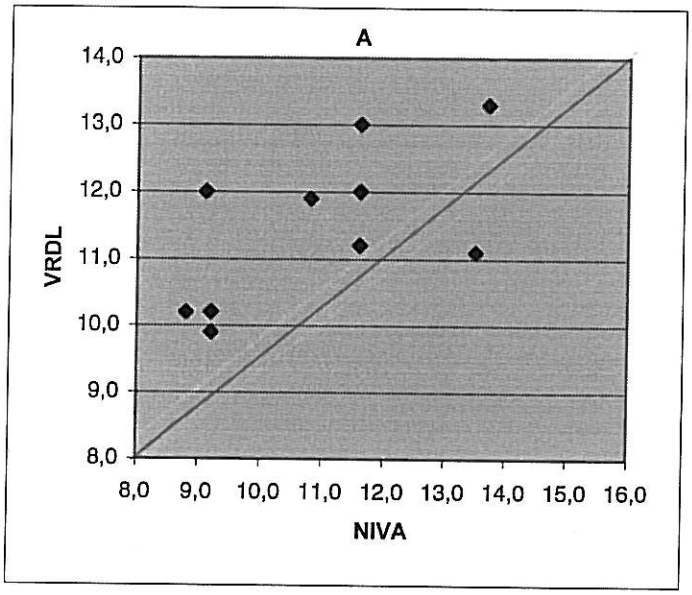
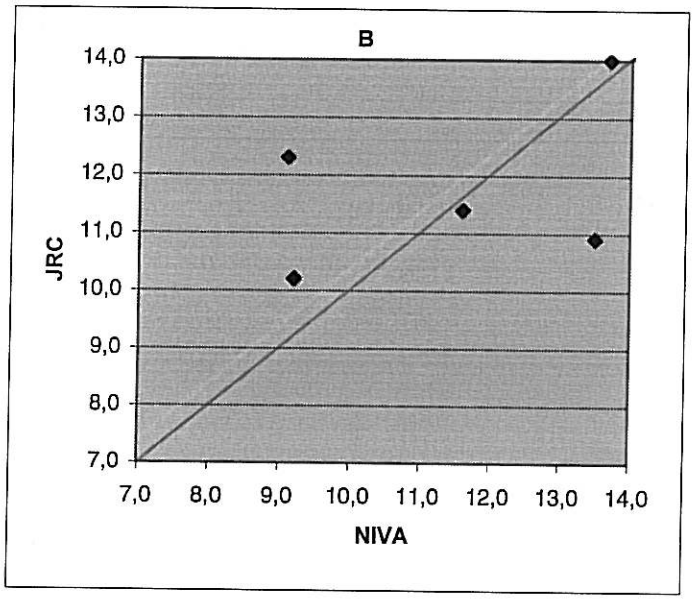


Figure A3.11. Chloride





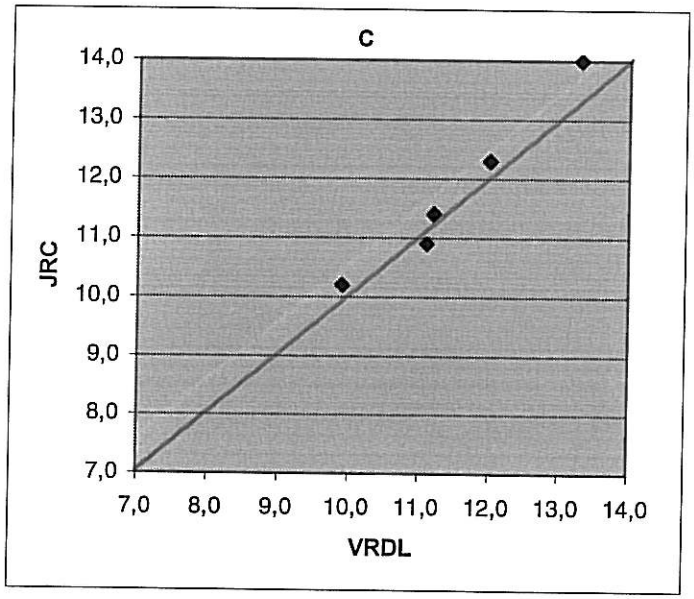
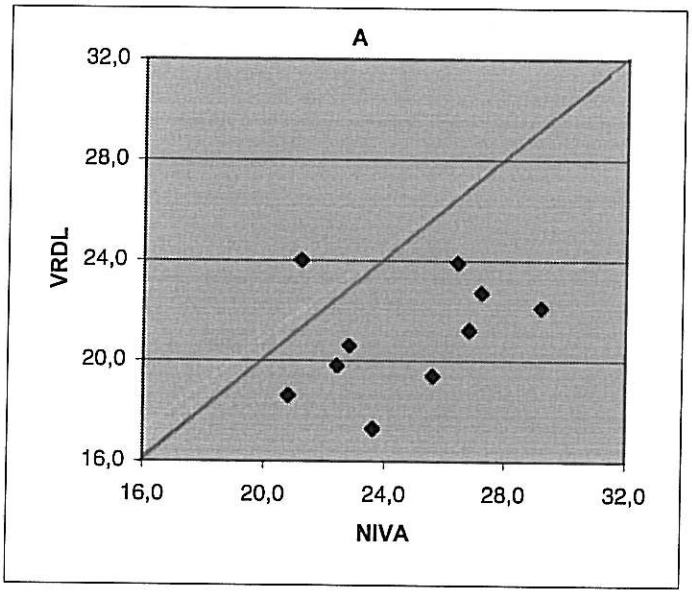
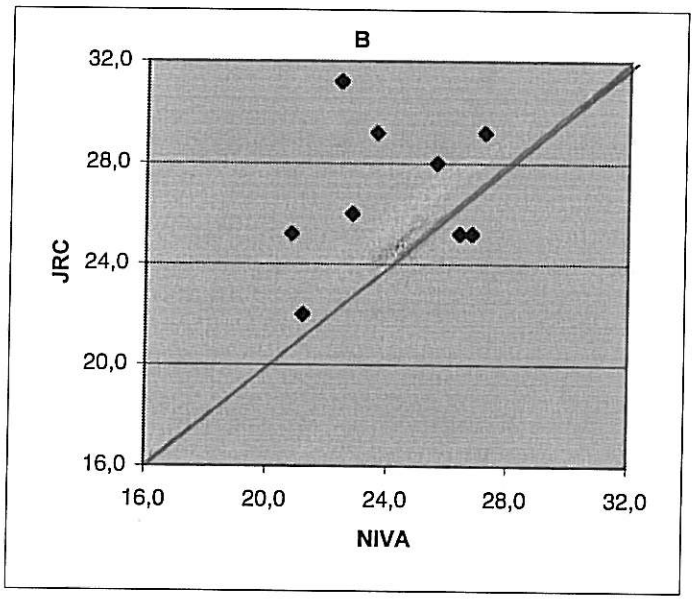


Figure A3.12. Sulfate





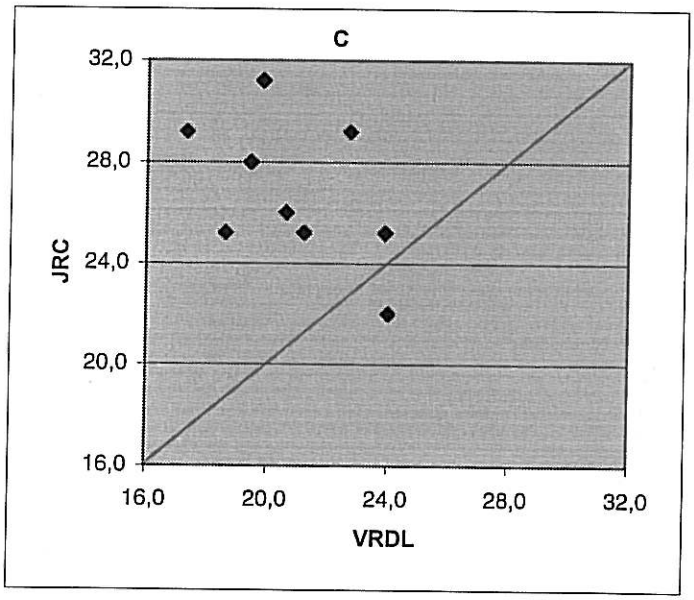
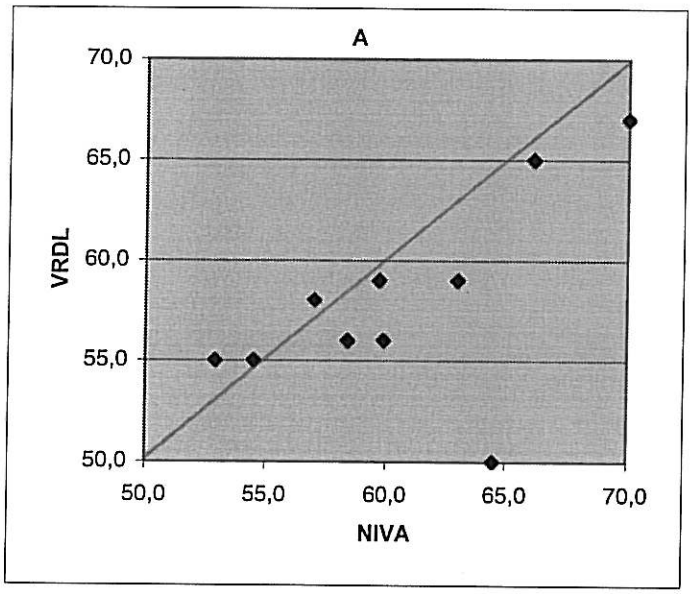
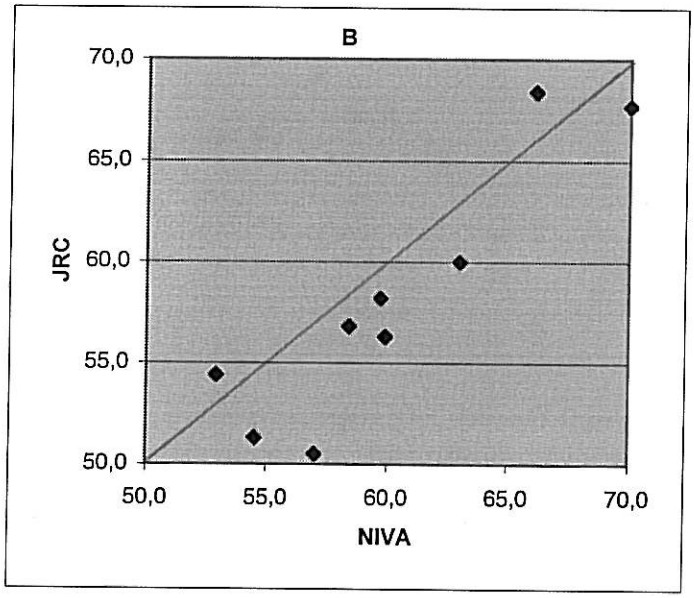


Figure A3.13. Calcium, mg/l





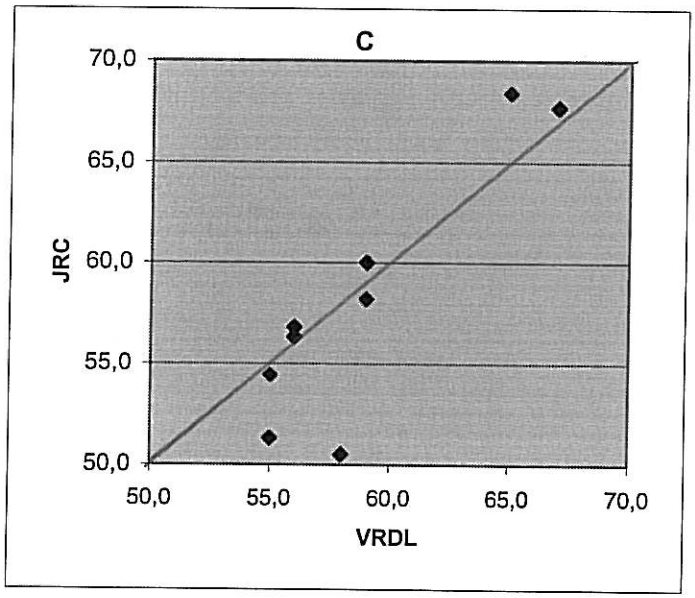
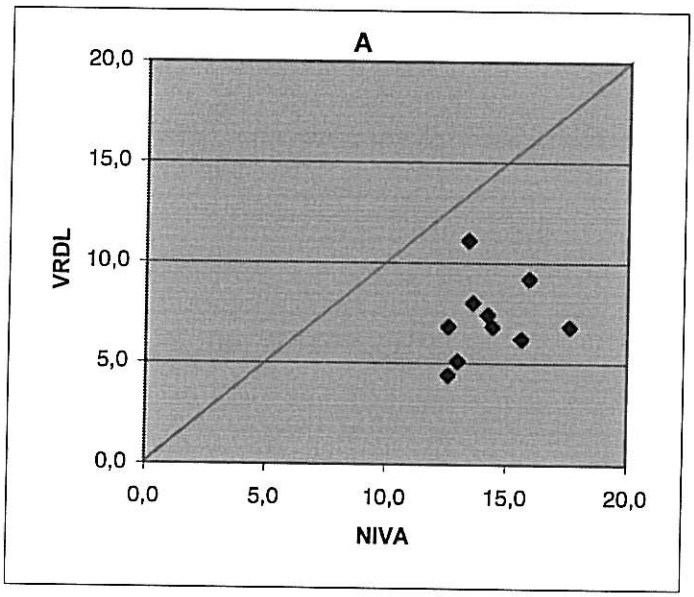
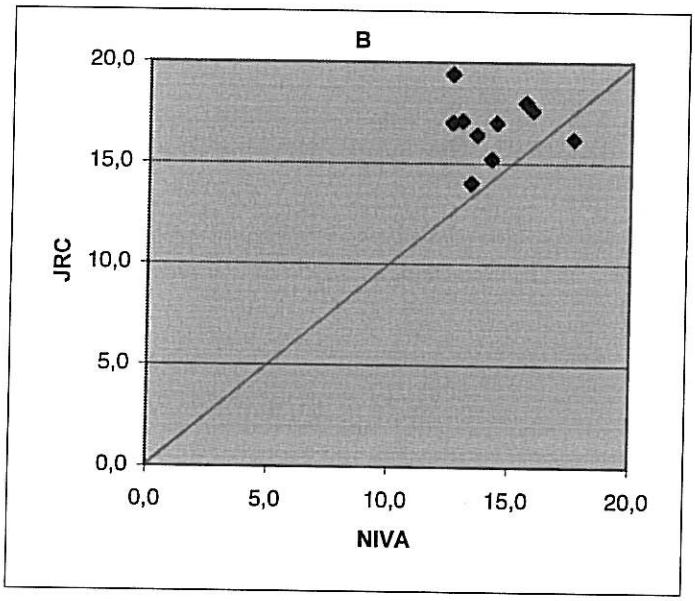


Figure A3.14. Magnesium, mg/l





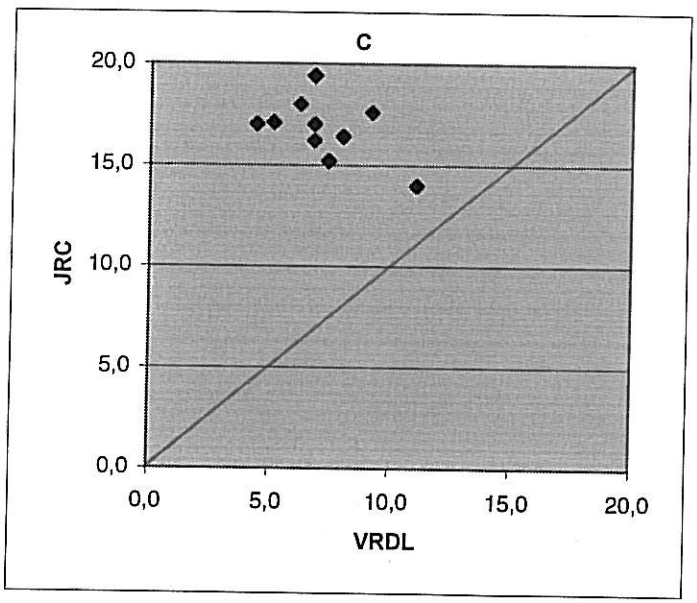
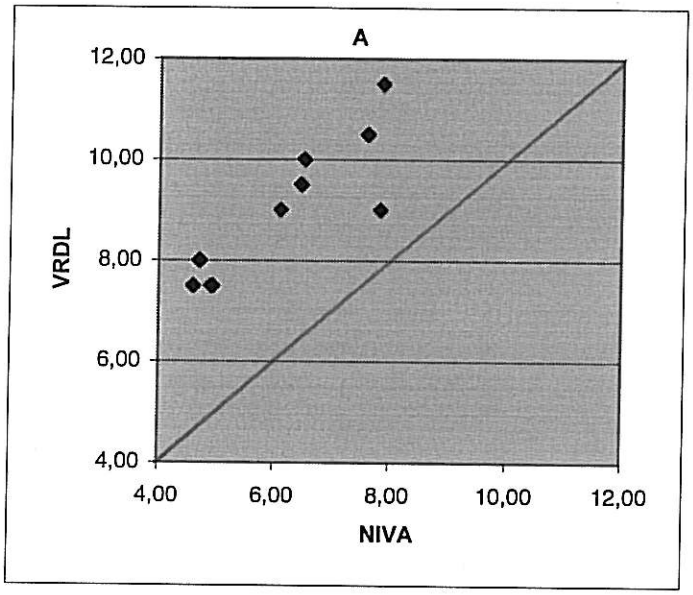
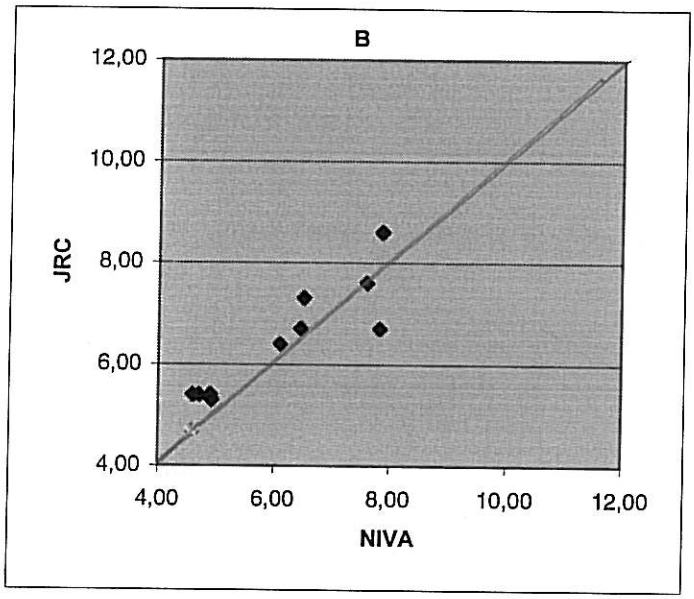


Figure A3.15. Sodium, mg/l





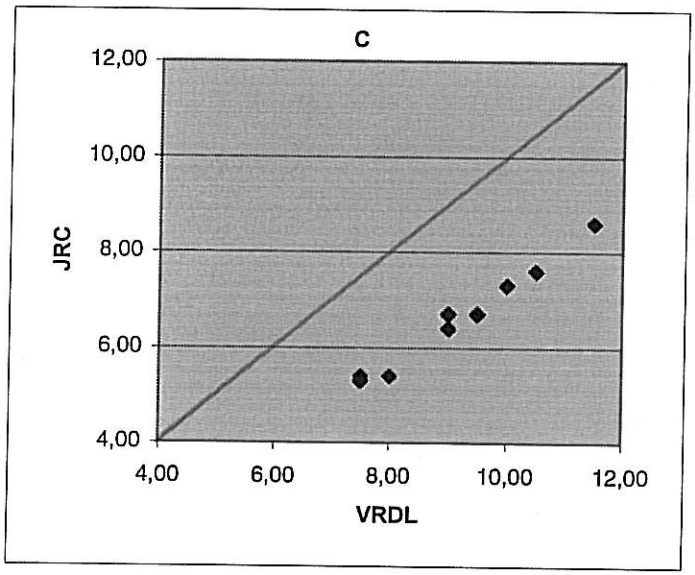
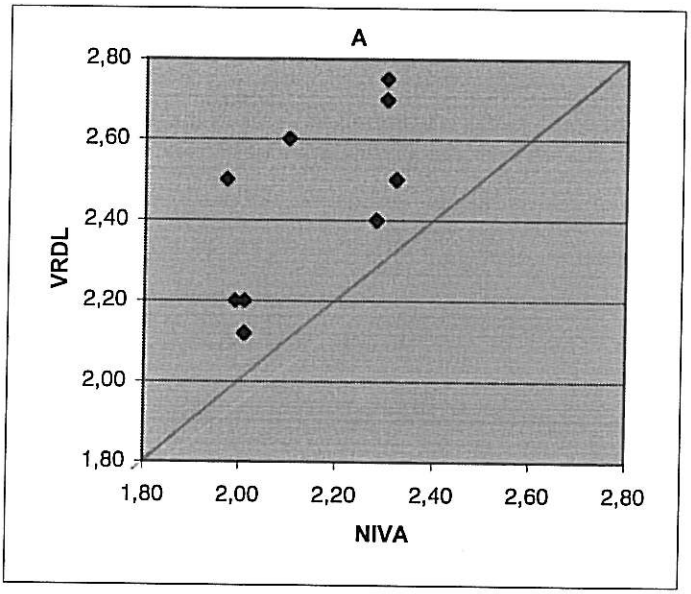
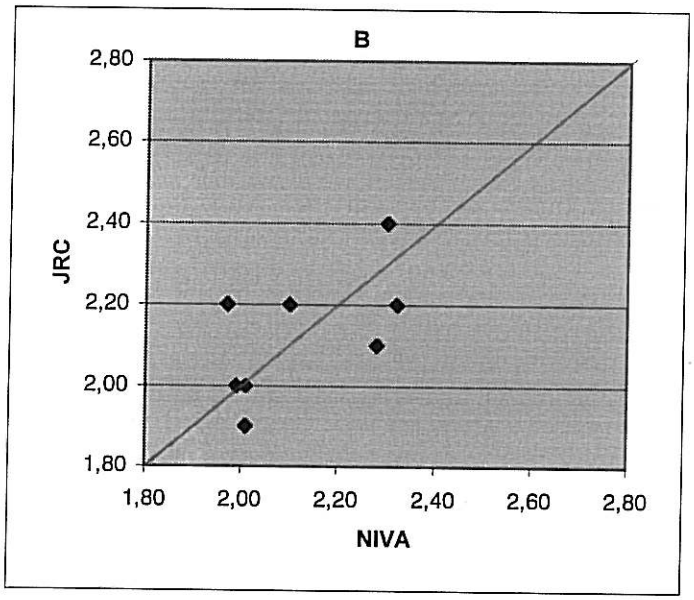
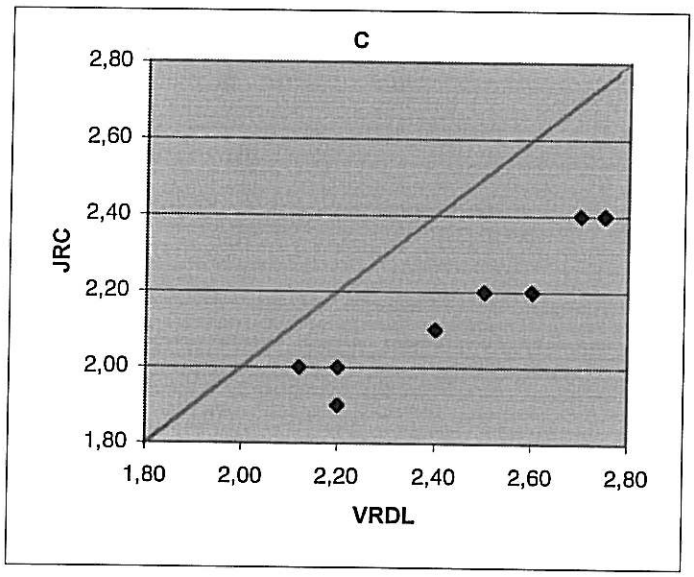


Figure A3.16. Potassium, mg/l







Intercomparison results 1998, from NIVA, VRDL and JRC

pH	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	7,97	7,72	8,14	-0,25	0,17	0,42
	2	8,06	7,78	8,14	-0,28	0,08	0,36
	3	8,03	7,74	8,16	-0,29	0,13	0,42
	4	8,11	7,80	8,20	-0,31	0,09	0,40
	5	8,10	7,81	8,00	-0,29	-0,10	0,19
	1	8,33	8,69	8,75	0,36	0,42	0,06
	2	8,46	8,72	8,80	0,26	0,34	0,08
	3	8,53	8,60	8,90	0,07	0,37	0,30
	4	8,51	8,58		0,07		
	5	8,57	8,78	8,60	0,21	0,03	-0,18
Mean value, March		8,05	7,77	8,13	-0,28	0,07	0,36
Mean value, May		8,48	8,67	8,76	0,19	0,29	0,07

Cond	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	36,5	40,9	40,6	4,4	4,1	-0,3
	2	37,3	41,4	41,1	4,1	3,8	-0,3
	3	39,0	43,1	42,5	4,1	3,5	-0,6
	4	40,3	44,0	42,7	3,7	2,4	-1,3
	5	44,5	46,0	47,5	1,5	3,0	1,5
	1	36,6	39,3	37,4	2,7	0,8	-1,9
	2	35,4	39,4	37,6	4,0	2,2	-1,8
	3	37,8	41,0	38,9	3,2	1,1	-2,1
	4	43,6	38,5	36,5	-5,1	-7,1	-2,0
	5	44,5	48,7	46,2	4,2	1,7	-2,5
Mean value, March		39,5	43,1	42,9	3,6	3,4	-0,2
Mean value, May		39,6	41,4	39,3	1,8	-0,3	-2,1

Alk	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	196	125	199	-71	3	74
	2	202	146	201	-56	-1	55
	3	207	128	224	-79	17	96
	4	212	134	216	-78	4	82
	5	239	168	220	-71	-19	52
	1	204	156	205	-48	1	49
	2	203	143	205	-60	2	62
	3	212	171	216	-41	4	45
	4	247	146	207	-101	-40	61
	5	255	183	252	-72	-3	69
Mean value, March		211	140	212	-71	1	72
Mean value, May		224	160	217	-64	-7	57

NO2-N	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1		10				
	2		9				
	3		14				
	4		10				
	5		9				
	1		8	10			2
	2		9	11			2
	3		9	11			2
	4		3	3			0
	5		9	10			1
Mean value, March			10,4				
Mean value, May			7,6	9,0			1,4

NO3-N	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	1395		1070		-325	
	2	1445		1020		-425	
	3	1630		1170		-460	
	4	1830		1220		-610	
	5	2160		1500		-660	
	1	325	300	270	-25	-55	-30
	2	280	310	250	30	-30	-60
	3	205	240	200	35	-5	-40
	4	420	20	10	-400	-410	-10
	5	420	400	400	-20	-20	0
Mean value, March		1692		1196		-496	
Mean value, May		330	254	226	-76	-104	-28

NH4-N	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	18		40		22	
	2	18		10		-8	
	3	21		170		149	
	4	17		80		63	
	5	22		70		48	
	1	111	50	40	-61	-71	-10
	2	98	10	20	-88	-78	10
	3	109	17	15	-92	-94	-2
	4	126	17	18	-109	-108	1
	5	111	24	26	-87	-85	2
Mean value, March		19		74		55	
Mean value, May		111	24	24	-87	-87	0

TOT-N	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	1810		1380		-430	
	2	1870		1480		-390	
	3	2080		1570		-510	
	4	2210		1570		-640	
	5	2600		1880		-720	
	1	1110	1310	1420	200	310	110
	2	1200	1400	1530	200	330	130
	3	1270	1500	1420	230	150	-80
	4	1440	1600	1740	160	300	140
	5	1440	1800	1800	360	360	0
Mean value, March		2114		1576		-538	
Mean value, May		1292	1522	1582	230	290	60

TOT-P	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	56	64		8		
	2	54	62		8		
	3	109	110		1		
	4	93	89		-4		
	5	83	79		-4		
	1	94	110	110	16	16	0
	2	94	91	130	-3	36	39
	3	181	200	210	19	29	10
	4	148	140	180	-8	32	40
	5	133	260	150	127	17	-110
Mean value, March		79	81		2		
Mean value, May		130	160	156	30	26	-4

PO4-P	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	39	22		-17		
	2	47	20		-27		
	3	86	61		-25		
	4	70	48		-22		
	5	63	44		-19		
	1	16	14		-2		
	2	16	19		3		
	3	33	10		-23		
	4	71	86		15		
	5	29	5		-24		
Mean value, March		61	39		-22		
Mean value, May		33	27		-6		

COD-Mn	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	7,2	7,5	7,6	0,3	0,4	0,1
	2	7,6	7,2	7,4	-0,4	-0,2	0,2
	3	7,2	7,2	7,3	0,0	0,1	0,1
	4	7,3	7,5	7,4	0,2	0,1	-0,1
	5	8,3	8,5	8,6	0,2	0,3	0,1
	1	9,6	11,0	9,3	1,4	-0,3	-1,7
	2	9,4	9,6	9,3	0,2	-0,1	-0,3
	3	9,1	9,5	9,6	0,4	0,5	0,1
	4	9,5	9,8	11,2	0,3	1,7	1,4
	5	10,1	11,0	10,1	0,9	0,0	-0,9
Mean value, March		7,5	7,6	7,7	0,1	0,1	0,1
Mean value, May		9,5	10,2	9,9	0,6	0,4	-0,3

Cl	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	8,8	10,2		1,4		
	2	9,2	10,2		1,0		
	3	11,6	12,0		0,4		
	4	10,8	11,9		1,1		
	5	11,6	13,0		1,4		
	1	9,1	12,0	12,3	2,9	3,2	0,3
	2	9,2	9,9	10,2	0,7	1,0	0,3
	3	11,6	11,2	11,4	-0,4	-0,2	0,2
	4	13,5	11,1	10,9	-2,4	-2,6	-0,2
	5	13,7	13,3	14,0	-0,4	0,3	0,7
Mean value, March		10,4	11,5		1,1		
Mean value, May		11,4	11,5	11,8	0,1	0,3	0,3

SO4	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	22,4	19,8	31,2	-2,6	8,8	11,4
	2	23,6	17,3	29,2	-6,3	5,6	11,9
	3	25,6	19,4	28,0	-6,2	2,4	8,6
	4	27,2	22,7	29,2	-4,5	2,0	6,5
	5	29,2	22,1	35,0	-7,1	5,8	12,9
	1	20,8	18,6	25,2	-2,2	4,4	6,6
	2	21,2	24,0	22,0	2,8	0,8	-2,0
	3	22,8	20,6	26,0	-2,2	3,2	5,4
	4	26,4	23,9	25,2	-2,5	-1,2	1,3
	5	26,8	21,2	25,2	-5,6	-1,6	4,0
Mean value, March		25,6	20,3	30,5	-5,3	4,9	10,3
Mean value, May		23,6	21,7	24,7	-1,9	1,1	3,1

Ca	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	59,9	56,0	56,3	-3,9	-3,6	0,3
	2	58,4	56,0	56,8	-2,4	-1,6	0,8
	3	59,7	59,0	58,2	-0,7	-1,5	-0,8
	4	63,0	59,0	60,0	-4,0	-3,0	1,0
	5	70,0	67,0	67,7	-3,0	-2,3	0,7
	1	54,5	55,0	51,3	0,5	-3,2	-3,7
	2	52,9	55,0	54,4	2,1	1,5	-0,6
	3	57,0	58,0	50,5	1,0	-6,5	-7,5
	4	64,5	50,0	47,7	-14,5	-16,8	-2,3
	5	66,1	65,0	68,4	-1,1	2,3	3,4
Mean value, March		62,2	59,4	59,8	-2,8	-2,4	0,4
Mean value, May		59,0	56,6	54,5	-2,4	-4,5	-2,1

Mg	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	14,2	7,4	15,2	-6,8	1,0	7,8
	2	13,4	11,1	14,0	-2,3	0,6	2,9
	3	13,6	8,0	16,4	-5,6	2,8	8,4
	4	14,4	6,8	17,0	-7,6	2,6	10,2
	5	17,6	6,8	16,2	-10,8	-1,4	9,4
	1	12,6	6,8	19,4	-5,8	6,8	12,6
	2	12,6	4,4	17,0	-8,2	4,4	12,6
	3	13,0	5,1	17,1	-7,9	4,1	12,0
	4	15,6	6,2	18,0	-9,4	2,4	11,8
	5	15,9	9,2	17,6	-6,7	1,7	8,4
Mean value, March		14,6	8,0	15,8	-6,6	1,1	7,7
Mean value, May		13,9	6,3	17,8	-7,6	3,9	11,5

Na	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	4,93	7,50	5,30	2,57	0,37	-2,20
	2	4,90	7,50	5,40	2,60	0,50	-2,10
	3	6,46	9,50	6,70	3,04	0,24	-2,80
	4	6,11	9,00	6,40	2,89	0,29	-2,60
	5	7,60	10,50	7,60	2,90	0,00	-2,90
	1	4,71	8,00	5,40	3,29	0,69	-2,60
	2	4,60	7,50	5,40	2,90	0,80	-2,10
	3	6,52	10,00	7,30	3,48	0,78	-2,70
	4	7,83	9,00	6,70	1,17	-1,13	-2,30
	5	7,86	11,50	8,60	3,64	0,74	-2,90
Mean value, March		6,00	8,80	6,28	2,80	0,28	-2,52
Mean value, May		6,30	9,20	6,68	2,90	0,38	-2,52

K	Station	NIVA	VRDL	JRC	V-N	J-N	J-V
	1	2,01	2,12	2,00	0,11	-0,01	-0,12
	2	1,99	2,20	2,00	0,21	0,01	-0,20
	3	2,10	2,60	2,20	0,50	0,10	-0,40
	4	1,97	2,50	2,20	0,53	0,23	-0,30
	5	2,30	2,75	2,40	0,45	0,10	-0,35
	1	2,01	2,20	1,90	0,19	-0,11	-0,30
	2	2,01	2,20	1,90	0,19	-0,11	-0,30
	3	2,32	2,50	2,20	0,18	-0,12	-0,30
	4	2,28	2,40	2,10	0,12	-0,18	-0,30
	5	2,30	2,70	2,40	0,40	0,10	-0,30
Mean value, March		2,07	2,43	2,16	0,36	0,09	-0,27
Mean value, May		2,18	2,40	2,10	0,22	-0,08	-0,30

TURB	Station	NIVA
	1	2,0
	2	2,3
	3	2,2
	4	3,0
	5	4,0
	1	4,9
	2	5,0
	3	4,9
	4	4,8
	5	6,2
Mean value, March		2,7
Mean value, May		5,2

Sampling stations:

1	Near Buivydziai
2	Before Vilnius
3	After Vilnius, middle
4	Before Jonava
5	After Jonava