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International Activities

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WATER POLLUTION ABATEMENT PROGRAMME

THE CZECH REPUBLIC

PROJECT 4

Acid Rain The Czech Score Method for Biomonitoring Effects of Acid Rain

Project Report for Phase I and Programme of Work for Phase II

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Abstract: As a result of the bilateral environmental protection agreement between the Governments of Czech and Slovak Federal Republic and Norway one of the projects coming up and given priority is dealing with the Acid Rain problem in the Czech Republic. Scientists from the two countries established a team in spring 1992 with the intention to develop a tool for the assessment and monitoring of environmental quality of running water ecosystems affected by Acid Rain in the Czech Republic. This will be done by integrating physico-chemical data and biological data from the communities of benthic macro invertebrates in brooks and streams. And from that information develop a response model, a system for water quality classification of effects generated by acid deposition. The system will be an important tool in the Czech Republic to get a national picture of the degree of deterioration and the geographical distribution of these problems in the< running water resources.

1992 was the first phase in this project and was used to exchange experience and knowledge about the acidification of running water ecosystems, and to do some preliminary fieldwork. We defined the objects for the Acid Rain project, the organization and developed a working plan and a programme for the project. The report from phase I gives some background information about the Acid Rain problem in the Czech Republic, and a status of the work so far, together with a description of the workplan for phase II .

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2. Forsuring
3. Bunnfauna
4. Elver og bekker

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WATER POLLUTION ABATEMENT PROGRAMME
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Project 4
Acid Rain

The Czech Score Method for Biomonitoring the Effects of Acid Rain

Project Report for Phase I and
Programme of Work for Phase II

Oslo, Norway,
March 1993

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Ilia Bernardova

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Preface

As a result of the bilateral agreement established in 1991 between Czechoslovakia and Norway one of the projects ranked as an important priority task for collaboration was a study aimed to improve the knowledge about the Acid Rain problem and its effect on the surface water resources. After the first symposium under this agreement, which was held in Ostrava in October 1991 the project-plan was further developed during the mission to Czechoslovakia in April 1992 where scientists from NIVA responsible for the different activities visited the Czech co-workers. Responsible for co-ordination of project no 4 the Acid Rain project: The Czech Score Method for Biomonitoring Effects of Acid Rain in Czechoslovakia, later The Czech Republic, was Ing. Ilia Bernardová and Dr. Michal Fiala both from the Masaryk Water Research Institute, Branch Brno.

The overall objective of this activity is to enhance the knowledge and then improving abatement techniques of water pollution problems connected to Acid Rain in the Czech Republic, with special emphasis on the running water ecosystems. Through the project the two countries are given the possibility to exchange knowledge and experience about this very serious kind of pollution in general and with a special relevance to water related problems generated by the acid deposition.

Norway, having delt with studies of water related effects generated by the deposition of aciditying for three decades, has a natural position in such a work to contribute and encourage to initiate national research on the effects of acid rain. The Czech-Norwegian project will from preliminary studies (phase I), develop a National System for water quality classification with respect to acidification of surface waters, based on the benthic fauna. And on a general basis initiate and advice in the process to develop a national monitoring program to collect information about the degree and geographical distribution of effects seen from acid deposition in Czech running water resources. Another goal of this project would be to generate an interest for a Czech data-base on physico-chemical and biological data relevant for the acidification of surface waters in such a way that it can communicate with data-base for the international co-operative programme on assessment and monitoring of acidification of rivers and lakes under the convention on Long-Range Transboundary Air Pollution.

In the developing phase of the project through exchange of experience, knowledge and relevant data,(papers and reports) a familiarization of the project team was achieved. A constructive atmosphere for co-operation was established and a common view on the importance to fullfil the objectives for this project.

The report presented gives background information for the joint project, how it was developed, its activity in phase I - through the year 1992, its objectives and progress so far. In the report is included a proposal for further activity listed in the programme for phase II to be executed in the next two years: 1993 and 1994.

The report has been written by Karl Jan Aanes, NIVA, with assistance from Michael Fiala, Brno and Torleif Bækken, NIVA, and should give a reasonable well picture of the activity from the beginning of the project, the dimension of the acidification problem so far seen in the Czech Republic and the need for further activity progress.

Oslo, March 1993

Karl Jan Aanes

Project Manager

G:aan/acidrain

Table of contents

1. BACKGROUND AND RELATED STUDIES.

1.1 Developing the acid rain project

As a result of the bilateral environmental protection agreement between the Governments of Czech and Slovak Federal Republic and Norway a symposium was held in Ostrava in October 1991. The symposium was entailed a discussion on how to develop an active co-operation between scientists/institutions working on common environmental problems and how to develop projects, and engage people with the relevant background, knowledge and position. During the symposium and through the evaluation afterwards several topics connected to the deterioration of the fresh water resources/ecosystems in the Czech Republic were given priority, one of them was connected to the acid rain problem.

The monitoring of the running water ecosystems in The Czech and The Slovakian Republic had up till now given very little information about the effect of acid precipitation. Knowledge about how the increased acidity in the deposition (wet and dry) had changed the physico-chemical environment and biological communities in the running water ecosystems, particularly in the upper part of the catchment areas was missing. At the same time Norway has been occupied in this field of environmental research for a long period.

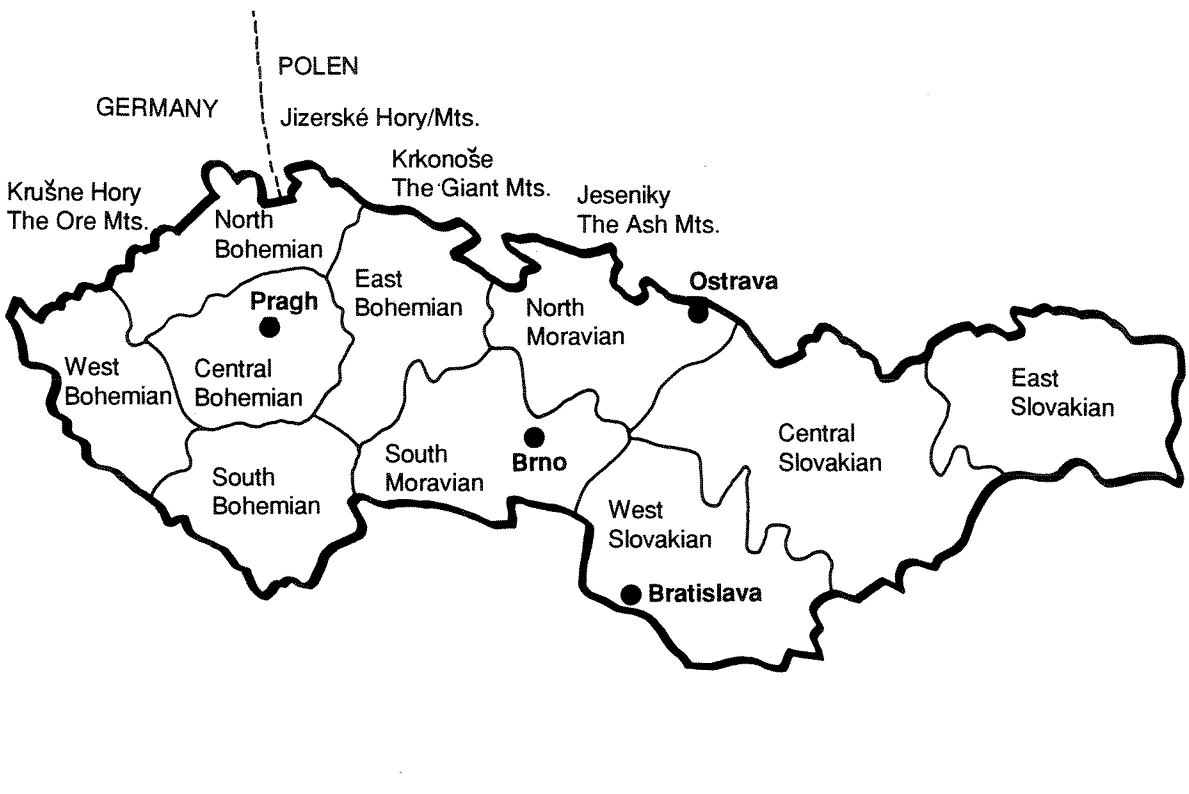


Figure 1. Map of the former Czechoslovakia with its 10 regions.

The Acid Rain project was further developed during NIVA's mission to Pragh, Brno and Ostrava in April 1992. It had now been given the necessary priority under the bilateral environmental protection agreement.The visit had the intention to initiate co-operation between scientists from the two countries familiar to topics relevant to the acid rain problem and the project. From the Czech side scientists from the T. Gj. Masaryk Water Research Institute Dr. Michal Fiala and Ing. Ilja Bernardova both from the branch in Brno were given the responsibility to take care of the acid rain project. From discussions during our mission a project plan was developed for the first phase to cover the year 1992. The project was later accepted by the two countries.

1.2 General about the acid rain situation in the Czech Republic

The Czech Republic and particularly its northern part, the Ore Mountains (Fig. 1), is one of the oldest air polluted areas in Europe (Cerný, 1991). The well known "ecological disaster" characterising the forest dieback began in the Ore Mountains in the early 50s. Following heavy damaged area where Jizera Mountains (in the mid 70s) and the Krkonose Mountains (the 70s-80s). The main cause of forest decline in Northern Bohemia is extremely high concentration of SO_2 in the air, where the mean annual concentration reaches 90 $\mu g/m^3$. The main source of SO_2 pollution is the set of brown coal power plants in Northern Bohemia and also the transboundary air pollution from Germany and Poland.

The process of disintegration of forest ecosystem is now confined not only to the area of Northern Bohemia. The symptoms of forest decline are observed also in Northern Moravia, Western and Southern Bohemia. It is nearly impossible to find any area in the Czech Republic which is not impacted by air pollution. The character of forest damage in these relatively new forest damage areas differs from the situation of Northern Bohemia. Contrary to direct impact of SO_2 the influence of acid deposition and subsequently the negative changes in the soils and disturbed forests nutrition take place here, along with impact from other pollutants (heavy metals, aluminium, ozone and nitrogen oxides). In table 1 results from mapping the intensity of defoliation in Europe are shown.

A comparison of the present state of pollution of the atmosphere by solid and gaseous emissions in the CSFR with other countries in Europe results in the conclusion that Czechoslovakia (the data are collected prior to the separation) belongs among the countries with the most polluted atmosphere (see Tables A-C in Appendix) and consequent maximum health, ecological and cultural damages and consequences. The present-day Czekoslovak economy has high demands on primary power resources,with specific consumption of more than 7 tons of fuel per inhabitant per year. This power consumption puts the country on the fore place of the rank list, and the share of the industry is as high as 54 % (Quitt, 1992). In addition the fuel power basis of the industry it is based to a decisive extent on brown coal of low caloric capacity, high ash content and still increasing sulphur content.

Whereas about 800.000 tons of fly ash and 930.000 tons of SO_2 were discharged to the atmosphere in Czechoslovakia at the end of the 50's, the values were twice as high at the end of the 60`s. To day the total SO_2 emissions amounts to 3.2 million tons per year, that of solid matter to 1.7 million tons per year. The annual emissions of other injurants amount to about 1 million tons of NO_x, 1.3 million tons of CO and nearly 200.000 tons of carbohydrate.

Episodic excessive pollution of the atmosphere occurs mostly in the winter months mainly in the North - Bohemian brown coal basin, in Pragh, in the Ostrava region and in Bratislava (Fig. 2). Excessive occasional atmospheric pollution is caused in industrial agglomerations and large cities by meteorological conditions unfavourable for the dispersion of the pollution. While the highest permissible concentration is 0.5 μg/m³ in the North-Bohemian brown coal basin the diurnal average SO_2 concentrations attained are 2500-3000 μg SO_2/m³ and at the same time reached a level of 3200 μg SO_2/m³ in Pragh on the 14th January 1982.

The north-western part of Czechoslovakia (now the Czech Republic) is loaded by a total deposition of sulphur of even 15 g/m², this value decreasing to 2 g/m² per year in the north-eastern part of the republic. Together with the pollution of the atmosphere created by the country itself, foreign sources contribute significantly to that detoriation as well. But in the last decade it is evident that the share of the sources in the territory of Germany and Austria decreased rapidly due to the reduction of the emissions in these countries (Tables A, B and C in Appendix) But at the same time one should have in mind that Czechoslovakia (data are from the period prior to the separation) is a significant exporter of injurants. According to model calculations, the total distance transfer from Czechoslovakia are 3.2 mill tons of SO_2 per year (Quitt, op. cit.). Out of that amount 2 million tons are supposed to enter in Czechoslovakia and "re-exported" into distance transfer. From the amount imported and produced in Czechoslovakia about 36 % is deposited on Czechoslovakian territory, the remainder falls in other European countries and the adjacent seas. Calculations made for the year 1990 shows that 3.800 tons S was transported from Czechoslovakia to Norway, which in amount is 50 % of what we in Norway produced by our own activity (Acid News,1991).

Table 1. Intensity of defoliation in 1990, in per cent of trees affected. For all tree species, unless marked * for conifers only. Based on nation-wide (N) or regional (R) surveys. Source: United Nations ECE, ICP Forests (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests). (Acid News, 1991)

Country	Moderate to severe (Classes 2-4)	Slight to severe (Classes 1-4)
USSR-Byelorussia (R)	*54.0	84.0
Czechoslovakia (N)	46.6	76.3
United Kingdom (N)	39.0	74.0
Poland (N)	38.4	85.7
Latvia (N)	36.0	69.0
Germany (former East)	35.9	65.7
Portugal (N)	30.7	46.9
Bulgaria (N)	29.1	50.3
USSR-Kaliningrad (R)	22.5	70.9
Hungary (N)	21.7	50.4
Denmark (N)	21.2	54.7
Lithuania (N)	20.4	68.5
Estonia* (N)	20.0	63.0
Belgium-Wallonia (R)	19.1	45.4
Yugoslavia-Slovenia (R)	18.2	35.7
Netherlands (N)	17.8	46.8
Greece (N)	17.5	60.5
Finland (N)	17.3	37.8
Norway (N)	17.2	46.2
Switzerland (N)	17.0	61.0
Sweden (N)	16.2	49.9
Germany (former West)	15.9	52.9
Italy (N)	14.8	38.6
Austria (N)	9.1	49.2
Belgium-Flanders (R)	8.3	54.9
France (N)	7.3	24.0
Liechtenstein* (N)	7.1	59.0
Ukrainian SSR (R)	6.4	35.9
Ireland* (N)	5.4	32.5
Spain (N)	3.8	20.8

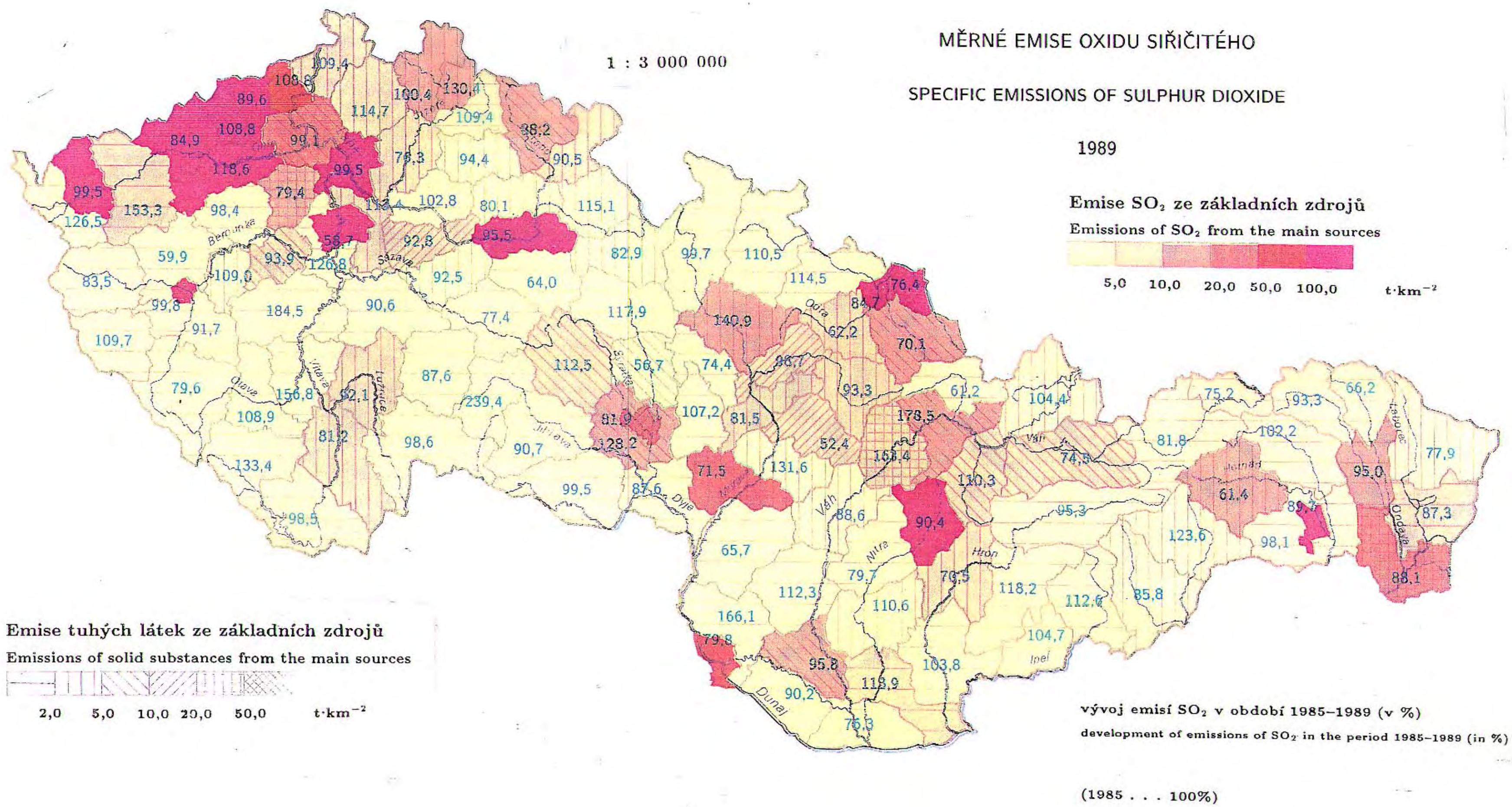


Figure 2 A. Specific emissions of Sulphur dioxide and emissions of solid substances from the main sources , data from 1989. The figure gives also a picture of the development of emissions of SO_2 in the period 1985 -1989 in %. Source Quitt, 1992.

1.3 Generally about acidification of surface water

1.3.1 Introduction

In recent years large areas of Europe have suffered from acid precipitation with resultant acidification of their fresh water resources, fish mortality and other ecological changes (e.g. the die back of forests). The extensive losses of fish populations in Norway (in more than 85000 km2 fish populations have been heavily affected) correlate in space and time with the escalation in Europe of atmospheric emissions of sulphur and nitrogen compounds. Acidic water has probably been the cause of fish mortality in Norway as far back as to the turn of the century, but it was only at the end of the 1950's that the link to acidic precipitation was established (SFT. 1988).

Norway has been a pioneer in documenting the correlation between acidic rain and fish mortality, and a forerunner in the research around other environmental aspects connected to the acid rain problem. During the large interdisciplinary project named " Acid Precipitation - Effects on Forest and Fish" (SNSF-project 1972-1980), an extensive registration of water quality and biological effects was conducted in Norway. From 1980 developments have been followed by the "National Programme for the monitoring of Long-Range Transported Air Pollutants and Precipitation, which is co-ordinated by the Norwegian State Pollution Control Authority (SFT).

Today a significant amount of scientific papers have been written about the effects seen from the acidification of the environment. Nearly every month the journals bring out articles about acidification, with special focus on the acids arriving from burning of coals and fuels.

1.3.2 Acid precipitation, water related problems, The Czech - and the Slovak Republics.

Biological responses due to acid deposition in surface waters were studied in a few lakes throughout the countries (plankton), but knowledge about changes in the benthic or the fish communities of running waters are still restricted. Acidification of water resources has so far not been given priority. This state has an origin in an huge number of point sources of organic pollution, and from (the next pollution problems ranging) a modern industry with effluents of organochemicals and heavy metals.

The Czech Repoblic is a country poor in lakes of natural origin. Today acidification of lakes is not felt as a problem. However, it occurs and it deserves attention (Fott et al., 1987).

The biggest losses of fish populations were caused by other reasons earlier than acidification of surface waters started to be a serious problem. A main factor for this was river regulations. In 1913 a 13 meter high weir was built at Strêkov - Ùsti nad Labem in the Labe river which definitely closed a way for salmons. Also heavy organic pollution from paper mills, sugar factories etc. started to be a serious problem from the end of the last century.

One obvious reason for paying attention to dams and lakes in the watercources are that these biotopes often function as drinking water reservoirs. Important is therefore to be aware of that lakes often function as traps for metals and nutrients mobilized and lost from the catchment area. The increased acidity in the precipitation and soil my result in a leakage of such elements to the watercources.

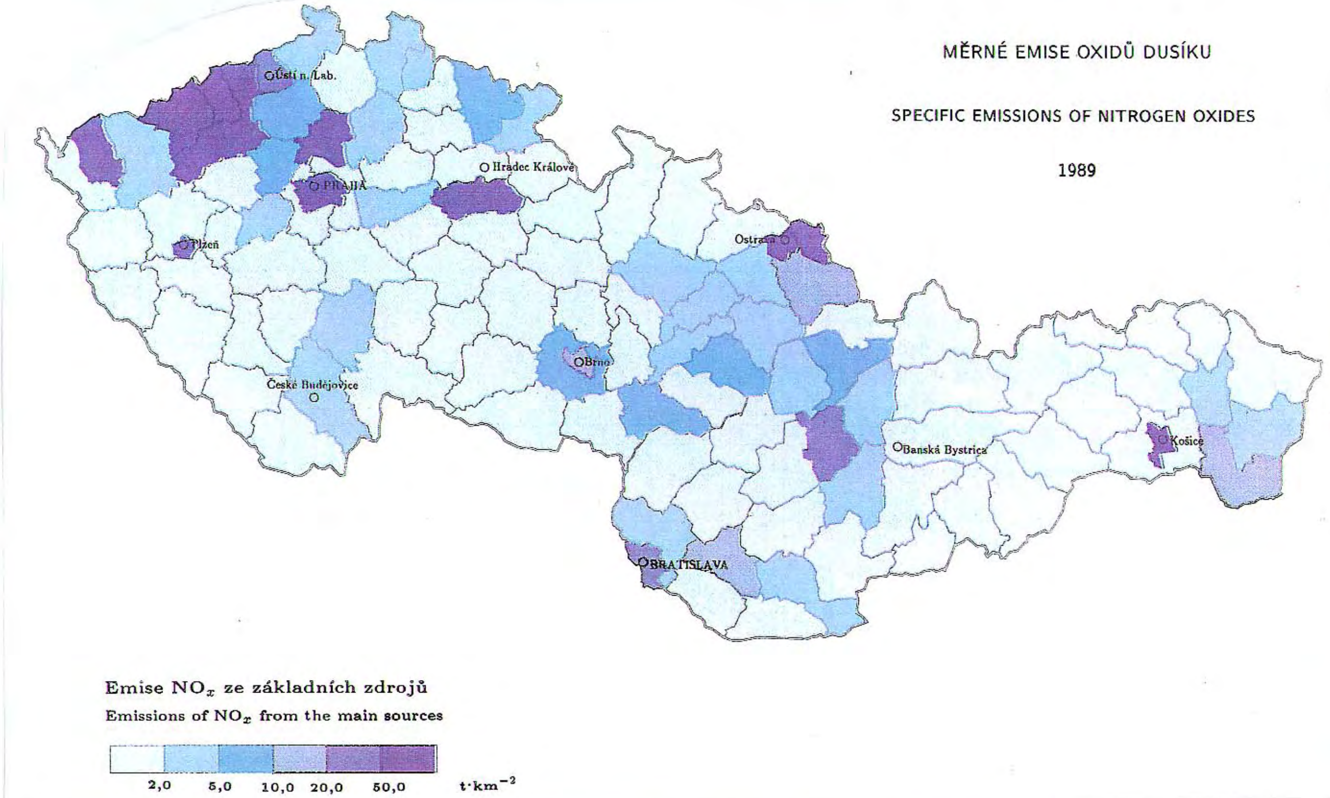


Figure 2 B. Specific emissions of Nitrogen oxides from the main sources, data from 1989. Source Quitt, 1992.

But overall this means that among the freshwater habitats, running water ecosystems are much more common, and of great importance as an element in the Czech landscape and as a water resource, for transport and for recreation, and as sensors to describe the effects from the acid deposition in the country.

In this first phase of the project resources were used to get a picture of the state of knowledge on this problem in the Czech Republic. A literature survey was started late summer 1992 to collect data and relevant information about studies done so far and ongoing, to investigate the effects of the acid precipitation on Czech water resources.

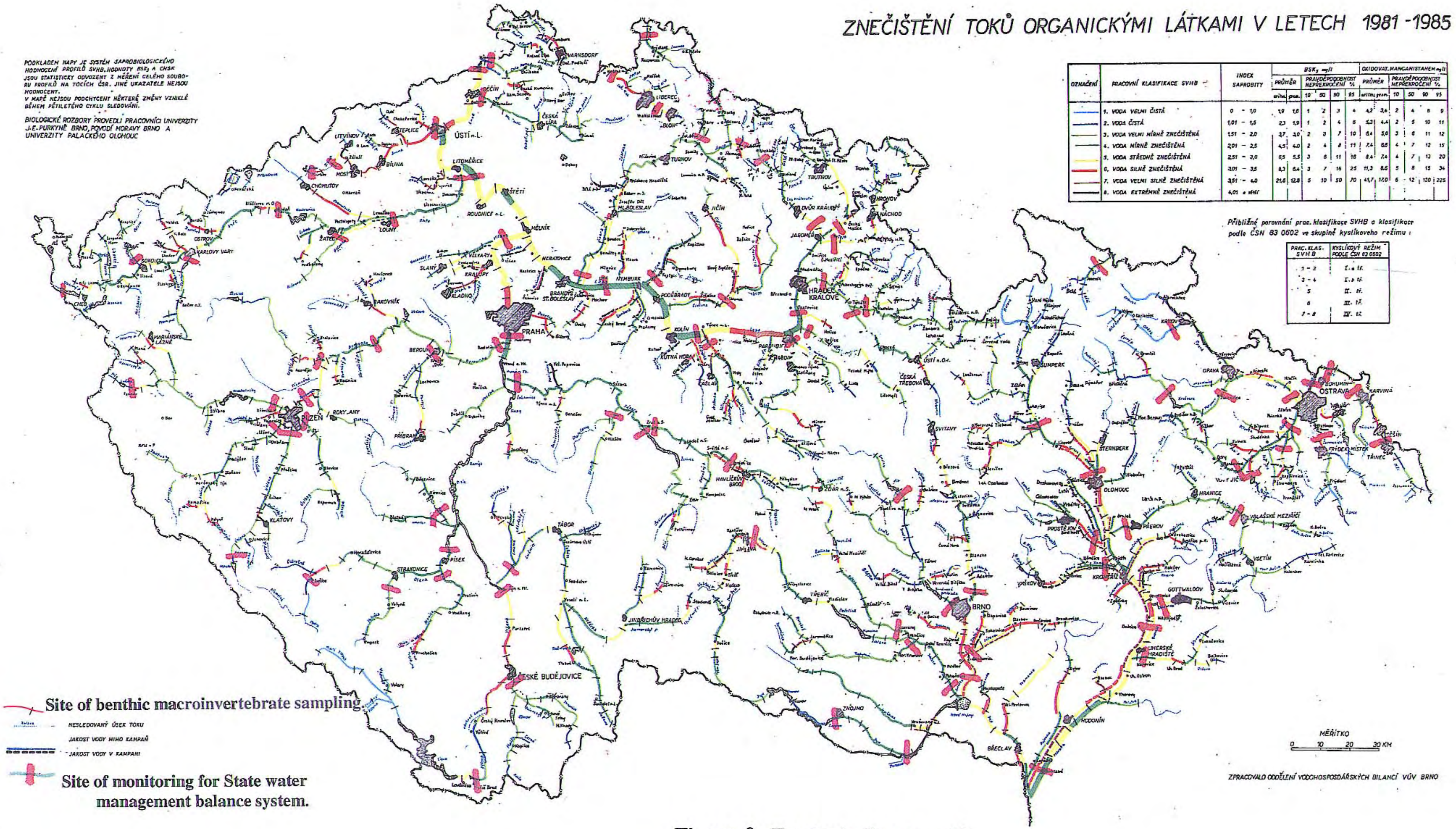
The literature survey is not yet finished, but so far we are surprised that so little has been done to describe the acidification of fresh waters resources in the region. An intense national monitoring program has been running for several years to describe the pollution status in running water ecosystems. In the first place aimed to evaluate the water quality as a result of organic pollution (saparobity) (Fig.3) Their sampling stations are usually located downstream cities, industries, farm lands and so on, where the water quality has been changed because of urban activity and for this reason the picture of the acidification of their headwaters are difficult to detect. This problem are also connected to the selection of parameters used and their level of detection.

The main effect of the acid rain problem so far "seen" have been connected to the dieback of forests. Consequently a lot of activities and resources are concerned with that problem; for references see M. Cerny 1991, Tichy 1991, Materna 1989.

In our survey for relevant information and ongoing activities we came across few projects in the Czech Republic which deal with acid precipitation, but none had included running waters, except one project. This was a project started in 1992, and named the GEOMON Project (The Geochemical monitoring system - particular task "State of Natural Environment monitoring system") and organized by the Czech Geological Survey in Prague. In the GEOMON project 44 small watersheds are studied in regions where it is expected that acid atmospheric deposition will have an effect on forests, soils and aquatic environments. A similar project is conducted in Slovakia named "The Geochemical Bomb".

In the GEOMON-project it was realized that nobody takes care of the aquatic communities in the water systems studied, so both the GEOMON-project and the Czech/Norwegian Acid Rain-project found it worth while with a co-operation. A selection of watersheds will be sampled in our project, both for physico-chemical water analysis and for studies of material collected from the benthic communities of macroinvertebrates. Through this co-operation we will be able to, get information about important processes and responses studied in the catchment area, all relevant to the effects seen in the running water ecosystems. The benthic fauna will be able to integrate and continuously monitor the variable effect of acidification in the watercources, information of much value to the GEOMON project.

Sampling stations will be selected where the water comes from catchment areas on alkaline to granitic bed rocks. This will give us the necessary variety in the sampled material to have a platform for later work and to build up a national Czech water quality classification system to describe the effect of acidification. A key element in this system will be the use of the benthic fauna to monitor the effect of fluctuating pH in the running water systems. The Czech water quality system will in many ways follow the same lines as we used when we developed our national waterquality system to classify effects of acidification for the State Pollution Control in Norway (Bækken and Aanes 1990).



OZNAČENÍ	PRACOVNÍ KLASIFIKACE SVHB	INDEX SAPROBITY	BSK_5 mg/l PRŮMĚR aritm.	geom.	PRAVDĚPODOBNOST NEPŘEKROČENÍ % 10	50	90	95	OXIDOVAT. MANGANISTANEM mg/l PRŮMĚR aritm.	geom.	PRAVDĚPODOBNOST NEPŘEKROČENÍ % 10	50	90	95
	1. VODA VELMI ČISTÁ	0 - 1,0	1,9	1,6	1	2	3	4	4,2	3,4	2	4	8	9
	2. VODA ČISTÁ	1,01 - 1,5	2,3	1,9	1	2	4	6	5,3	4,4	2	5	10	11
	3. VODA VELMI MÍRNĚ ZNEČIŠTĚNÁ	1,51 - 2,0	3,7	3,0	2	3	7	10	6,4	5,6	3	6	11	12
	4. VODA MÍRNĚ ZNEČIŠTĚNÁ	2,01 - 2,5	4,5	4,0	2	4	8	11	7,4	6,6	4	7	12	15
	5. VODA STŘEDNĚ ZNEČIŠTĚNÁ	2,51 - 3,0	6,5	5,5	3	6	11	16	8,4	7,4	4	7	13	20
	6. VODA SILNĚ ZNEČIŠTĚNÁ	3,01 - 3,5	8,3	6,4	3	7	16	25	11,3	8,6	5	8	15	34
	7. VODA VELMI SILNĚ ZNEČIŠTĚNÁ	3,51 - 4,0	21,6	12,8	5	10	50	70	41,7	17,0	6	12	130	225
	8. VODA EXTRÉMNĚ ZNEČIŠTĚNÁ	4,01 a více												

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3 - 4	I. b tř.
5	II. tř.
6	III. tř.
7 - 8	IV. tř.

Figure 3. For text: See page 13.

1.3.2 Acid rain - a global problem - relevance to Norway

Norwegian interests in the global Acid Rain problem are seen in the great problem it has created in our freshwater ecosystems. With a waterquality characterized by very low buffering capacity, the fresh water resources are very sensitive to an acidification. Being a pioneer in the research on this problem, parallel to an ongoing reduction in our own discharge of atmhospheric pollutants, we feel that our knowledge build up around this problem will be of great value to other countries now starting to penetrate this field of water pollution problems.

A heavy reduction in our own discharge of S with more than 50 % from 1980-1990 gives us a situation today where 95 % of the S deposited over Norway comes from abroad. Activities which will push on a reduction in this "import" is therefore very welcome. Should we have any hope in the future to turn back the negative effect of the acid deposition, this could only be reached by a drastic reduction in the import of atmospheric pollutants to our country.

Figure 3. Classification of running water resources in The Czech Republic - the effect of organic pollution.

Classified according to the structure in the communities of benthic macroinvertebrates
The different colours represent :

Light blue	**: Very clear water**	**Blue**	**: Clear water**
Light green	**: Very slightly polluted**	**Green**	**: Slightly polluted**
Yellow	**: Medial polluted**	**Red**	**: Heavy polluted**
Brown	**: Very heavily polluted**	**Black**	**; Extremely polluted**

These 8 categories of organic pollution are divided into 5 classes accompanied with suitability for applications :

I : very clear water , usually suitable for any applications
II : clear water , suitable for the majority of of applications
III : polluted water, suitable for supply of industry only
IV : very polluted water, suitable only for limited applications
V : Extremely polluted water, unsuitable for any applications

2. OBJECTIVES OF THE PROJECT

The objective of the project is to develop a manual for monitoring, classifying and mapping the fluctuations and levels of acidity (pH) in rivers and streams in the Czech Republic, using the benthic fauna. And in this manner expand the Czech national water quality classification system also to include the acidification of surface waters.

2.1 Identification of relevant material.

The first step in this project was to evaluate the water quality data and maps available. This was commenced in 1992. At the same time as we were searching for relevant material about the acidification of surface water in the Czech Republic, reprint lists which present nearly all publications written about these problems in Norway was given to our Czech members. Papers, reports and reprints asked for were sent to Brno.

The Czech material , which has been collected, give us a status about what has been done so far, and further, who has been dealing with these problems. It also gives us information about their knowledge as to how and where their fresh water resources are affected by the acid deposition, and their awareness about what kind of problems this acidification create for other users of these fresh water resources. Valuable information are data about what has happened to these running waters as ecosystems and their own value as such (- genetic material, species composition, diversity and so on), how the self purification ability are affected and how the habitats for freshwater fish are changed.

2.2 Field work.

Discussions with our Czech counterparts during our mission to Czechoslovakia in April last year were used to build up a strategy for the activities covered under the Acid Rain project. Parallel with the searching of relevant material (in national libraries, universities, research institutes) to build a platform for todays knowledge, it was an agreement to do some preliminary screening studies in the upper part of some catchment areas. This opportunity was possible when the team from WRI-Brno was running their field work to cover planned work for the national monitoring of the water quality. NIVA equipped the Czech team with a portable pH-meter, electrodes and calibration buffers making them able to initiate that part of the project. In September a new field trip was done. Jointly the Czech and the Norwegian team visited more than 40 localities in the head waters of the Morava and Elbe rivers (North Bohemian, East Bohemian and North Moravian , Fig 1). This material is further described in chapter 5.4.3.

2.3 Response model - Historical data.

To be able to develop a "Response model" and a system for water quality classification usable in the national monitoring program (a system parallel to that used in Norway, Bækken and Aanes, 1990) to describe and classify the effects of acid deposition on freshwater habitats, we need some information about the species composition under natural unpolluted situations in the Czech Republic.

This part of the work has not really started. Litterature has been collected, but it seems to be necessary to create a closer contact with The Entomological Institute in Ceshé Budejovice and their experts on the different groups in the Czech bentic fauna relevant to the water quality classification system.

This historical material about the species distribution will, together with our field data, give the current status of the distribution and describe the changes in the benthic fauna in the time period elapsed. Such information will help us to select a number of key species/indicators species usable to indicate small changes in pH in the water

From field data and if necessary, from bioassays, we would develop tolerance limits for the different species used in the classification system towards changes in pH. We expect that the groups which have shown to be usable in Norway, more or less would be the same in the Czech Republic, although some of the species probably might be different. To initiate a co-operation with the Hydrobiological Institute in Czcshé Budejovice will be of great value when we need assistance to identify or verify species found, or receive information and distribution maps for key species together with historical data.

3. RUNNING WATER ECOSYSTEMS - ENVIRONMENTAL STATUS.

For a long period water quality classification of running water ecosystems in Czechoslavakia has been conducted by the WRI and their branch in Brno. Well functioning national systems using the benthic fauna have been developed with a standardised procedure for sampling, preparation and presentation of the results. The material is evaluated mainly to describe the organic pollution load at the sampling locations, mapping the effect of input of organic material upstream the sampling area.

Pin pointing on the organic pollution and the amount of dissolved oxygen in the water their sampling stations are naturally placed downstream urban activities as factories, arable land, cities and so on.

When we conducted a preliminary study to penetrate this huge material sampled for more than 30 years, very little information was directly relevant to the acidification of running water ecosystems. Several factors caused this. One of the most important being effluents from urban activities which may often change the conductivity and buffering capacity in the recipient, resulting in an increase in pH. Another aspect is the very diversified geology in the upper parts of the catchment areas, where some parts might be acidic (gneises, granitic and migmatic), and other areas of more alkaline nature. A mixing of the different water qualities will be the result before the water reach the national sampling localities and the results here will hide the acidification of upstream brooks and streams. Examples of this were seen in our results from the field trip in September last year.

Focusing on an increase in acidity in the water systems is only a symptom of something that has been changed in the watershed. Usually the first sign of an ongoing acidification is a pH-drop in the water in small streams and brooks during the early phase of the melting period in Spring. However, with the drop in pH several processes start in the catchment area. Very important is the remobilization of kations and among them several toxic heavy metals. Many of them deposited from the polluted atmosphere through a long period and with the acidification of the upper soil, leak to the ground water and to the running water systems. In the brooks and rivers the decrease in pH and a water quality with a low buffering capacity will increase the mobility and the bioavailability of the metals.

Aluminium is one of the metals where the mobility and toxicity change drastically with the changes in pH. With an acidity just below pH 5, several unstable species of aluminium are formed which are very toxic. Fish kill and dieback of the fish populations are common results.

With the leakage of metals from the catchment area the running water systems will work as a transportation system for these toxic elements. Often bound to small particles the metals will fall out to the sediment and resuspend again on a travel downstream before they are trapped in a more permanent situation. That trap will often be a drinking water reservoir.

The increased level of metals (Pb, Cd, Hg....) in these acidified water systems will affect self-purification processes in the recipients (the ability the water has to take care of and degrade organic pollution) - fish populations directly and indirectly through their food items both from reduced availability of food and from bioaccumulation of heavy metals through the food chain. The fish may not be usable for consumption because of the content of heavy metals. The increased levels of metals may also change the suitability as drinking water, water for irrigation as well as fish farming. With an increased acidity the result will be an increased corrosion in for instance pipelines and other installations for drinking water supply, which again will increase the levels of metals in the tapwater. All important factors to have in mind when dealing with acidification.

An effective monitoring tool to describe the degree of change in pH and the effects of this on Czech fresh water ecosystems is necessary to give a status of the pollution problem in the country today and make us able to monitor the situation in the future.

Using the benthic fauna one has a monitoring system which integrate the pH-situation in the watercourse for a long period prior to each sampling (1/2 - 1 year). A system like this will also indicate any sudden drop in the pH-level (e.g. in connection with situations under rainstorms and melting periods). The system is easy to handle on a regional basis, very cost-effective and has a high degree of precision. From our point of view such a system will be a very valuable tool in the future Czech monitoring and evaluation of the effects from the acidification of the fresh water resources.

This is supported by our own experience gained in Norway with a national water quality classification system to characterize the acidification of our surface waters through several years. And by corresponding statements from groups monitoring the effects of acidification all over the world (for instance in Sweden, England, Germany, North America and Canada).

4. FIELD WORK.

In 1992 some preliminary field work was done to get more information about the Acid Rain problem in certain head waters in North and East Bohemian and North Moravian (Fig. 1). WRI Brno realized the field work during 31.August - 4. September mainly on the GEOMON sampling sites. This information was needed for further developing of the Chech - Norwegian Acid Rain project. Later a joint field trip by the Czech and Norwegian project members were done from the 17. to the 21. September. Together with important material collected was the valuable effect of familization this field work gave the team members, along with the possibility jointly on the spot at the shore to discuss and exchange information about the acidification problem.

5. PROPOSED WORK PROGRAMME.

5.1 Introduction.

The working programme for the Acid Rain Project no.4 named The Czech Score Method for Biomonitoring the Effects of Acid Rain, describe the work to be done in a two-years period to build up a system for classifization of water quality in running water ecosystems. Together with this water quality classification system to develop a manual for monitoring and mapping the distribution and effects of acid deposition.

A water quality classification system focusing on the effects of acidification will be a valuable and necessary expansion of the well functioning national water quality classification system. This system is using the benthic fauna in the Czech running water ecosystems to describe the effect of the organic pollution - saprobification. With only some small adjustments such a system to characterize the effects of acidification will also function well for the neighbouring countries.

The Czech Saprobic system has been in function for more then 20 years. A limitation is, however, that it only classifies organic pollution and that the location of the sampling stations and the parameters measured are selected to take care of that kind of pollution. Indeed organic pollution has been the dominating in Czech running water ecosystem, and still is. But at the same time the acid rain problem seems to be increasing in the head water sections of the streams which would be obvious with all the data generated about the heavy deposition of air pollutants and the response seen on the forests.

5.2 Objectives of the project.

The main long-term objective of the project is:

- to develop a tool for the assessment of the environmental quality of running water ecosystems in the Czech Republic, influenced by the acid rain problem - using physico-chemical and biological data,
- to develop a system for classification of the water quality in those biotopes to detect the effect of acidification, using the benthic fauna as a tool for monitoring,
- to report on the regional distribution of potential acid rain affected brooks and streams in the Czech Republic, to describe the degree and geographical extent of the Acid Rain problem in the country,
- to initiate work to develop a national data-base on physico-chemical and biological data (macro invertebrates) related to the acidification of surface waters,
- to promote international harmonization of monitoring practise through assistance and transfer of experience. And by that give the Czech Republic the possibility to join the International Co-operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes.

Short term objectives

- to organize a co-operating team to work with and exchange experience on the acidification of running water ecosystems, and further develop the intention of the project through meetings, discussions and surveys in the Czech Republic and in Norway,
- to identify available data which are relevant and may be connected to the acidification of surface waters in the Czech Republic,
- to test data particularly from the National Watercourse Monitoring Programme in the Czech Republic compared to Norwegian methods used for monitoring acidification,
- to describe the ability of the Czech material collected so far to detect the effects of acidification in the fresh water ecosystems,
- to specify additional parameters if needed to fit a system for assessment of environmental quality of rivers affected by the acid deposition.
- to initiate some preliminary studies in potential acidified streams and brooks in some selected catchment areas at the border against Germany (previous DDR) and Poland.

5.3 Organization.

The project is executed jointly by Norwegian Institute for Water Research (NIVA), and T.G. Masaryk Water Research Institute - Brno branch (WRI-B). Each institution has appointed key staff responsible for the execution of the project. The Czech team members are Ing. Ilja Bernardova and Dr. Michael Fiala (both WRI-B). The co-ordinator of the Czech activity is Michal Fiala. The Norwegian team members are Senior Researcher Karl Jan Aanes, Deputy Director Merete Johannessen and Researcher Torleif Bækken, all at NIVA, Oslo. The Norwegian contact person is Karl Jan Aanes.

5.4 Work accomplished.

5.4.1 Developing the project - Background material.

During NIVAs mission to Czechoslavakia 31 March - 3 April 1992, the Acid Rain Project was discussed and further developed. The need for Czech data relevant to the Acid Rain Project was identified. Literature reviews connected to papers and reports dealing with the acidification of surface waters in our country were exchanged. Later papers wanted from the Czech team were sent to the group in Brno.

In May the Norwegian team received extensive material from the National Monitoring Program of Water Quality in running water ecosystems in the Czech Republic. From the data mainly collected to describe the level of organic pollution, we were not able to detect any direct effects of acidifications on the benthic fauna. A probable reason for this, perhaps some unexpected results are connected to the intention of the Czecks national monitoring programme. The programme is conducted mainly to describe the degree of organic pollution/the oxygen consumption of the pollutans (degree of saprobiety), and the localities for sampling are for this reason located downstream human activities (Fig. 3).

Through our search for data in 1992, connected to the Acid Rain problem in Czechoslavakia (later the Czech Republic), among scientists, institutions and other organizations, focusing on effects seen on fresh water ecosystems, we were not able to come up with much relevant data. This work will continue in 1993, particularly among institutions and scientists dealing with fresh water entomology.

Through this activity, however, a valuable contact was established with the GeoBioMon-programme. This programme is organized by the Czech Geological Survey in co-operation with the UN ECE Task Force on Integrated Monitoring of Air Pollution Effects on Ecosystems UN ECE, The Environmental Data Center in Helsinki and Ministry of Environment of the Czech Republic. The purpose of GeoBioMon is to bring together experts of various disciplines to interpret and scientifically evaluate data from integrated monitoring of small catchments affected by the Acid Rain problem and related monitoring programmes.

Physico-chemical data which we received from the Czech Geological Survey indicate lowered pH and reduced buffering capacity in several of the catchment areas used in the programme. Another interesting aspect with the GeoBioMon was that they have covered most of the compartments in the terrestrial and aquatic ecosystems in the water sheds studied. Only one important part was missing, namely the aquatic communities.

By joining the GeoBioMon, which was very appreciated by the co-ordinators of the programme, a lot of relevant information from their sampling stations were available to our project. In this way by studying the effects seen in the benthic fauna here, we were able to contribute with very valuable information to the GeoBioMon program and increase the possibility to detect and monitor the intergrated effect of changing levels of acid deposition and the different processes going on in the catchment area. Some of the GeoBioMon catchment areas was used for further sampling and included in our project.

5.4.3 Field Work

In the process towards a Czech water quality classification system for the effects of acid deposition on the running water ecosystem, preliminary studies were done late spring/early summer by the Czech members of the project team. A portable pH-meter with necessary equipment was borrowed from NIVA. In connection with the national monitoring programme,this instrument was used to search for effects of acidification in headwaters when they visited their regular sampling locations downstream.

From the information so far sampled, a field sampling programme was conducted from the 17th to the 21st of September. A joint field trip by the Czech and Norwegian project members were done with the aim to study the acidification of small brooks and rivers in the regions north of Pragh, along the border of Germany (former DDR) and Poland to the highlands north of Ostrava. For the Norwegian team members the intention was to get a more direct impression of the effects seen from the acid deposition in general and with a particular interest to the response seen in the running water ecosystems. The days in the field was also used to exchange experience and knowledge where the reactions were seen. Different ways of conducting field work were shown in practice and was discussed. A standardised way of monitoring acidified recipients used in Northern Europe was shown and equipment for sampling the benthic fauna in accordance with international standards was borrowed to the Czech members of the team.

All together the field trip gave an important familiarisation with the Acid Rain problem in this part of the world, as well as important information about the running waters and catchment areas - what they look like and how they are functioning. Valuable knowledge about possibilities and methods for sampling and monitoring the acidification of surface waters were also collected; all information necessary when the activities for phase II are developed.

5.4.3.1 Results - field work, September 1992

Being the smallest among the projects in phase I under the Czech-Norwegian environmental protection program, limited resources have restricted the possibility of a thoroughly analysis of the material from the field trip in September. Indications of acidification are seen both in the physico - chemical material and in the biological material.

During the field trip in September as much as 41 running water localities were visited and a limited set of parameters both biological and physico-chemical were registered. Because of limited resources the material will be evaluated in 1993.

At 10 of the localities a complete set of samples were taken. The water samples were brought to NIVA, Oslo, and analyzed in according to our standardised methods and parameters used to describe the acidification in fresh water. The results from the physico-chemical analysis are shown in Table 2. The biological material collected from the benthic communities parallel with the physico-chemical material was handled by the WRI, branch BRNO. Preliminary results from the material is presented as species lists with information about their abundance, and are shown in Table D in the Appendix.

The interpretation of the material collected will be done when the resources for phase II are available. This information, then generated, will be an important pillar on the platform of knowledge developed through phase I for further progress to fullfil the objects in the Acid Rain Project; The Czech Score Method for Biomonitoring effects of Acid Rain.

Table. 2. Results from water samples taken during the joint Czech-Norwegian field trip in September 1992. Physio-chemical data from localities with a complete sampling programme.

Stasjon	pH	Kond mS/m	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO4 mg/l	NO3 µg/l	Tot-N µg/l	TOC mg C/l	ALK 4,5 mmol/l	Al/R µg/l	Al/L µg/l
St. 1 Uhlirska	6,36	6,36	5,40	1,06	3,81	0,53	1,9	14,8	1570	1640	3,8	0,104	89	78
St. 2 Jezdeka	6,65	3,89	3,03	0,65	2,67	0,35	1,3	8,6	905	1010	3,5	0,095	73	69
St. 3 Stary Polom	5,44	3,89	2,33	0,66	2,36	0,26	1,3	13,2	114	296	4,9	0,027	197	95
St. 4 Jizera Korem	6,55	4,79	3,65	0,89	3,14	0,45	1,7	12,4	660	803	3,3	0,089	71	88
St. 5 Pudlava	5,55	3,39	2,45	0,45	1,64	0,36	1,0	8,1	1130	1200	1,42	0,026	102	51
St. 6 Labe Mysliom	5,49	3,86	2,96	0,64	1,68	0,34	1,1	10,6	975	1020	1,18	0,026	126	45
St. 7 Bile labe	6,35	3,80	3,25	0,66	1,59	0,38	1,1	9,2	1040	1155	0,77	0,053	55	39
St. 8 Upa Obriove	6,76	5,46	6,10	1,02	1,18	0,39	1,1	14,0	1035	1085	0,38	0,147	18	<10
St. 9	5,49	6,08	5,04	0,99	2,21	0,68	1,5	16,8	2230	2210	1,23	0,025	197	51
St. 10	4,96	7,52	6,27	0,99	2,42	0,78	1,4	20,0	2870	2800	1,17	0,015	484	48

5.4.4 Workshop Oslo, October 1992.

Under the joint Czech-Norwegian environmental protection programme entitled the "Water Pollution Abatement Programme" a Project Workshop was held in Oslo, Norway, from 6th to 11th October 1992. Because of invariable reasons the Czech members in the Acid Rain project were not able to participate. The group will therefore arrange a small workshop in Norway during spring 1993, focusing on Acid Rain effects seen in running water systems relevant to our project in the Czech Republic. A one day field trip to some acidified localities will be included in the workshop.

5.4.5 Status-evaluation-progress.

A useful and effective tool in the management of water resources when dealing with acidification is a system using accepted water quality criteria and classification standards for the degree of pollution/acidification developed from tolerance limits set by the different compartments in the benthic fauna.

A good system should be specific and with a high degree of information, assess the environmental quality and degree of pollution, and give guidelines for the suitability of waters for specific uses. The system should give backgrounds for the requirements of remedial actions and be used when monitoring effects of reduced or increased pollution on a short and long time scale. Many of the highlands in the Czech Republic are heavily polluted by acid deposition and management of these water resources will be of great interest in the years to come.

In general, up till now, a long list of parameters have been measured in the national monitoring of running water systems in the country. Potentially toxic materials as heavy metals and some organic micro pollutants and nitrite-nitrate are measured less frequently or are lacking. And up till now when sampling profiles downstream cities and in drinking reservoirs these parameters have been given priority. Dealing with the acid deposition problem such parameters should also be sampled in the headwaters of the rivers. Besides that, the material so far has shown that the detection limits for some heavy metals are high relative to both EC and Norwegian standards, and for that reason could hide possible variations between sites.

The modern approach to pollution problems is to assess the environmental quality, and focusing not only on the water as so in a stretch of a river, but also on the accumulation of potentially toxic materials in the sediments and the accumulation and biomagnification of toxicants in organisms, particularly in eatable organisms as fish.

With the acidification of a catchment area the mobility of the different cations increase, and there are a transport both to the surface water and to the ground water. With the increase in acidity the bioavailabililty of these pollutants also increase, as do the mobility in the watercourse, as seen for aluminium which are very toxic for fish at pH-levels around 4.8 to 5.2. This is a very important effect in the changing of the pH-regime because a majority of common toxic substances and heavy metals are more or less adsorbed to organic and inorganic particles which settle out as sediments. These sediments are therefor reservoirs built up through a long period and are potential sources of pollution when the acidity in the water increases and the metals are mobilized. When toxic materials are present in high concentrations in the sediments, the biological communities disappear and the capability of self purification of organic matter in the rivers is seriously reduced. With an increased bioavailability the toxicants accumulate through the food chain and reach ourselves when, for instance, fish are used as food.

Both the extent of bioaccumulation and biomagnification of toxic elements are of utmost importance when assessing the environmental quality of a river. In addition the content of toxic compounds in fish are important from a public health point of view.

The biological effects of the pollutants are a crucial point in the assessment of environmental quality of rivers. The national biological classification systems commonly used in The Czech and The Solovak Republic considers so far mostly the effects of organic pollution. The system used: the Saprobic index, is particularly designed for that kind of pollution.

However, frequently we assume, that the headwaters within many catchment areas are effected by the acid deposition at least during the spring runoff. A biological monitoring/classification system which includes this aspect should be developed.

The project no 4 has developed a possibility to work in co-operation between the Czech and the Norwegian scientists, leading to an important exchange of knowledge, material and methods, which in an effective way will push forward the creation of a Czech national system for monitoring and classification of the detorioration created by the acid deposition in running water systems.

6. PROPOSED WORK PROGRAMME FOR PHASE II

From a progressive phase I we anticipate there will be an extention of the Acid Rain Project connected to the Czech Score Metod for Biomonitoring Effects of Acid Rain under the joint Czech - Norwegian environmental protection programme.

To follow up the objectives of the project (see page 14.) the activities during 1993 will focus on 4 main topics.

1993:

1. Continue the work to get a complete overview of relevant material already available. Particularly it seems necessary to strengthen the activity towards material collected from benthic communities (macro invertebrates) in Czech running water ecosystems. Species lists, distribution maps - both old and new - are very important. A closer contact with the University of Pragh and the Department of fresh water ecology/entomology, together with the Hydrobiological Institute in Ceske Budejovice seems obvious.

   Initiate the creation of a data-base where physico-chemical data and results from studies of benthic communities are combined for further development of a response model towards acidity and the effects seen in the benthic fauna.

2. Continue the field work in selected catchment areas both through physico-chemical and biological sampling to fill in gaps in the data base and for developing and testing of the response/hypothesis generated in the first draft of "The Czeh Score Method for Biomonitoring the Effects of Acid Rain".

1993/1994:

3. Refine the National Water Quality Classification System using the benthic fauna to be a operative tool for monitoring running water ecosystems affected by acid deposition in the Czech Republic. Such a system will also, with some small adjustments, be an effective tool in neighbouring countries to classify the effects of atmospheric pollution in their streams and rivers.

4. Initiate regional monitoring programmes to get information on the degree and geographical distribution of the acidification of surface water resources in the Czech Republic. Promote harmonization of monitoring practice towards international practice as one part of a Manual together with recommendations of site selection, sampling methods and frequency, plus handling, preservation and doccumentation of the biological material sampled. Such a Manual should also give advice for parameters necessary in a physico-chemical programme to accompany the monitoring programme for the benthic fauna. Combined with advice of required accuracy and quality needed for the different parameters and for the laboratories used. Together with a system for data management (Initiate and advice in the development of a national data base for information about the acidification of surface waters in the Czech Republic) and reporting procedures.

7. BUDGET FOR THE STUDY

Remuneration 1993.

Name	Weeks	Hours	Rate	Total Nkr.
K.J. Aanes (project-coordinator)				
M. Johannessen				
T. Bækken				
Sub.total				

Reimbursements 1993

Air transport Oslo - Pragh (2 times - 2 persons)
Transport in The Czech Republic (Field work: 2 times, 1 week)
Expences related to car rent, taxi etc.

Per Diem

Analysis of water samples: Chemistry, Biology and evaluation of indicator organisms:

Reporting, prepare publications and presentations of the results together with co-ordination of the project.
Expenses related to visits by Czech counterparts:

Sum total

Total budget for activities in the Acid Rain project - "The Czech Score Method for Biomonitoring the Effects Rain" during the year 1993:

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Appendix

The data shown in the tables A, B and C is from the EMP MCS-W Repport 1/91, entitled Calculated Budgets for Airborne Acidifying Components in Europe, 1985, 1987, 1988, 1989 and 1990. It can be had from the Norwegian Meteorological Institute, Box 43, Blindern, N-0313 Oslo, Norway.

Table A. **EMEP data on Emissions of Sulphur and Nitrogen oxides.**

EMEP is an acronym for European Monitoring and Evaluation Programme (officially the Co-operative Programme for Monitoring and Evaluation of Long Range Transboundary Air Pollution). It was started in 1977 and is carried out under the UN ECE Convention on Long Range Transboundary Air Pollution. Acid News 1991.

		Sulphur (1000 tons)		Nitrogen oxides (1000 tons as NO_2)	
		1980	1990	1985	1990
Albania	AL	[25]	[25]	[9]	[9]
Austria	AT	185	47	230	201
Belgium	BE	414	210	281	300
Bulgaria	BG	517	515	150*	150
Czechoslovakia	CS	1550	1400*	1127	950*
Denmark	DK	224	133	258	254
Finland	FI	292	126	251	276*
France	FR	1669	667*	1615	1772*
German Dem. Rep.	DD	2132	2621*	955*	1005*
German Fed. Rep.	DE	1605	530*	2930	2860*
Greece	GR	200	250*	746	746*
Hungary	HU	816	582	262	264
Iceland	IS	3	3*	12	12*
Ireland	IE	111	84	91	135
Italy	IT	1900	1205*	1595	1700*
Luxembourg	LU	12	5	19	15
Netherlands	NL	233	127*	544	552*
Norway	NO	71	33*	203	226*
Poland	PL	2050	2250	1500	1480*
Portugal	PT	133	106	96	142
Romania	RO	900	900*	[390]	[390]
Spain	ES	1625	1095*	950	950*
Sweden	SE	257	102	394	373
Switzerland	CH	63	31	214	184
Turkey	TR	138*	199*	[175]	[175]
Soviet Union**	SU	6400	4790	3369	4406*
United Kingdom	GB	2424	1916	2278	2573
Yugoslavia	YU	650	775*	400	430*
Remaining area	REM	[256]	[256]	[100]	[100]
Int. trade, Baltic Sea	BAS	[36]	[36]	[80]	[80]
Int. trade, North Sea	NOS	[87]	[87]	[192]	[192]
Int. trade, rem. Atl.	ATL	[158]	[158]	[349]	[349]
Int. trade, Mediter.	MED	[6]	[6]	[13]	[13]
Int. trade, Black Sea	BLS	no data			
Biogenic sea emis.	NAT	[755]	[755]	[0]	[0]
Sum		27897	22025	21777	23263

The table shows national official data received at the ECE secretariat up to February 6, 1991.

* Interpolated data (no data have been officially submitted).

** European part of USSR within EMEP area of calculation.

Table B. **Provisional estimate of sulphur budget for Europe 1990. Total (dry + wet) deposition of sulphur. Unit: 100 tons sulphur per year. See also page 32.**

	AL	AT	BE	BG	CS	DK	FI	FR	DD	DE	GR	HU	IS	IE	IT	LU	NL	NO	PL	PT	RO	ES	SE	CH	TR	SU	GB	YU	REM	BAS	NOS	ATL	MED	BLS	NAT	IND	SUM
AL	41	0	0	18	9	0	0	3	9	1	14	11	0	0	30	0	0	0	9	0	12	2	0	0	1	5	2	37	2	0	0	0	0	0	7	57	271
AT	0	118	23	2	284	3	0	93	321	110	0	64	0	1	224	1	9	0	171	0	8	11	1	12	0	13	48	88	1	1	5	2	0	0	7	153	1774
BE	0	0	403	0	12	1	0	130	47	59	0	1	0	2	2	1	29	0	13	0	1	7	0	0	0	3	123	1	0	0	13	2	0	0	6	45	902
BG	4	2	2	1282	64	1	0	7	67	9	37	87	0	0	29	0	1	0	88	0	340	1	0	0	7	83	10	136	1	0	1	0	0	0	12	189	2461
CS	0	24	31	7	3565	7	1	75	1295	148	1	347	0	2	55	1	15	0	679	0	47	7	2	3	0	34	76	96	1	2	6	2	0	0	8	208	6748
DK	0	0	13	0	18	149	1	19	94	37	0	2	0	3	1	0	11	1	29	0	0	2	6	0	0	5	124	1	0	5	10	1	0	0	11	57	601
FI	0	1	7	1	35	20	372	11	97	19	0	9	0	2	4	0	5	5	117	0	5	3	45	0	0	461	62	5	0	14	4	1	0	0	36	323	1664
FR	0	3	182	1	113	7	0	2180	331	202	0	16	0	12	224	6	56	0	113	11	3	320	2	14	0	15	382	32	3	1	45	45	0	0	85	701	5107
DD	0	2	59	0	521	22	0	93	6429	280	0	9	0	4	12	2	35	1	187	0	4	7	3	1	0	24	155	4	0	4	14	2	0	0	12	152	8040
DE	0	12	247	2	349	27	1	494	1201	1614	0	16	0	11	93	10	133	1	230	1	7	37	3	22	0	33	493	15	0	4	46	9	0	0	32	368	5510
GR	8	1	2	206	25	0	0	6	28	4	470	28	0	0	38	0	1	0	36	0	82	5	0	0	17	44	7	47	7	0	0	0	0	0	26	219	1307
HU	0	18	8	9	298	2	0	24	190	30	2	1515	0	0	85	0	3	0	188	0	102	6	1	1	0	25	17	259	1	1	2	1	0	0	6	150	2944
IS	0	0	1	0	1	0	0	1	2	2	0	0	5	1	0	0	1	0	2	0	1	0	0	0	0	1	14	0	0	0	0	1	0	0	22	50	106
IE	0	0	5	0	4	0	0	8	15	5	0	0	0	178	0	0	3	0	1	1	0	3	0	0	0	0	86	0	0	0	2	9	0	0	23	73	416
IT	2	15	21	14	172	2	0	182	228	63	14	100	0	1	3163	1	8	0	146	4	24	64	1	22	1	17	46	248	22	1	4	4	0	0	63	570	5223
LU	0	0	3	0	1	0	0	11	4	4	0	0	0	0	0	8	1	0	1	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	4	40
NL	0	0	102	0	13	2	0	77	57	121	0	1	0	4	2	0	189	0	13	0	0	4	0	0	0	3	241	0	0	0	20	2	0	0	9	54	916
NO	0	0	24	0	38	41	13	40	142	44	0	6	0	10	2	0	20	75	67	1	6	11	26	0	0	114	362	3	0	6	22	8	0	0	79	425	1585
PL	0	12	69	10	1301	53	6	113	3276	282	1	226	0	6	44	2	44	2	7405	0	71	11	16	2	0	201	256	91	1	15	20	4	0	0	29	520	14090
PT	0	0	1	0	1	0	0	8	3	2	0	0	0	0	3	0	1	0	1	235	0	112	0	0	0	0	9	2	2	0	0	22	0	0	14	69	484
RO	3	7	8	138	297	4	2	23	269	33	13	442	0	1	67	0	5	0	362	0	2717	4	1	0	5	290	25	397	1	1	2	1	0	0	12	362	5490
ES	0	0	16	0	12	2	0	128	53	21	0	2	0	3	35	0	7	0	15	116	0	2875	1	1	0	1	89	9	16	0	5	48	3	0	67	430	3958
SE	0	1	26	1	98	124	61	41	350	85	0	12	0	6	3	0	22	27	231	0	8	7	278	0	0	193	287	7	0	25	20	6	0	0	65	465	2453
CH	0	2	11	0	30	1	0	116	62	38	0	3	0	1	166	1	5	0	30	1	1	16	0	84	0	2	25	8	0	0	2	2	0	0	5	77	690
TR	1	1	2	94	40	1	0	6	46	7	44	40	0	0	13	0	1	0	73	0	105	2	1	0	509	296	8	27	4	0	1	0	0	0	43	626	1991
SU	2	20	103	136	1277	130	221	169	2278	324	24	651	0	13	99	2	69	13	4035	1	900	21	101	3	63	19241	518	273	1	61	38	9	0	0	188	5181	36165
GB	0	0	28	0	16	6	0	59	67	30	0	0	0	71	2	0	20	1	17	1	0	17	1	0	0	6	4775	1	0	1	38	28	0	0	64	233	5483
YU	15	24	12	163	270	3	1	55	272	46	29	402	0	1	443	0	5	0	232	1	168	21	1	3	2	46	32	2482	8	1	3	2	0	0	34	494	5269
REM	0	1	4	10	30	1	0	35	49	8	19	17	0	1	95	0	2	0	21	6	9	96	0	1	2	3	26	24	626	0	1	4	1	0	62	682	1837
BAS	0	44	118	2	190	296	153	80	884	203	0	32	0	9	10	1	46	11	755	1	16	11	176	1	0	453	394	16	0	120	32	6	0	0	135	520	4712
NOS	0	1	196	0	93	118	3	360	414	218	0	7	0	63	8	1	253	32	110	4	2	49	21	1	0	25	3763	4	0	9	285	44	0	0	262	691	7037
ATL	22	1	99	1	76	35	63	356	297	129	0	10	11	216	16	1	57	37	134	215	6	1415	33	1	0	586	1767	9	3	7	61	650	0	0	2114	3421	11851
MED	42	18	40	267	367	6	1	355	476	87	513	275	0	4	2330	1	19	0	343	23	216	823	2	8	116	150	138	618	342	1	10	16	2	0	597	2126	10331
BLS	1	2	4	130	114	3	11	8	100	13	19	65	0	0	14	0	2	0	179	0	286	1	1	0	123	875	15	38	1	1	1	0	0	0	103	553	2663

Explanation of the tables

The two and three-letter codes are given in Table A. To find the contribution from other countries to a certain country, follow the horizontal row starting from the relevant country code on the far left. To find the contributions from a certain country to other countries, follow the vertical column starting from the relevant country code at the top. REM signifies contribution to and from the part of the domain for deposition calculations which is not covered by European countries. IND signifies the part of the calculated depositions which cannot be attributed to any known emission sources by the present models (Acid News, 1991).

Table C. **Provisional estimate of oxidized-nitrogen budget for Europe for 1990. Total (wet + dry) deposition of nitorgen. Unit: 100 tons nitrogen per year. See also page 32.**

	AL	AT	BE	BG	CS	DK	FI	FR	DD	DE	GR	HU	IS	IE	IT	LU	NL	NO	PL	PT	RO	ES	SE	CH	TR	SU	GB	YU	REM	BAS	NOS	ATL	MED	BLS	NAT	IND	SUM
AL	1	1	0	2	3	0	0	3	2	4	12	2	0	0	17	0	0	0	3	0	2	1	0	0	0	2	1	8	0	0	0	0	0	0	0	18	82
AT	0	43	15	0	65	2	0	97	49	247	0	9	0	1	102	1	21	1	43	0	1	4	2	21	0	5	32	15	0	1	5	2	0	0	0	60	846
BE	0	0	25	0	4	1	0	69	7	53	0	0	0	2	1	1	22	0	4	0	0	3	0	1	0	1	60	0	0	0	8	3	0	0	0	18	283
BG	1	4	1	30	19	1	0	7	12	22	41	17	0	0	20	0	3	0	26	0	45	1	1	1	2	27	6	23	0	0	1	0	0	0	0	53	363
CS	0	27	22	1	223	7	1	80	141	327	2	41	0	2	37	2	34	2	129	0	8	3	4	7	0	12	53	21	0	2	8	2	0	0	0	81	1276
DK	0	0	8	0	4	18	1	20	14	59	0	0	0	3	1	0	18	3	7	0	0	1	5	0	0	2	84	0	0	2	7	2	0	0	0	23	284
FI	0	1	6	0	15	22	112	17	28	58	0	2	0	2	4	0	14	17	46	0	1	2	62	1	0	99	50	2	0	12	5	2	0	0	0	110	687
FR	0	5	69	0	34	5	0	875	51	350	0	4	0	9	105	5	80	1	34	8	1	126	3	20	0	5	197	8	1	1	32	47	0	0	0	257	2333
DD	0	2	35	0	71	14	1	94	174	419	0	2	0	3	8	2	64	3	39	0	1	3	6	3	0	9	98	1	0	3	13	3	0	0	0	63	1134
DE	0	12	110	0	87	15	1	402	138	1033	0	3	0	10	43	8	174	5	60	1	1	14	7	33	0	12	297	3	0	3	36	10	0	0	0	154	2671
GR	1	2	1	13	8	1	0	9	5	11	148	6	0	0	25	0	2	0	11	0	15	3	0	0	4	16	6	10	2	0	0	0	0	0	0	73	373
HU	0	22	5	1	65	2	1	27	31	77	3	71	0	0	60	0	8	0	52	0	13	2	1	3	0	8	12	44	0	1	2	1	0	0	0	50	561
IS	0	0	1	0	0	0	0	3	1	7	0	0	2	1	0	0	3	1	1	0	0	0	1	0	0	0	15	0	0	0	1	1	0	0	0	29	68
IE	0	0	3	0	2	0	0	11	4	13	0	0	0	17	0	0	6	0	0	1	0	2	0	0	0	0	38	0	0	0	2	8	0	0	0	30	140
IT	0	22	14	2	51	2	0	210	36	151	19	19	0	1	599	1	18	1	39	3	5	35	2	33	0	6	29	50	4	1	5	5	0	0	0	195	1558
LU	0	0	1	0	0	0	0	7	1	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	19
NL	0	0	25	0	4	1	0	47	8	72	0	0	0	3	1	0	55	1	4	0	0	2	1	0	0	1	116	0	0	0	10	3	0	0	0	22	375
NO	0	0	19	0	15	32	13	61	33	124	0	2	0	10	1	0	47	57	26	1	2	7	38	1	0	18	264	1	0	6	22	9	0	0	0	174	984
PL	0	18	48	1	266	43	8	132	395	617	1	35	0	5	32	3	97	8	611	0	12	4	32	6	0	62	184	20	0	13	22	5	0	0	0	192	2873
PT	0	0	1	0	0	0	0	9	1	5	0	0	0	0	2	0	2	0	0	40	0	34	0	0	0	0	8	1	0	0	1	17	0	0	0	39	161
RO	0	12	5	12	82	4	2	24	46	82	15	71	0	0	44	0	10	1	102	0	138	2	3	1	2	69	17	61	0	1	2	1	0	0	0	107	916
ES	0	1	11	0	5	2	0	138	10	56	0	1	0	2	28	1	15	0	5	62	0	422	1	2	0	0	58	3	3	0	6	45	3	0	0	188	1069
SE	0	2	20	0	34	76	52	53	77	209	0	3	0	7	3	1	50	51	74	0	2	3	146	1	0	67	214	2	0	18	22	6	0	0	0	181	1374
CH	0	3	7	0	9	0	0	111	9	79	0	1	0	1	53	1	10	0	7	0	0	7	0	35	0	1	17	2	0	0	3	2	0	0	0	30	388
TR	0	3	2	7	14	1	0	8	9	20	50	8	0	0	9	0	2	0	26	0	20	1	1	0	59	120	6	6	1	0	1	0	0	0	0	209	584
SU	0	37	78	17	395	128	192	219	458	863	31	114	0	12	74	3	161	40	1124	1	135	9	186	11	24	3322	370	65	0	59	43	10	0	0	0	1497	9679
GB	0	0	12	0	7	7	0	53	17	63	0	0	0	37	1	0	24	3	7	1	0	8	4	1	0	2	561	0	0	1	19	24	0	0	0	92	944
YU	2	34	9	14	79	3	1	68	46	119	29	68	0	1	259	1	12	1	69	1	31	10	2	8	1	15	21	167	2	1	3	2	0	0	0	157	1231
REM	0	2	3	2	12	1	0	53	9	25	32	4	0	1	62	0	5	0	7	4	3	43	1	2	1	1	19	8	40	0	2	4	1	0	0	353	701
BAS	0	3	34	0	45	89	57	84	133	347	0	5	0	9	7	1	84	22	127	0	3	4	115	2	0	83	250	3	0	28	27	6	0	0	0	163	1732
NOS	0	1	61	0	25	40	3	207	61	283	0	1	1	39	4	1	147	27	28	3	0	20	23	2	0	8	1120	1	0	6	68	37	0	0	0	247	2466
ATL	0	3	58	0	27	35	33	277	61	297	0	2	3	76	9	2	106	80	41	41	1	164	44	3	0	61	844	2	0	7	53	244	0	0	0	1492	4074
MED	2	24	22	18	82	5	1	303	58	173	275	37	0	3	601	1	32	1	74	11	31	162	4	15	18	42	71	88	26	1	8	13	1	0	0	600	2801
BLS	0	2	2	6	17	2	1	6	12	23	18	9	0	0	8	0	3	0	34	0	26	0	2	0	15	167	6	6	0	1	1	0	0	0	0	105	471

G:aan/acidrain

Table D. Benthic macroinvertebrates. Results from the field trip , September 1992
To be continued on page 35.

	ST1	ST2	ST3	ST4	ST6	ST7	ST8
	Uhlířská Černá Nis	Jezdecká Černá DesL	Starý pol trib.	Kořenov a Jizera	Myslivna Labe	U dívčí l Bílé Labe	Obří důl Úpa
km	12.3	9.8	0.1	144.8	253.6	0.3	76.1
pH	6.22	6.75	4.97	6.85	5.5	6.5	6.65
tW	6	9.5	9.3	9.3	5.6	5.1	5.1
date	18.9.	18.9.	18.9.	18.9.	19.9.	19.9.	19.9.
Ephemeroptera SZ							
Baetis alpinus						1	
Baetis buceratus		17				5	
Baetis fuscatus						18	
Baetis niger						8	
Baetis rhodani	1					55	
Baetis vernus	1	43	22	116	8		4
Baetis sp.				1			1
Heptagenia sp.juv.						2	
Plecoptera RG							
Brachyptera sp.				1			
Diura bicaudata	11	19	14		22		2
Leuctra albida		5				1	1
Leuctra aurita			4				
Leuctra autumnalis				4			
Leuctra hippopus		3		4			
Leuctra inermis	1					10	
Leuctra leptogaster				1			
Leuctra nigra	23		14		28	12	1
Leuctra pseudosignifera					12	4	
Leuctra rauseri	2			4			
Leuctra sp.juv.	51	12	11	10	20	42	4
Nemoura cambrica	4		2				
Nemoura sp.juv.	26		30				
Nemouridae g.sp.juv.		4	20	16			
Nemurella picteti	3						
Perlodes microcephala						1	
Protonemura auberti	3		1			1	2
Protonemura intricata					2		
Protonemura lateralis	7						7
Protonemura nitida				40			
Protonemura sp.juv.	3		5		4	8	12
Trichoptera JZ							
Drusus ?bipunctatus							1
Drusus annulatus	18	1					
Drusus biguttatus							1
Drusus discolor				1			
Drusus sp.juv.	40	8	6	3			
Ecclisopteryx dalecarlica				7			
Plectrocnemia conspersa	4	3	11		37	8	
Plectrocnemia sp.juv.	14		4	2	14	11	
Potamophylax cingularis	2						
Rhyacophila evoluta	36	15	12	6			1
Rhyacophila mocsaryi juv.							1
Rhyacophila nubila						6	
Rhyacophila sp.juv.	4	3		7	1	6	
Rhyacophila sp.pupae		4	1				
Diptera							
Tipulidae RG							
Tipula Sawtshenkia simulans		1					
Tipula sp.	1					1	

Table D. Continues

	ST1	ST2	ST3	ST4	ST6	ST7	ST8
	Uhlířská	Jezdecká	Starý pol	Kořenov a	Myslivna	U dívčí l	Obří dŭl
	Černá Nis	Černá Des	L trib.	Jizera	Labe	Bílé Labe	Úpa
km	12.3	9.8	0.1	144.8	253.6	0.3	76.1
pH	6.22	6.75	4.97	6.85	5.5	6.5	6.65
tW	6	9.5	9.3	9.3	5.6	5.1	5.1
date	18.9.	18.9.	18.9.	18.9.	19.9.	19.9.	19.9.
Limoniidae RG							
Dicranota sp.	94	38	28	17	12	6	62
Limnophila Eloeophila submarmorata	2		5	1			
Limnophila Eloeophila sp.							
Pedicia Crunobia straminea					1		
Pedicia Pedicia rivosa							2
Simuliidae MF							
Eusimulium aureum	6		6				2
Eusimulium cryophilum	5	3		1			23
Eusimulium latipes	8						
Odagmia monticola	1	12	2	3	1	28	19
Odagmia ornata	65	5	14				2
Twinia hydroides							1
Athericidae RG							
Atherix ibis				53			
Coleoptera RG							
Elmis sp.		1				1	
Ilybius crassus	3						
Ilybius sp.	1						
Limnius volckmari larva		1	1	3	8	12	11
Limnius volckmari imago		5					
Dytiscidae g.sp.			7				
Hydraenidae g.sp.		1					1

Determined by:

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SZ Světlana Zahrádková
MF Michal Fiala

Table E. Information about the sampling sites.

Site	Site river km	River	Sampling site	Height above sea level lowest masl	highest masl	Discharge Qa m^3	Q270 m^3	Q355 m^3
1	12.3	Černá Nisa	Uhlířská	770	886			
2	9.8	Černá Desná	Jezdecká	777	1025	0.49	0.18	0.09
3	0.1	Tributary	Starý polom	820	899			
4	144.8	Jizera	above Kořenov	620	1025			
5	0.0	Pudlava	mouth	1060	1503			
6	253.6	Labe	Myslivna	780	1503	0.65	0.29	0.14
7	0.3	Bílé Labe	U dívčí lávky	783	1554	0.77	0.33	0.17
8	76.1	Úpa	Obří důl	890	1602			
9	75.0	Úpa	above Modrý potok	891	1602			
10	0.0	Modrý potok	mouth	891	1554			
11(10)	0.0	Tributary	Vilèmínka	830	1321			
12(9)	351.7	Morava	above Vilemínka	840	1423			

Site	area km^2	Distance f.source km	Average year value precip mm	runoff mm	specif.runoff l/s.km^2
1	2.60	2.0	1070	666	21.11
2	13.96	4.5	1403	1099	34.82
3	0.08	1.0			
4	22.55	19.2	1349	1013	32.1
5	0.09	3.0			
6	17.00	6.9	1450	1203	38.1
7	20.54	7.7	1430	1179	34.7
8	5.90	2.4	1212	1058	33.5
9	9.00	3.5			
10	8.80	3.0			
11(10)	10.27	1.5			
12(9)	8.88	2.4	985	683	21.7

Site	Site river km	River	Sampling site
1	12.3	Černá Nisa	Uhlířská
2	9.8	Černá Desná	Jezdecká
3	0.1	Tributary	Starý polom - Left side tributary of Černá Desná at r.km 8.9
4	144.8	Jizera	above Kořenov
5	0.0	Pudlava	mouth
6	253.6	Labe	Myslivna - above Bílé Labe
7	0.3	Bílé Labe	U dívčí lávky
8	76.1	Úpa	Obří důl
9	75.0	Úpa	above Modrý potok
10	0.0	Modrý potok	mouth
11(10)	0.0	Tributary	Vilemínka - Left side tributary of Morava at r.km 351.6
12(9)	351.7	Morava	above Vilemínka

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