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REPORT

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Abstract
The report describes the abatement part of the Sino-Norwegian project CHN 017 "Surveillance of Water Quality in the Songhua River System in Heilongjiang Province, P.R. of China". The Mudanjiang river catchment was selected as a case catchment in the Songhua River catchment for abatement strategy purposes. The whole co-operation project is focused on the application of ENSIS as a database and data analysis tool. The river and lake monitoring data from Mudanjiang river catchment was stored within ENSIS. The development of ENSIS and its functions represents an important part also of the abatement work, e.g. data collection part, data analysis. The sources of pollutants focused upon in the project were industry, domestic sewage and diffuse sources such as pollutants from agricultural activities. Focus on the abatement issue at this stage was on data collection, storage and handling, and on the overall principles of abatement plans. The next steps in the abatement strategy planning will be to identify detailed user interests and possible conflict areas, to make the list of measures more exhaustive, to prioritise amongst the possible measures (cost-effectiveness analysis), and to propose timetables for implementing the selected measures.

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1. Mudanjiang elvens nedbørfelt	1. Mudanjiang River catchment
2. Tiltaksplanlegging	2. Abatement
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Surveillance of Water Quality in the Songhua River, Heilongjiang Province, P.R. of China

Mudanjiang River catchment

Abatement Strategy- Principles and some examples

Preface

The project "Surveillance of the Water Quality in the Songhua River System in Heilongjiang Province, P.R. of China" was launched in November 1996, when an agreement was signed between the Norwegian Agency for Development Co-operation (NORAD) and the Chinese State Science and Technology Commission (SSTC). The Chines executive institutions of the project were the Heilongjiang Environmental Protection Bureau (HEPB) and the Heilongjiang Environmental Monitoring Central Station (HEMCS). From Norway the co-operative institute were the Norwegian Institute for Water Research (NIVA) and the NORGIT Centre.

This report describes the abatement part of the overall project.

Participants in this part of the project were Ms Kjersti Dagestad, Tor Haakon Bakken, Mr JonLasse Bratli and Mr Stig Borgvang from NIVA and Mr Sun Zi Meng, Mr Ye Dan, Mr Niu Xian Chun, and Ms Yu Shi Hong from Mudanjiang Monitoring centre.

Overall project leader in Norway has been Bente M. Wathne at NIVA and Mr. Guo Yuan at HEPB supported by Chen Aifeng at HEMC.

Oslo, August 2001

Stig A. Borgvang

Contents

Summary

Background
This report is part of the Sino-Norwegian Study Co-operation: "Surveillance of Water Quality in the Songhua River, Heilongjiang Province, P.R of China".

Water resources development and management are planned in an integrated manner, incorporating environmental, economic and social considerations. An Abatement strategy is a comprehensive methodology used in the management of rivers and lakes to reach a better water quality.

During discussions between the Sino-Norwegian project partners, it was decided to focus on the Mudanjiang river catchment as a case catchment in the Songhua River catchment for abatement strategy purposes.

The Mudan Jiang river is a tributary to the Song Hua Jiang, which again runs into the Heilong Jiang. The Mudan Jiang river is 705,4 km long and has its source within the Jin Lin Province. The main tributaries to the Mudan Jiang river are the Hai lang river, the Hama river and the Wusihun river.

The whole co-operation project is focused on the application of ENSIS as a database and data analysis tool. The river and lake monitoring data from the Mudanjiang river catchment is stored within ENSIS. The development of ENSIS and its functions represents an important part also of the abatement work, e.g. data collection part and data analysis (see Annex A for general information about ENSIS).

The sources of pollutants focused upon are:

Industry
Domestic sewage
Diffuse sources such as pollutants from agricultural activities

Environmental problems and goals
According to Mudanjiang Environmental Authorities, the pollution due to organic matter is perceived as the main environmental problem in the Mudanjiang river and its tributaries. It is shown by high values of COD.

The goals for user interests are set by the Heilongjiang Environmental Protection Bureau (HEPB) and thereafter approved by the Heilongjiang government. The Mudanjiang river is currently categorised as class 2 in the upper part, class 3 in the middle part and class 4 in the lower part (according to the Chinese National Water Classification System).

The current objectives concerning the water quality of the Mudanjiang are as follows:

- To reach water quality class II for the river stretch down to Mudanjiang city, including the Jin Bo Hu that has already water quality class II;
- To reach water quality class III for the river stretch from Mudanjiang city to Lian Hua, the site where the Mudanjiang river flows into the Song Hua Jiang.

Recommendations
A dialogue should be launched to advise environmental authorities on strategies for the management of water resources based on the above-mentioned principles. Advice should be given on how to organise the planning process and how to prepare cost-effective pollution abatement strategies.

It is important to ensure that the identification of ‘what are the main problems in the catchment’ has been carried out, taking all main user interests into account. This identification will determine which

substances represent the main problems, and thereby also which parameters should be monitored. It is therefore also important to identify the most important sources for the identified water related problem.

The next steps in the abatement strategy planning will be to make the list of pollution sources more exhaustive, to prioritise amongst the possible measures to reduce the inputs of identified pollutants and their effects in the environment (cost-effectiveness analysis) and to propose timetables for implementing the selected measures.

Further improvement of the water quality of the identified main water bodies in the Mudanjiang watershed could be reached by means of improved:

- Field and 'in-house' equipment;
- Monitoring programme;
- Laboratory performance;
- Knowledge of the actual environmental problems in the catchment; and
- Implementation of cost-effective measures.

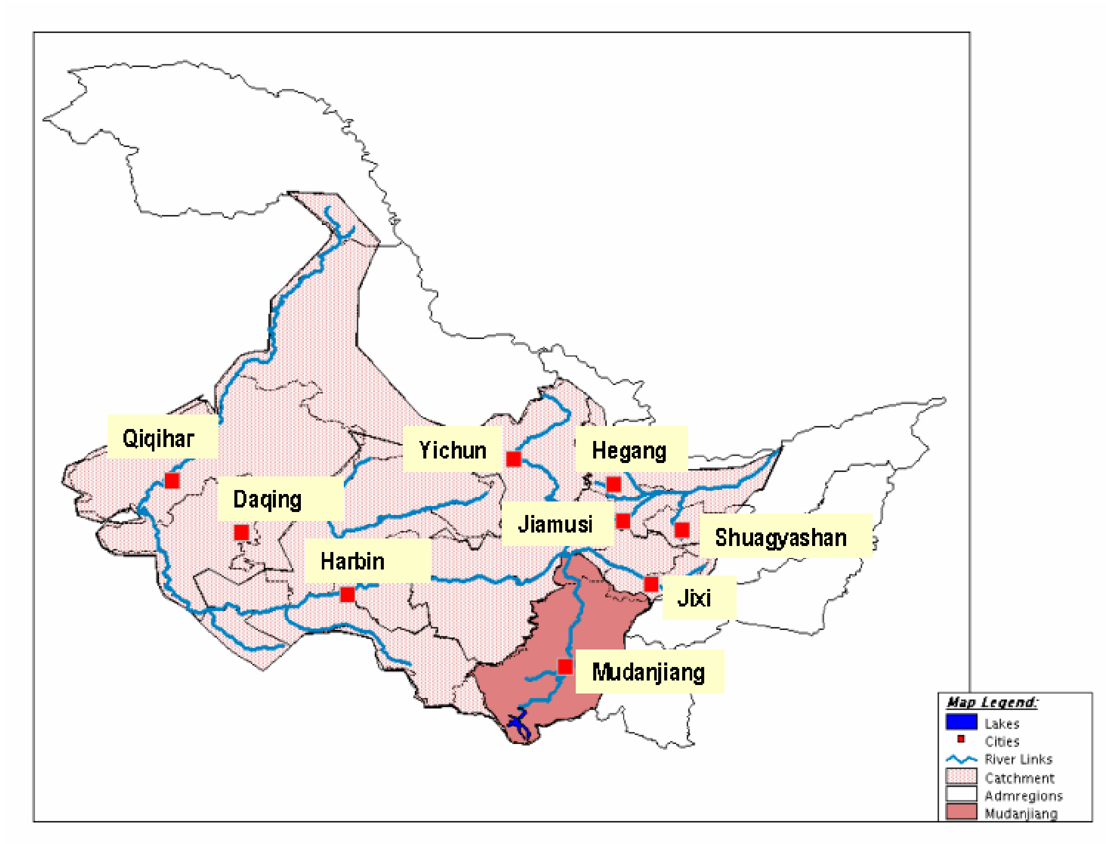

Figure 1: The Heilongjiang river catchment, including the Mudanjiang river catchment

1. Introduction

1.1 Sub-project description

1.1.1 Introduction

This report is part of the Sino-Norwegian Study Co-operation: "Surveillance of Water Quality in the Songhua River, Heilongjiang Province, P.R of China".

During discussions between the Heilongjiang Environmental Protection Bureau (HEPB), the Heilongjiang Environmental Monitoring Central Station (HEMCS) and the Norwegian Water Research Centre (NIVA), it was suggested to select one sub-catchment as a case catchment in the Songhua River catchment.

After consideration, the Mudanjiang catchment (see Figure 1) appeared to be appropriate for the purpose of the co-operation project. The criteria used in the selection process were, *inter alia*, the presence of:

- A certain number of industrial activities in small and large plants;
- A wide range of agricultural activities;
- Planned construction of wastewater plants
- A number of existing chemical and hydrological monitoring stations
- A number of user interests linked to the river
- Varying land-cover
- Appropriate catchment size

Furthermore, the Mudanjiang catchment includes a natural lake (see Figure 2) and one artificial reservoir and had local expertise about the catchment, which facilitated the work of NIVA.

This report outlines various principles for abatement strategy for later use in other areas/catchments and provides some examples for the specific catchment of the Mudanjiang river system. Furthermore it lists the monitoring data available and recommends how to take the process further.

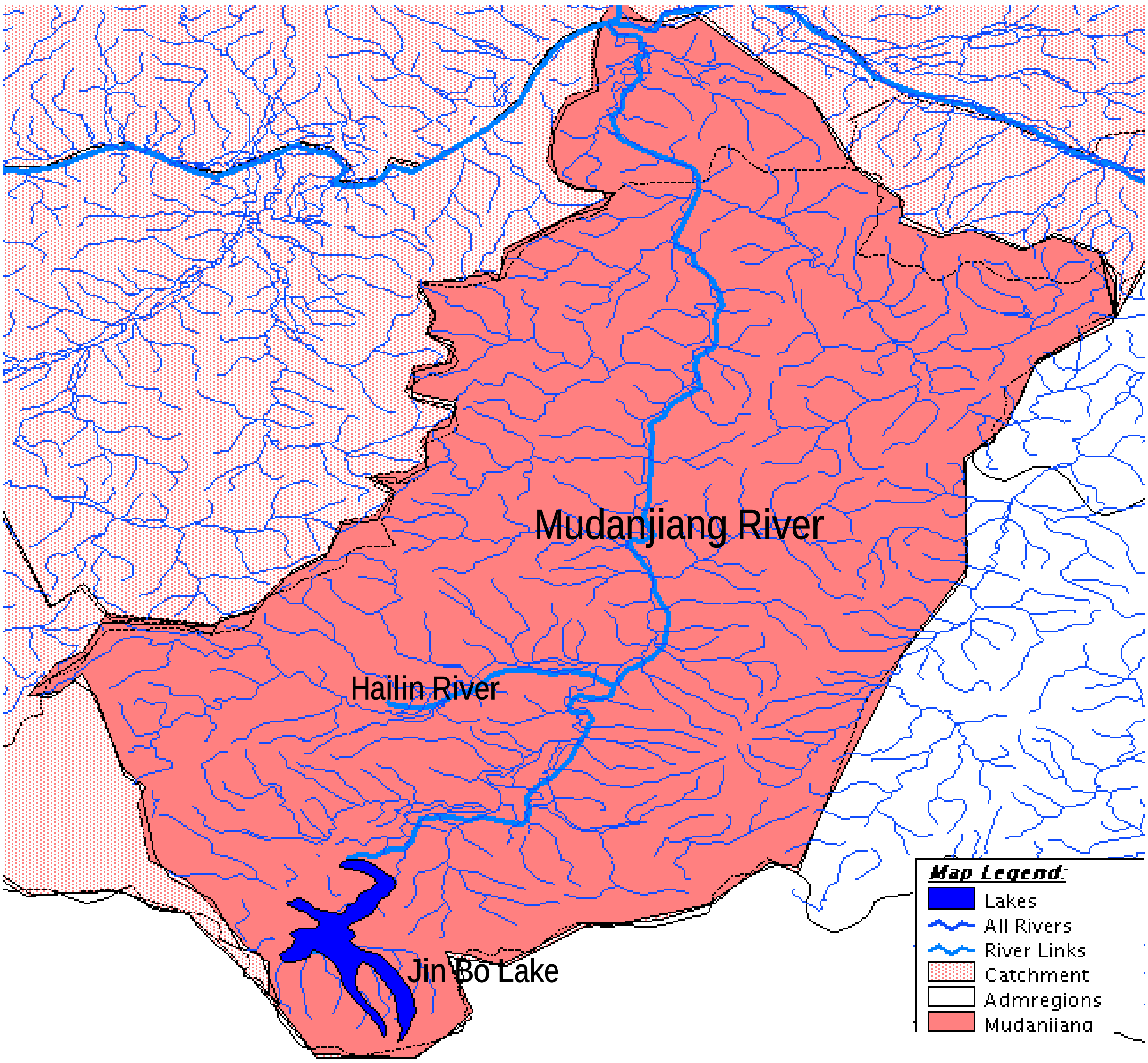

Figure 2: The Mudanjiang river catchment

1.2 Abatement strategy, what does it mean and which strategy to choose?

Water resources development and management are planned in an integrated manner, incorporating environmental, economic and social considerations. All planning is based on the principle of sustainability, taking into account short term, as well as long term planning objectives. In that respect, it is important to remember that misuse of water resources is one of the world's major water related problems. The cause of the problem is complex, but limited knowledge of the environment and the effects of human impacts, as well as local economic and social conditions are influencing factors.

An Abatement strategy is a comprehensive methodology to use in the management of rivers and lakes to reach a better water quality. Some basic elements are to be taken into concern. Firstly, it may be useful and time efficient to carry out a preliminary rough screening of easily available monitoring data and industrial sources lists and to identify the most important water quality problems (e.g. eutrophication/organic load, hazardous substances). Such a screening facilitates the data collection process by focusing on parameters qualifying the identified problems.

Thereafter, the water quality should defined on the basis water quality classification systems (see Appendices B and C for a description of the Chinese and Norwegian systems). The classification of quality status is based on measured concentrations that have two components; a natural component, which stems from natural processes in the catchment area, and a component, which stems from human influence, *e.g.* effluents from industry and sewage, and agricultural runoff. The latter is defined as 'pollution.

Then the water-quality goals should be set. These should be set on the basis of peoples user interests (drinking, fishing, irrigation etc.) and the goals related to aquatic life.

The identification of pollution sources will depend on the identified pollution problems. It is also important to bear in mind that discharges of pollutants upstream will have effects downstream (e.g. the discharges from the Dun Hua city in the Ji Lin Province, upstream the Jin Bo Lake). It is therefore not sufficient only to consider pollution sources within one specific administrative area, but also consider pollution sources located upstream and downstream, in neighbour municipalities or counties. Of this follows that the basis of a sound Abatement strategy is the catchment area.

There may be different types of sources (both point and diffuse), for example when the problems are linked to COD concentrations, sources such as industrial (pulp and paper or brewery), municipal wastewater from households or fertiliser from agriculture. Hence, a wise strategy would be to take all sources of a given pollutant into consideration. An Abatement Strategy will consist of several steps that all are part of an Abatement Plan. A possible abatement strategy could consist of the elements or working tasks as outlined in Figure 3 below.

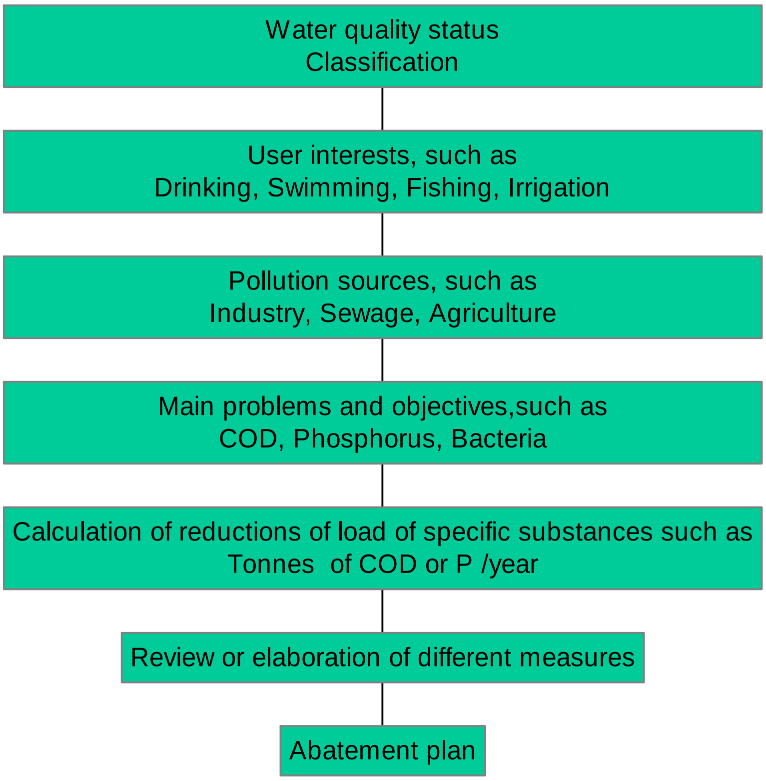

Figure 3: Outline of an Abatement Strategy

2. Data collection: River/lake monitoring data

2.1 Starting point

Relevant monitoring authorities/stations have provided available monitoring data for the Mudanjiang watercourse. That includes data on the main river and also its contributors. The data should be assessed with regard to reliability- Quality Assurance Procedures. It is hoped that all measured data conform to standardise «Good Field and Laboratory Practices». It was important to get access to time series (monitoring over several years) as time series of water quality data are often strongly dependent on climatic factors such as precipitation and runoff. Thus, the inter-annual variations in load can vary substantially and cause spurious trends and lead to misinterpretation.

Appropriate quality assurance (QA) procedures should be applied to field and laboratory work. For example it is important to apply QA to the measurement of river flow and discharges, and to the collection and storage procedures for samples as well as to the laboratory measurements. The analytical measurements carried out under appropriate internal quality control schemes, and periodically validated. NIVA has carried out intercomparison exercises, in which several laboratories in China have participated (see Appendix D). It is hoped that laboratories providing monitoring data for the Mudanjiang river catchment will participate in any future exercise. Finally, it is necessary to identify and describe significant gaps in the available information.

2.2 Data on point and diffuse sources

2.2.1 Point sources

Task
Identify individual discharges (or a number of discharges in close proximity) to a watercourse or a body of water, such as effluent discharged from a sewage collecting and treatment system via an outfall pipe or channel and industrial sources. As a first step, sources (small and large) discharging substances that are related to identified water quality problems in the water bodies of concern, should be identified.

Industrial sectors
Status:
Average data for ten industrial plants on 1-2 parameters has been made available.

Table 1. Main industries in the county of Mudanjiang (see also Figure 4).

Name of industry	Type	Number (Figure 4)	COD t O/y	SS t/year
MDJ Paper Mill	Papermaking	1	5343.6	3237.0
MDJ Petrochemical Works	Petrochemistry	2	108.4	
MDJ Timber Mill	Papermaking	3	5640.6	529.2
MDJ Brewery	Food Processing	4	849.5	282.3
MDJ HUALING Rubber Plant	Rubber	5	1028.5	3686.7
MDJ White Spirit	Food Processing	6	1575.0	831.4
MDJ Pharmaceutical Factory	Pharmacy	7	684.0	
NingAn Sugar Refinery	Food Processing	8	686.3	291.6
NingAn Chemical Fertiliser Plant	Chemical Combination	9	466.5	380.2
ChaiHe Paperboard Plant	Papermaking	10	10482.6	4985.9

Principles

It is necessary to identify those sectors that may discharge significant quantities of polluting substances (possible linked to preliminary screening). For example if eutrophication represents an environmental problem, the below listed industrial sectors may discharge phosphorus and/or nitrogen directly to surface waters:

- Fertiliser industry;
- Food and drink related industry, including dairy industry, soft drinks, wine production and brewing industry; meat and fish processing, alcoholic beverages manufacture and bottling, manufacture of fruit and vegetable products, manufacture of gelatine, production of yeast;
- Organic chemical and biochemical industry, incl. pharmaceutics, detergents industry, manufacture of glue, production of industrial alcohol, manufacture or removal of ink;
- Waste processing industry, including manure processing industry;
- Pulp and paper industry;
- Cokeries and refineries; and
- Other sectors, such as non-ferrous metal industries that are considered to be of catchment related or national importance.

Ideally, all industrial discharges with polluting substances should be quantified/estimated. Practical difficulties will arise when there are small plants with small discharges. It will therefore, in many cases, be necessary to use a ‘discharge limit figure’ for the purpose of distinguishing between significant and less significant annual discharges.

Data Gaps

The monitoring programmes should be plant-specific and related to water quality problems. Hence, discharges from e.g. a fertiliser plant should be analysed for nitrogen and phosphorus concentrations (eutrophication related) and discharges from a pulp and paper plants should be analysed for e.g. nutrient content, organic matter and dioxins (if chlorine bleaching is applied).

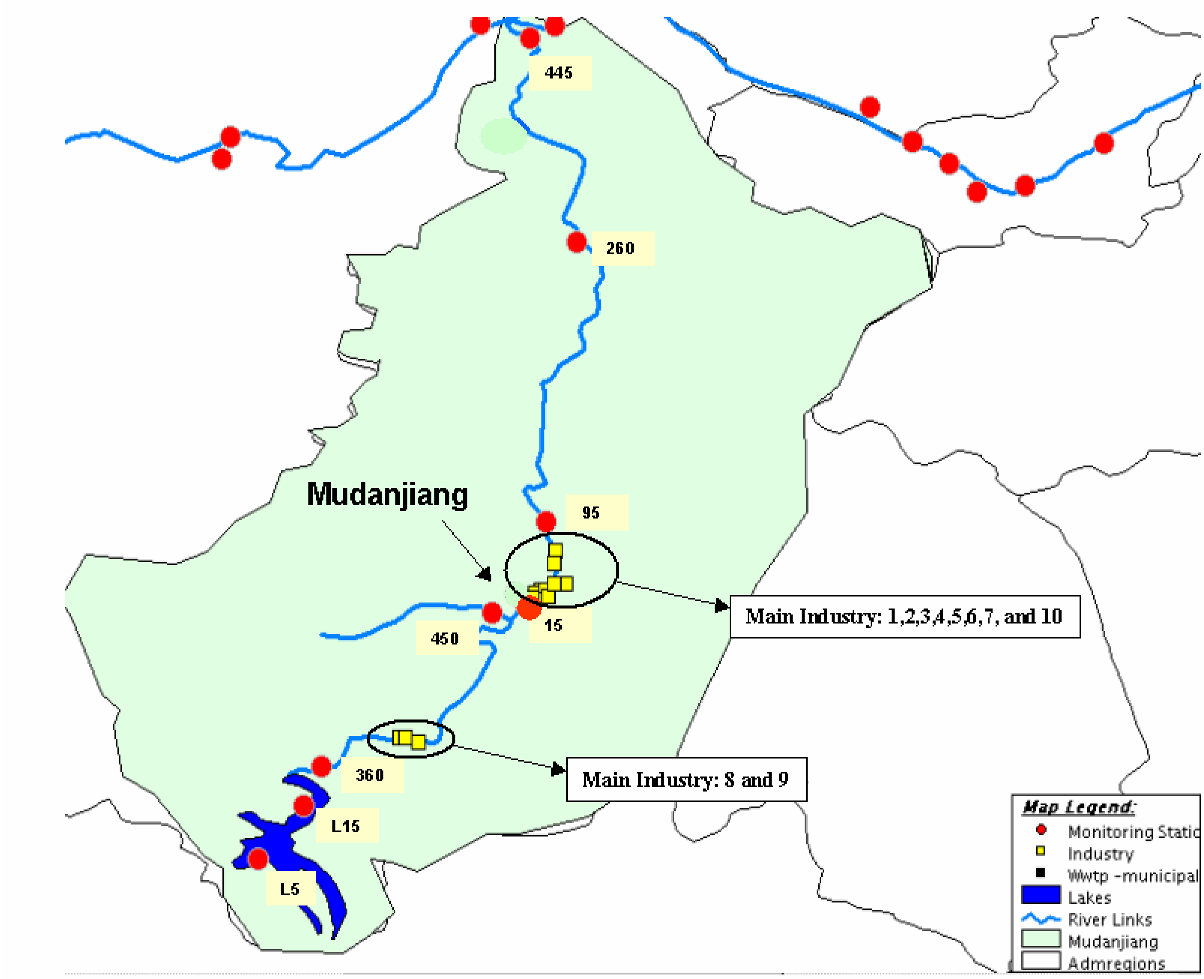

Figure 4: Monitoring stations and main industrial plants in the Mudanjiang river catchment

Wastewater

Status

Information about the population in 1995 in seven municipalities has been made available.

Table 2: Land cover and population for the cities (municipalities) in the county of Mudanjiang.

City (municipality)	Land cover, Km^2	Land proportion %	Pop. Density Persons/km^2
TOTAL	40 566	100.0	64.1
Mudan jiang city proper	1 351	3.3	545.0
Us Fen he	423	1.0	82.7
Ning an	7 852	19.4	56.0
Hai lin	9 902	24.4	43.6
Mu ling	6 347	15.6	48.5
Dong ning	7 529	18.6	30.5
Lin kou	7 162	17.7	58.6

Principles

It is necessary to take account of (see also Figure 5):

- Discharges by combined sewer systems;
- Discharges by separate sewer systems;
- Discharges by sewer systems that are not connected to a waste water treatment plants
- Losses from households not connected to sewerage into aquatic systems.

Urban wastewater means domestic wastewater or the mixture of domestic wastewater with industrial wastewater and/or run-off rain water. Domestic wastewater means wastewater from residential settlements and services, which originate predominately from the human metabolism and from household activities.

The basis for calculating the loads from wastewater is:

- a production coefficient for what one person discharges of phosphorus, nitrogen and organic matter per day
- the number of people connected to a sewerage system (or number of inhabitants multiplied adjusted for a percentage of people having water toilets)

An estimate of the number of people using public toilets, and how the waste is treated is also necessary.

Data gaps
For the purpose of an Abatement strategy, prognosis for population patter and number in the future would be useful. Furthermore, it will be necessary to adjust the catchments, sub-catchments to administrative unites. Population figures for areas outside the Mudanjiang county, but within the Mudanjiang river catchment, are also required.

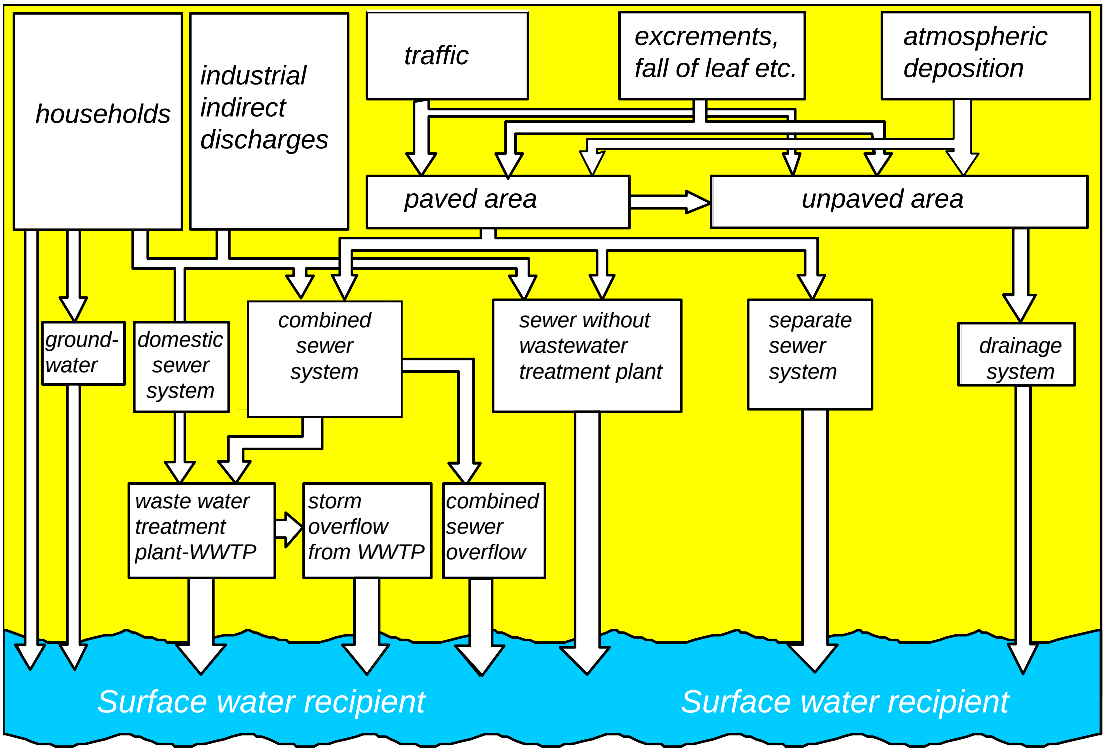

Figure 5: Sources and pathways of nitrogen and phosphorus discharges and losses in urban areas (according to Behrendt,1993; modified).

2.3 Diffuse sources

Status
Information about land-use for the year 1995 has been made available, per municipality.

Table 3: Land use for the cities (municipalities) in the county of Mudanjiang given in km^2.

City (municipality)	TOTAL	City proper	Sui fen he	Ning an	Hai lin	Mu ling	Dong ning	Lin kou
Total land square	40 566	1 351	423	7 852	9 902	6 347	7 529	7 162
Farming land	3 596	192	22	965	584	556	311	966
Gardening land	143	21	1	68	9	7	11	26
Forest	31 828	978	292	5 548	8 280	5 208	5 832	5 690
Feeding grass land	792	22	21	107	176	53	194	219
Industrial and mining land	634	91	8	127	86	110	115	97
Transportation land	382	21	1	61	70	59	86	84
Water square	627	17	2	209	205	37	115	41
Unexploited land	2 564	9	76	767	492	317	864	39
Exploitable wild land	155	_	13	74	10	56	2	_

Furthermore there is information about the use of fertiliser and pesticides for agricultural purposes for the cities (municipalities) in the county of Mudanjiang (figures given in tonnes/year).

Table 4: Fertiliser use

City (municipality)	TOTAL	City proper	Sui fen he	Ning an	Hai lin	Mu ling	Dong ning	Lin kou
Compound (commercial):								
Nitrogen	43729	3737	160	13519	6497	945	4409	10462
Phosphorus	18014	1146	72	1632	1392	3317	2469	7986
Natural:								
Nitrogen	19464	1641	72	6353	3015	2139	1 947	4 297
Phosphorus	6125	461	31	483	534	1386	729	2 501
Pesticides	896	62	10	238	187	109	79	211

Principles

Any source that is not accounted for as a point source, is a diffuse source. Small, dispersed point discharges (e.g. from scattered dwellings or from point sources in agriculture, e.g. farmyards) should be dealt with as diffuse sources. Based on this definition, losses from scattered dwellings are diffuse sources. Diffuse sources will therefore comprise losses from:

- Agricultural land ;
- Other land categories;
- Scattered dwellings
- Direct atmospheric deposition on inland water surfaces; and
- Natural background losses.

Natural background losses are losses that would occur from unpaved areas if they were unaffected by human activities (except anthropogenic atmospheric deposition) and if they were in the state of natural pristine land. Natural background losses are part of the total estimated inputs to primary surface water recipients and include:

- Losses from unmanaged land; and
- That part of the losses from managed land that would occur irrespectively of anthropogenic activities.

Direct deposition of anthropogenic origin of substances from the atmosphere onto inland waters. Direct atmospheric deposition of specific substances on inland waters may represent an important input for some substances and should be quantified where it is considered as a major source of the total inputs to inland surface waters. The atmospheric deposition on land is accounted for within the quantification of specific substances reaching the primary surface water recipients via the soil-related pathways.

The potential inputs to primary surface water recipients are transferred via a number of pathways. A large number of removal, storage or transformation processes may influence the final quantities of specific substances entering primary surface water recipients. The loss pathways to surface waters include (see Figure 6):

- Losses by surface runoff (transport of dissolved substances);
- Losses by soil erosion(transport of particular, adsorbed substances)
- Bank and riverbed erosion;
- Losses by artificial drainage flow (through drainage pipes/tile drainage);

- Losses by leaching (net mineralisation, percolating waters i.e. interflow, tile drain flow, spring water and groundwater); and
- Direct atmospheric deposition on inland waters

Agriculture
Pollution from agriculture is often divided into two categories, diffuse pollution from runoff from the areas, and direct (point) sources from manure tanks etc.

The latter can be quantified on the background of the number of animals, type of animals, the number of months a year they are inside the barn, and the type of manure tanks in use.

The diffuse sources from the crop areas are more difficult to estimate. Soil losses are often calculated using a version of USLE (Universal Soil Loss Equation) calibrated for the conditions in the country or region in question. The equation takes into account the soil erodibility the slope length, the slope steepness and the cultivation system (crop type, fertiliser use)

The load from the agricultural areas can also be estimated on the basis of empirical data (monitoring data from different fields).

Whatever method is used for quantifying the losses, the result is a loss coefficient, for example 80 kgP/km^2/year.

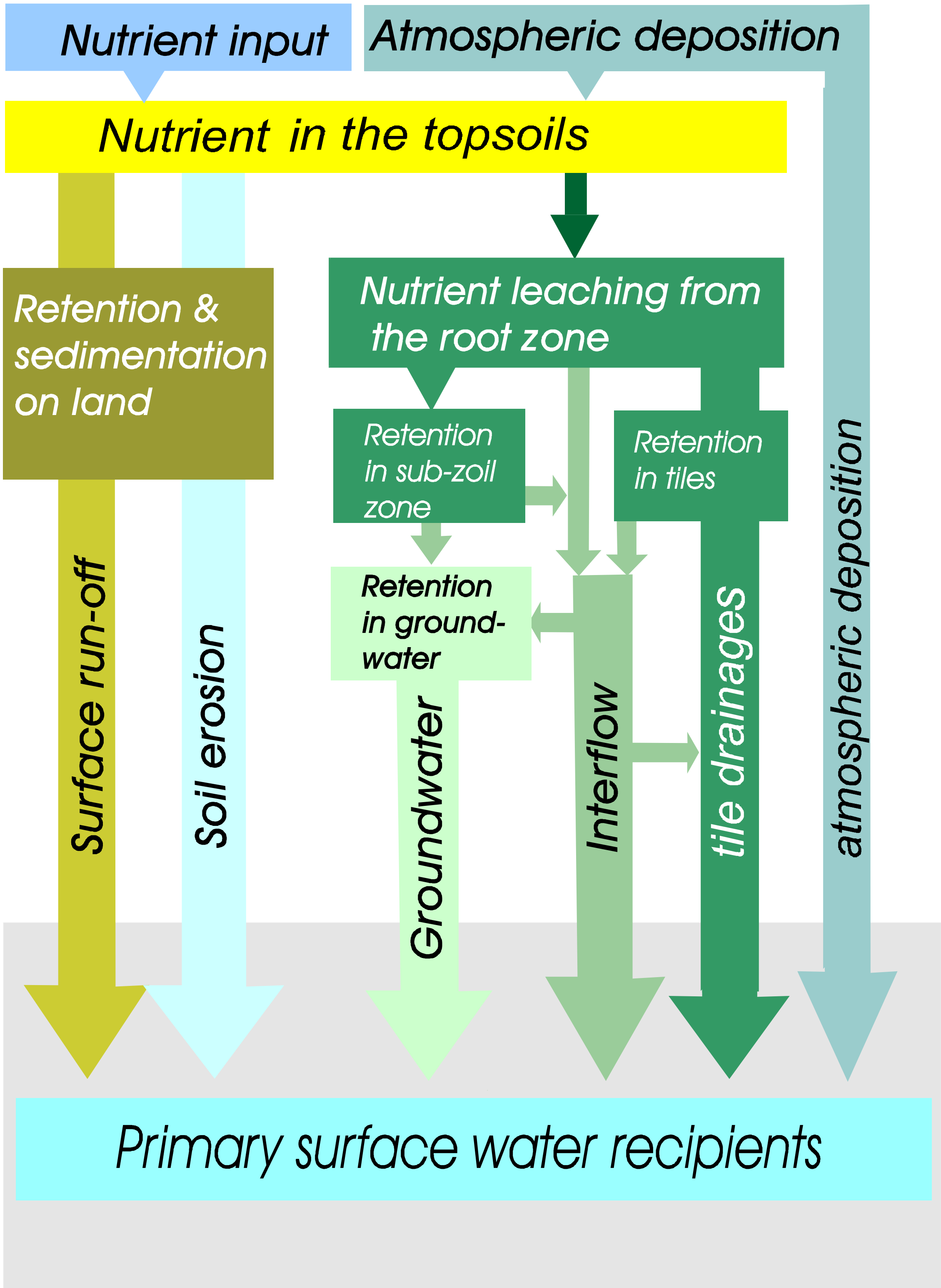

Figure 6: Pathways of nitrogen and phosphorus losses from diffuse sources to primary surface water recipients (Borgvang & Selvik, 2000).

Households not connected to a sewage system (Scattered dwellings)
The quantification should be made on the basis of national statistics. The national statistics should be as up to date as possible. It is possible that the national register will provide information on:

- The number of households not connected to sewerage systems; and of
- The number of people living in the households, taking account the 'part of the year inhabitants' (e.g. offices, shops, hotels, tourist accommodations and secondary houses).

General statistics should provide information about:

- The waste-water treatment methods and water consuming devices in the households; and
- Location of the households in relation to watercourses (if available) and soil conditions (the part of the load actually reaches the surface waters).

Annual load quantification are carried out on the basis of:

- Time-series of river flow (flow data on a monthly basis, preferably based on daily values); and
- Time-series, with calculated riverine loads of relevant substances- dissolved and particulate- the data resolution should at least be on a monthly basis.

In order to estimate the annual input from the river system, there should be a minimum of data sets, collected within a 12-month period. The data sets should in principle be collected at regular monthly intervals, but could also be collected at a frequency, which appropriately reflects the expected river flow pattern.

3. Description of the Mudanjiang catchment

3.1 Physical characteristics of the catchment

3.1.1 River

The Mudan Jiang is a tributary to the Song Hua Jiang (see Figure 1), which again runs into the Heilong Jiang. The Mudan Jiang is 705,4 km long and has its source within the Jin Lin Province. The main tributaries to the Mudan jiang are the Hai lang river, the Hama river and the Wusihun river.

The river is frozen, in general, from November to May.

3.1.2 Area

The Mudan Jiang catchment covers 37055 km^2, out of which:

- 31292 km^2 are in the Mudanjiang county;
- 3800 km^2 are area in the Ji Lin county, upstream the Jing Bo Hu; and
- 1963 km^2 in the Harbin county, downstream chemical monitoring site 260.

3.1.3 Precipitation

The average annual precipitation onto the said catchment is about 540 mm. The average humidity is 71 %.

3.2 Population

In 1997, the population in the Mudan Jiang catchment was a total of 2 774 708 people, out of which:

- 2 603 708 (subtract for the most of Muling and Dong ning municipality, and whole Sun Fe He) lived in the Mudanjiang county;
- 30 000 lived in the Ji Lin county, upstream the Jing Bo Hu; and
- 171 000 lived in the Harbin county, downstream chemical monitoring site 260.

The main cities (proper) are Mudan Jiang city (789 152 inhabitants), Sui fen he (42 292 inhabitants), Ning an city (431 766 inhabitants), Hai Lin city (437 945 inhabitants), Muling city (310 808 inhabitants). The Lin Kou county has 429 188 inhabitants and the Dang ning county 204 849 inhabitants.

The average water consumption per person in the catchment is about 100 l/day, out of which it is estimated that 12 l/day are used for personal hygiene.

3.3 Division of the Mudanjiang river Catchment into sections (sub-catchments)

The main aim of the division into sections is to provide a basis for evaluating pollution status and the need to introduce measures to achieve satisfactory water quality for various user interests.

It is important to define areas in which natural conditions and user interests/conflicts are as homogeneous as possible, and to ensure that the boundaries of the areas coincide as far as possible with administrative units (county and municipality boundaries).

As a result of this the following 6 sections have been defined:

- Upstream Jin Bo lake
- Jin Bo lake
- Mudanjiang river from Jing Bo lake to the border of Mudanjiang city proper
- Hailin river
- Mudanjiang river from Mudanjiang city proper to the border of Harbin county
- Mudanjiang river from the border of Harbin county until it runs into Songhua

3.4 Jing Bo Hu

3.4.1 General information

The Jing Bo Hu is located within the mountain chain of Changbai Zhangguang Cai and Laoye in northeastern China. It is a volcanic barrier lake. The average depth is 13,8 m and the maximum depth is 64,5 m.

The lake is 41 km long, and the circumference is 198 km at average water level. The lake is between 0,5 to 6 km large and its surface area 143,1 km^2. The water volume is on average 1 180 000 000 m^3, the largest 1 824 00 000 m^3. There is a difference of 13 meters between the highest and lowest water levels (354,43 m a.b.s and 341,02 m a.b.s.).

The lake receives water from the Jilin province at the lake's southernmost point (the river has its source in the Jilin province). On average 92,79 m^3/s, flows into the lake at the Dashan zhui, whereas, on average 93,61 m^3/s leaves the lake via the river now called 'the Mudanjiang river', at the northernmost point called Guo shuchang. The water flow at Dashan zhui is about 65,75 m^3/s.

The city of Dun Hua, located upstream the lake in the Jing Lin Province, discharges large quantities of organic matter into the lake via the Mudanjiang river. The figures are on average 5653 tonnes and 2313, measured as COD and BOD_5 respectively.

The lake is frozen, in general, from November to May.

There are about 76 900 people living in the 11 820 km^2 drainage area of to the Jing Bo Hu. About 76% of the land are forest, 3 % grass and 12 % agricultural land. The remaining is village and city areas and mountains (9 %).

On average 3000 people visit the lake area per day in the period June to August.

3.4.2 Chemical and biological information

The transparency in the lake varies throughout the year on average as follows at the following cross sections:
J_{10}: 0,72 m (LaoGuLazi)
J_{50}: 1,13 m (Dianshita, i.e. TV tower)
J_{65}: 2,00 m (BiShu Shangzhuang).

The average chlorophyll a value in the month of September is 8,32 µg/l.

The annual average total phosphorus concentration in the lake is 0,461 mg/l, whereas the total nitrogen concentration is 0,94 mg/l.

The COD concentration varies between 5 to 10 mg COD_{Mn}/l.

4. General description of the monitoring programme

The monitoring is carried out eight times a year, namely in January, February, May, June, August, September and October (see Map below). There are 19 parameters analysed, according to the "Technical Guidance for Environmental Monitoring". There are three times of 'synchronised monitoring', namely 20 September (during high flow), 15 October (during average flow) and 15 January (during low flow). The monitoring stretches are as follows (see Figure 7):

- Guoshuchang
- Hailang
- Chaihe railway bridge
- Hualiangou
- Mudan Jiang river mouth

All samples are taken on both riversides, sometimes also in the middle (left, middle and right position).

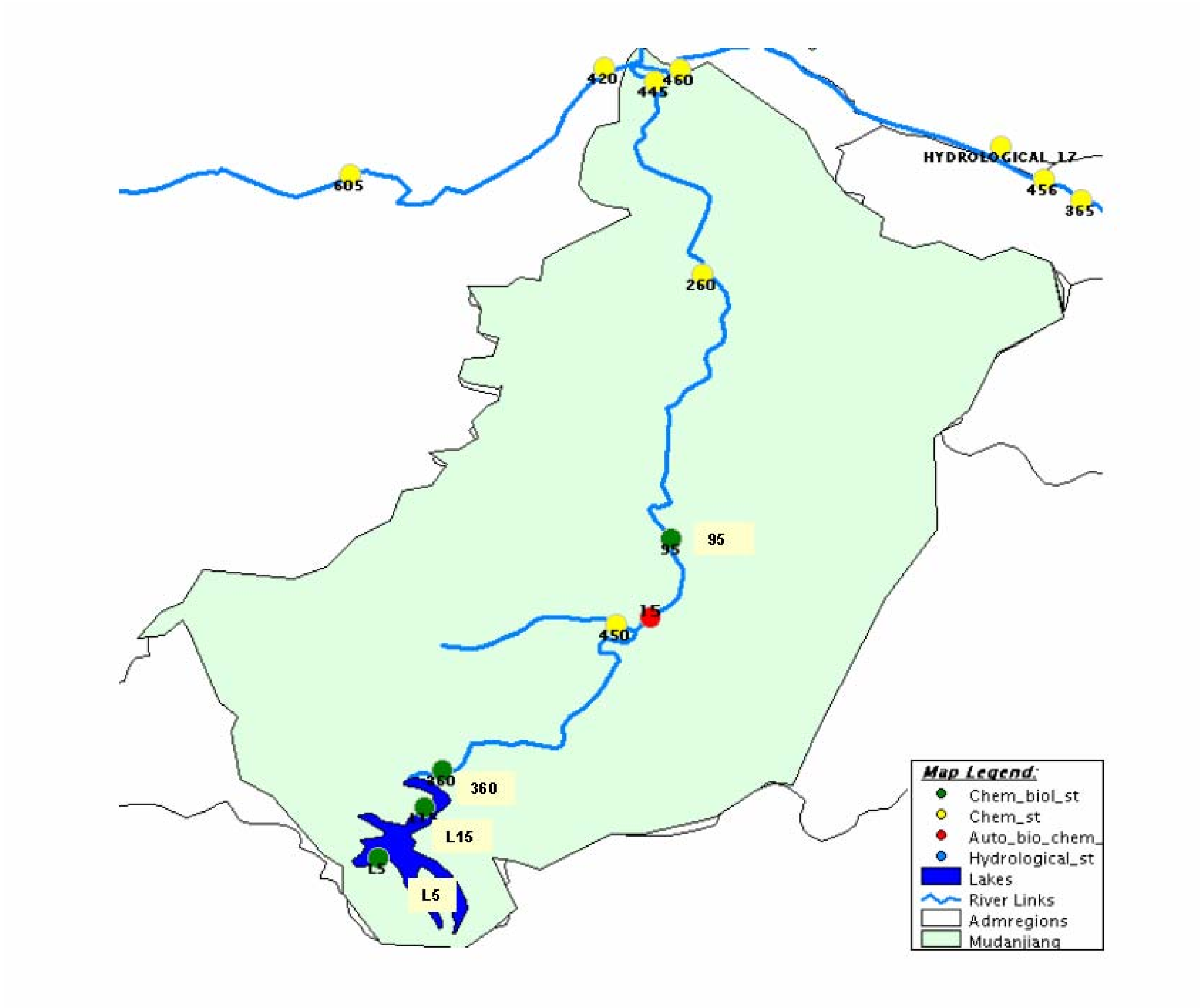

Figure 7: Monitoring sites in the Mudanjiang river catchment

Table 5: Monitoring sites in the Mudanjiang catchment area (see also Figure 7).

Description of the site	*Type of monitoring*	*Code*
Jin Bo lake, river inlet	Chemical/biological	5
Jin Bo lake, middle	Chemical/biological	15
Jin Bo lake, outlet	Chemical/biological	360
Hailin river	Chemical	450
M.J. river after the Hailin river before M.J. city proper	Chemical	15
M.J. river in M.J. city proper	Hydrological	14
M.J. river downstream M.J. city proper	Chemical/biological	95
M.J. river between M.J. city proper and Songhua	Chemical	260
M.J. river before Songhua	Chemical	445
M.J. river before Songhua	Hydrological	15

The river and lake monitoring data is stored within ENSIS (see Appendix A about ENSIS information). The development of ENSIS and its functions represent and important part also of the abatement work, e.g. data collection part, data analysis.

In the following, possible presentations of the data stored in ENSIS are given (Figures 8-18). Further analysis and correlations of the data should be carried out in a step 2 of the Abatement Strategy (see Recommendations). Appendix E summarises comments on the samples and COD_{Mn} analysis for all stations in the Mudanjiang River catchment for the period 1988-1997

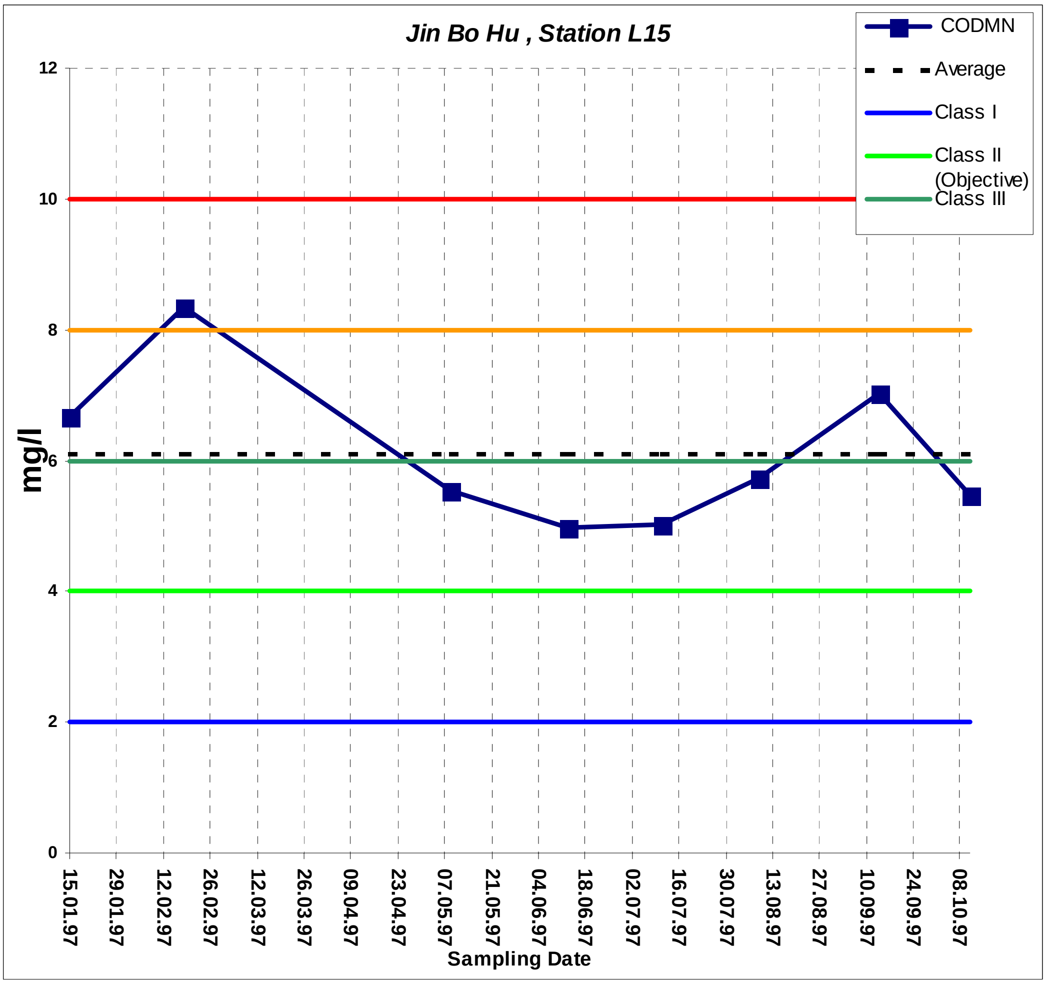

Figure 8: COD_{Mn} concentration at the Jin Bo Hu lake in 1997, station L15, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for the lake

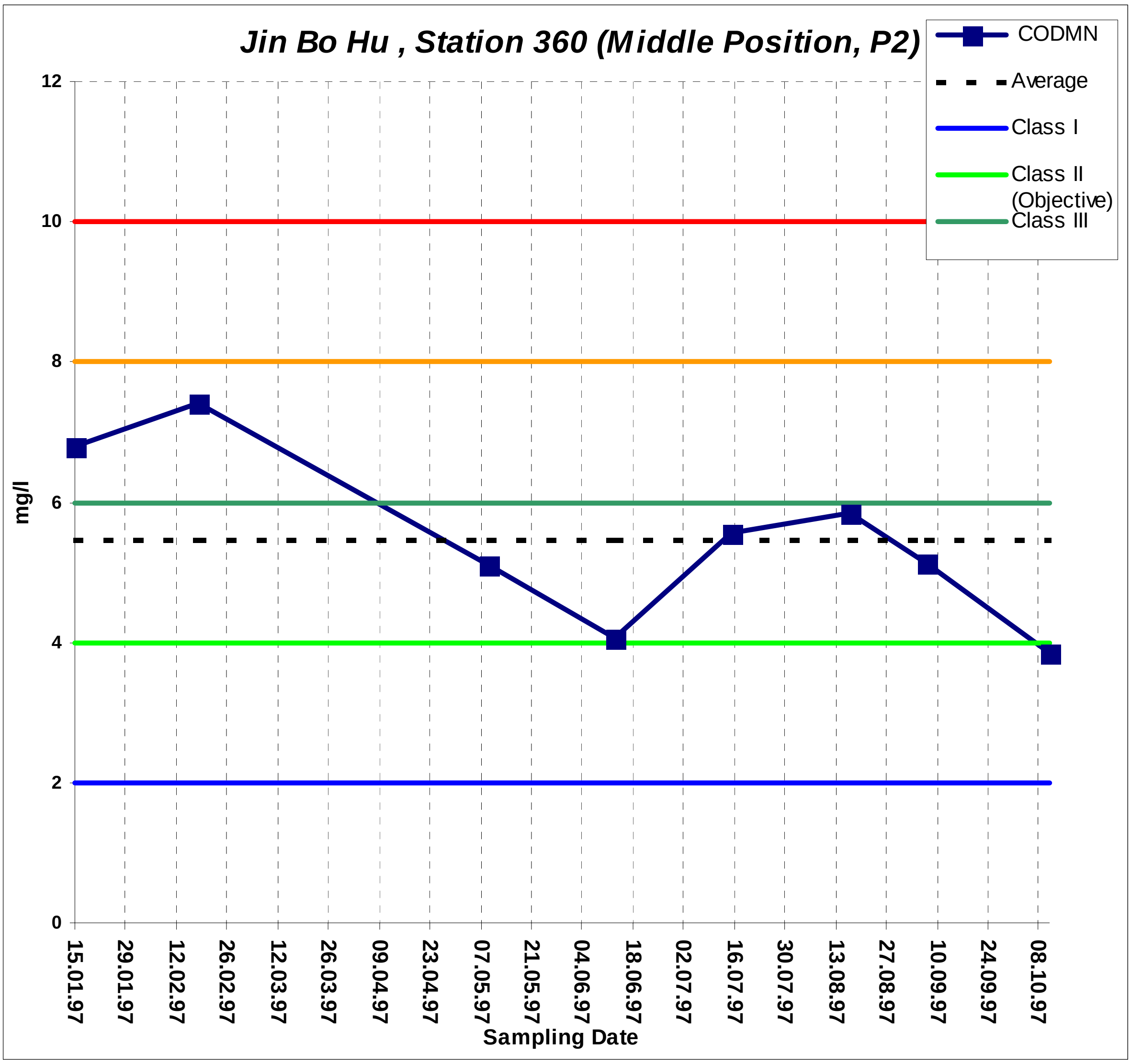

Figure 9: COD_{Mn} concentration at the Jin Bo Hu lake in 1997, Station 5, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for the lake

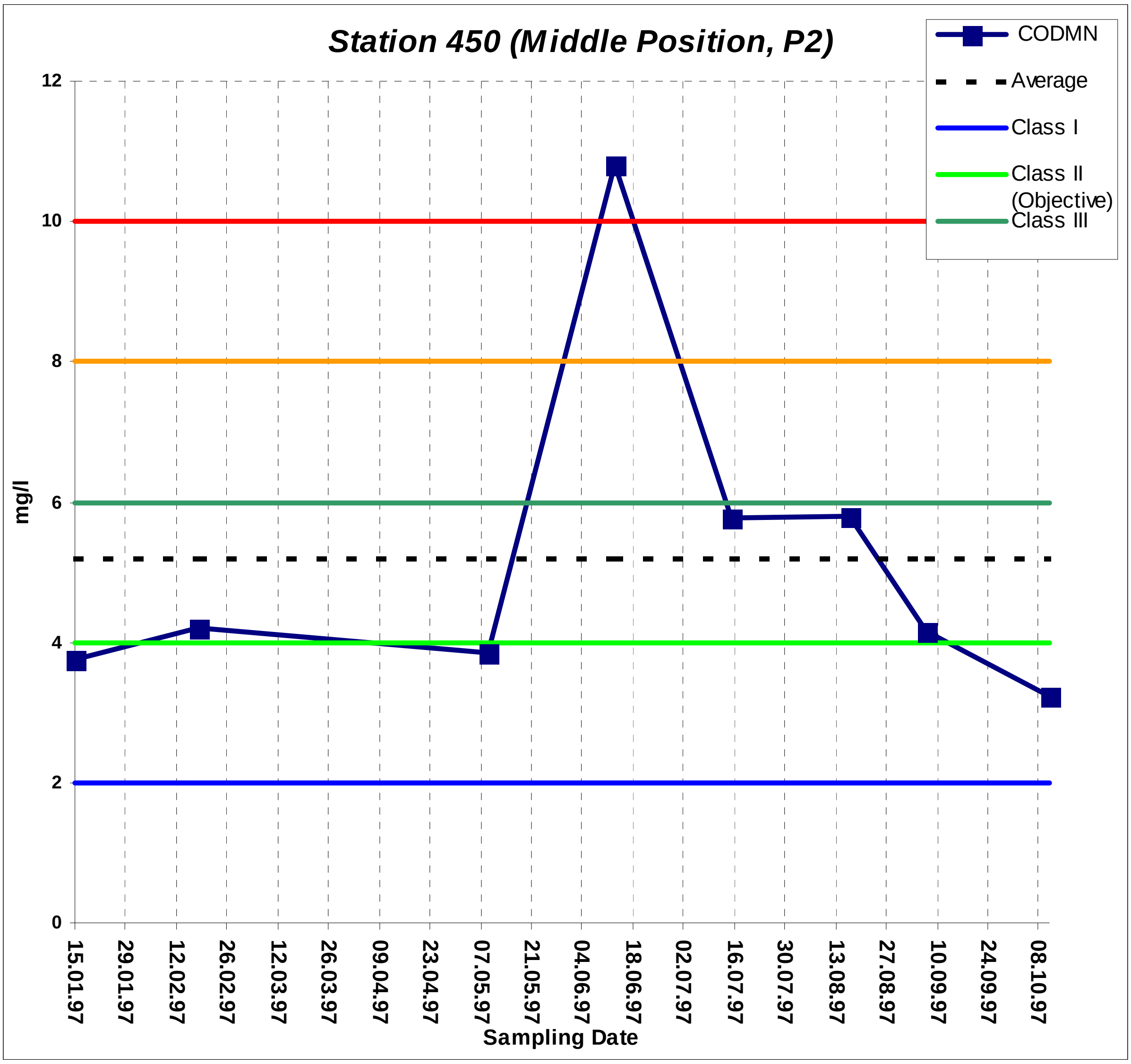

Figure 10: COD_{Mn} concentration at station 450, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for this river stretch

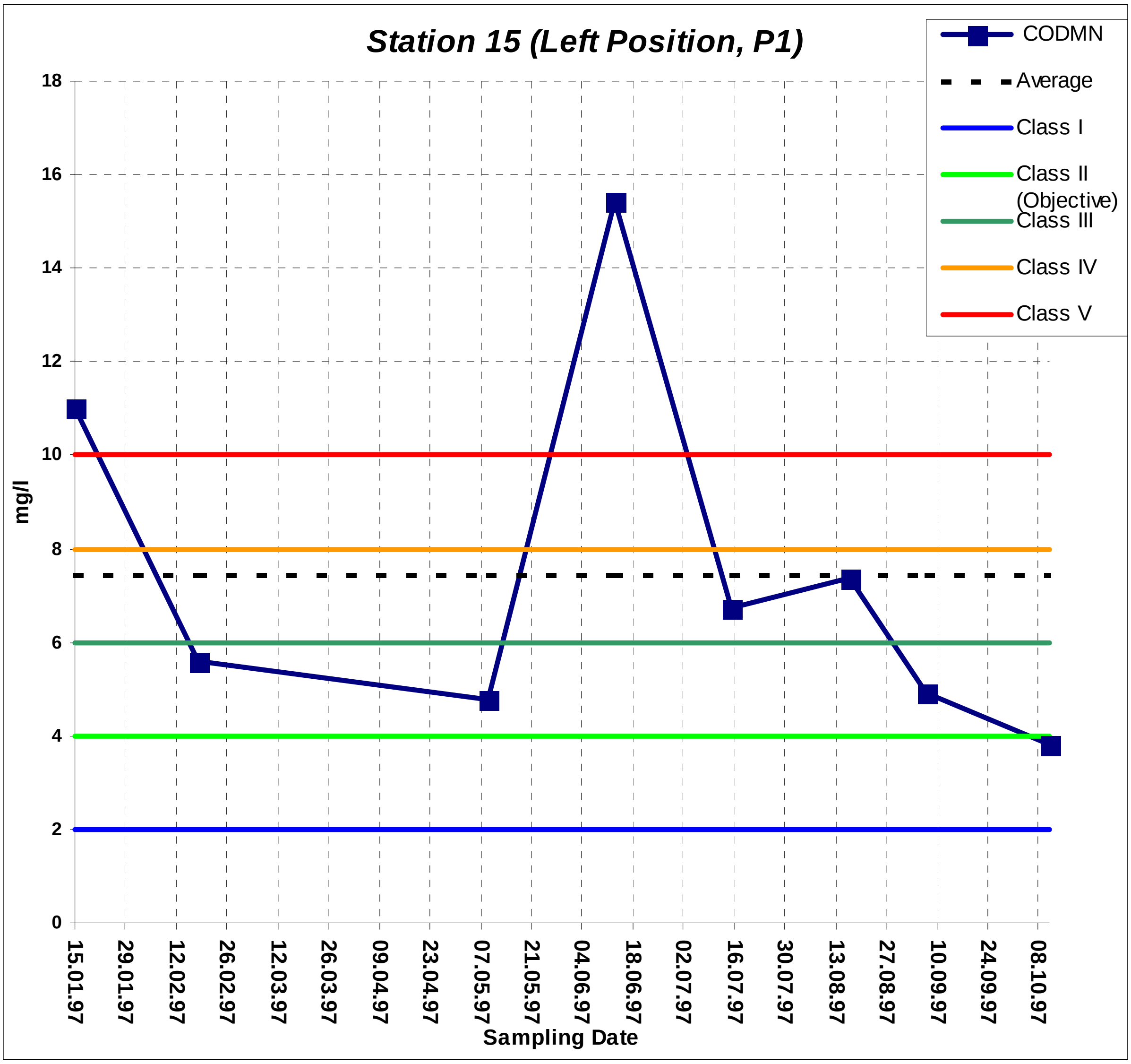

Figure 11: COD_{Mn} concentration at station 15, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for this river stretch

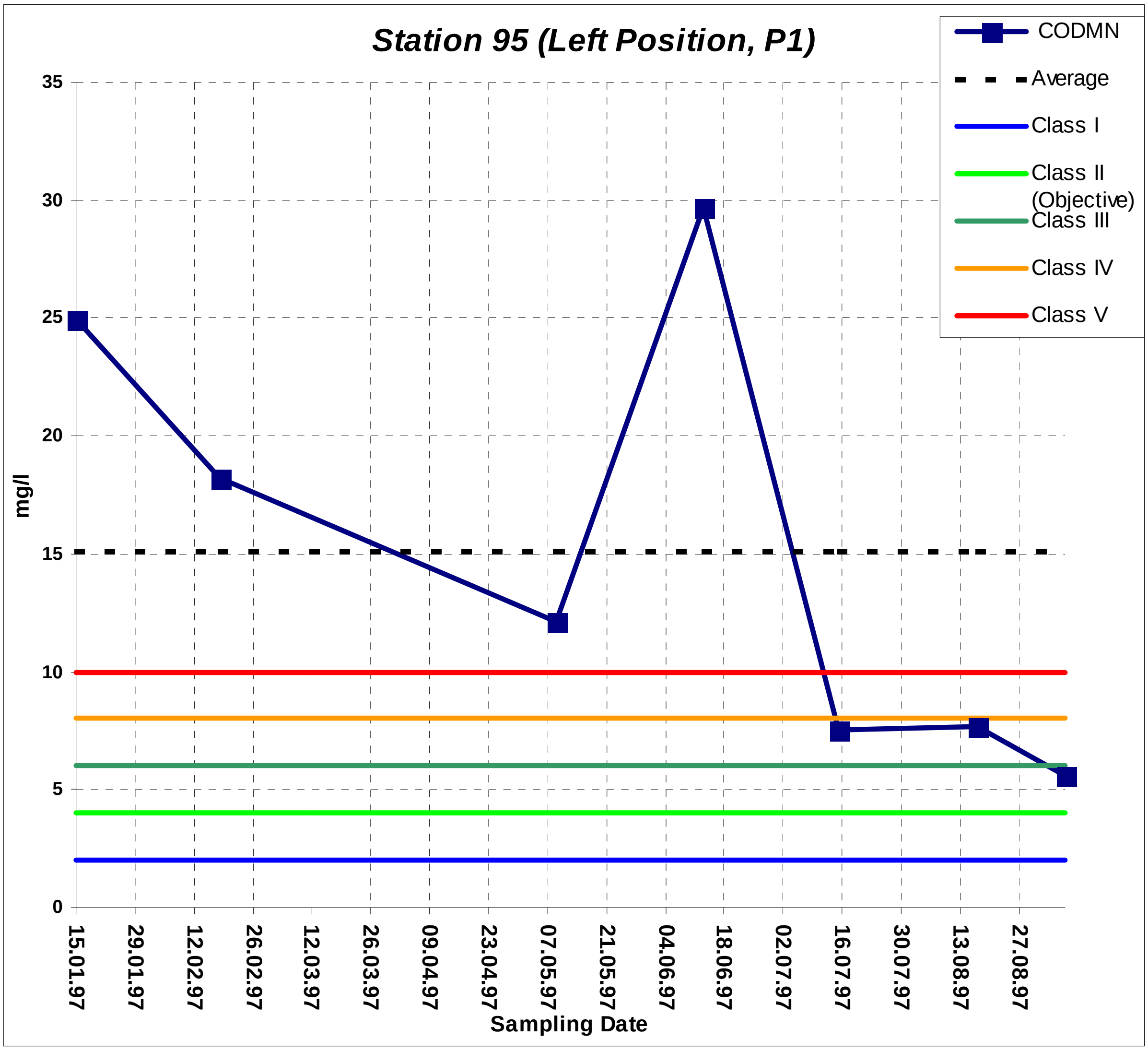

Figure 12: COD_{Mn} concentration at station 95, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for this river stretch

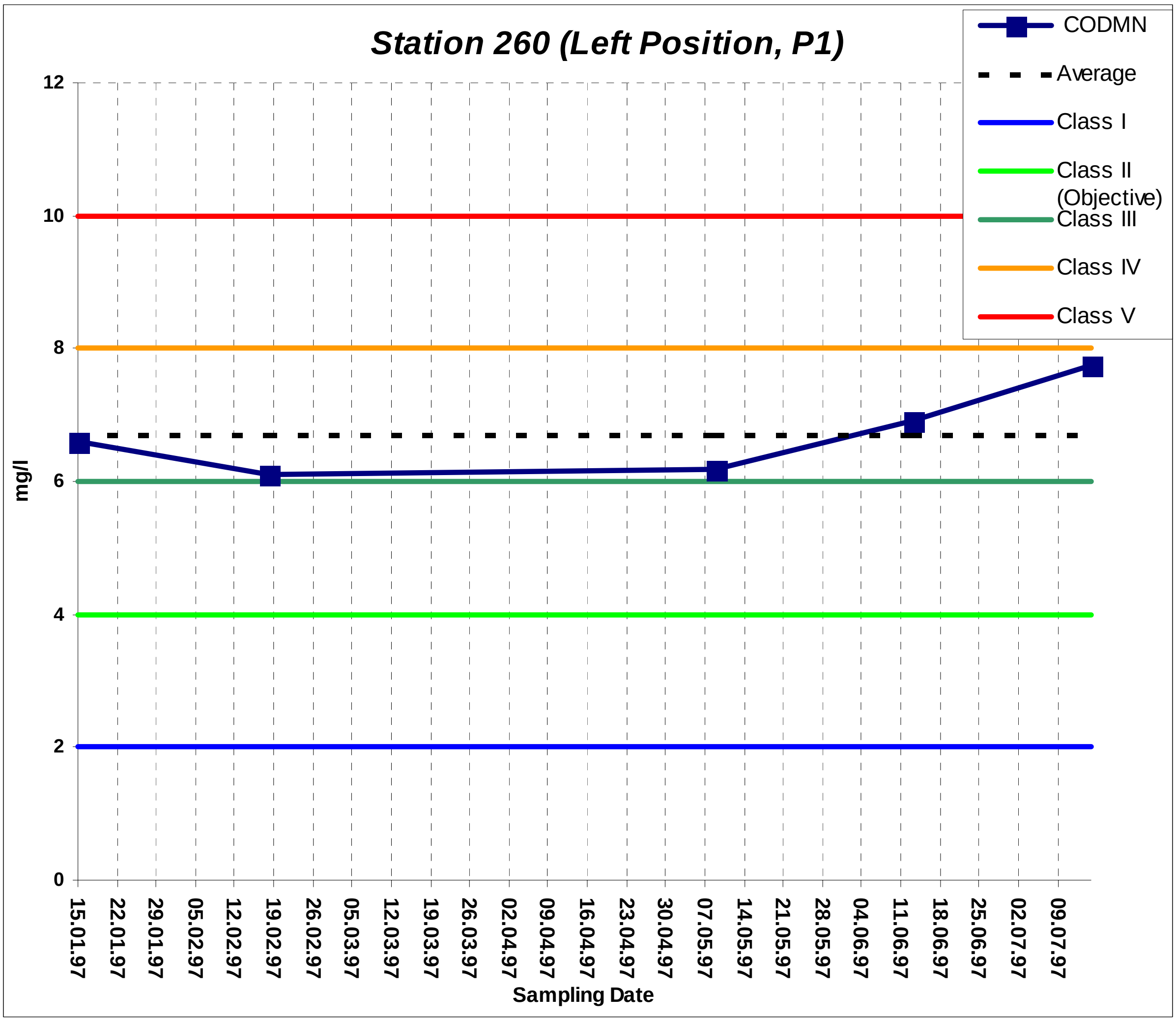

Figure 13: COD_{Mn} concentration at station 260, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for this river stretch

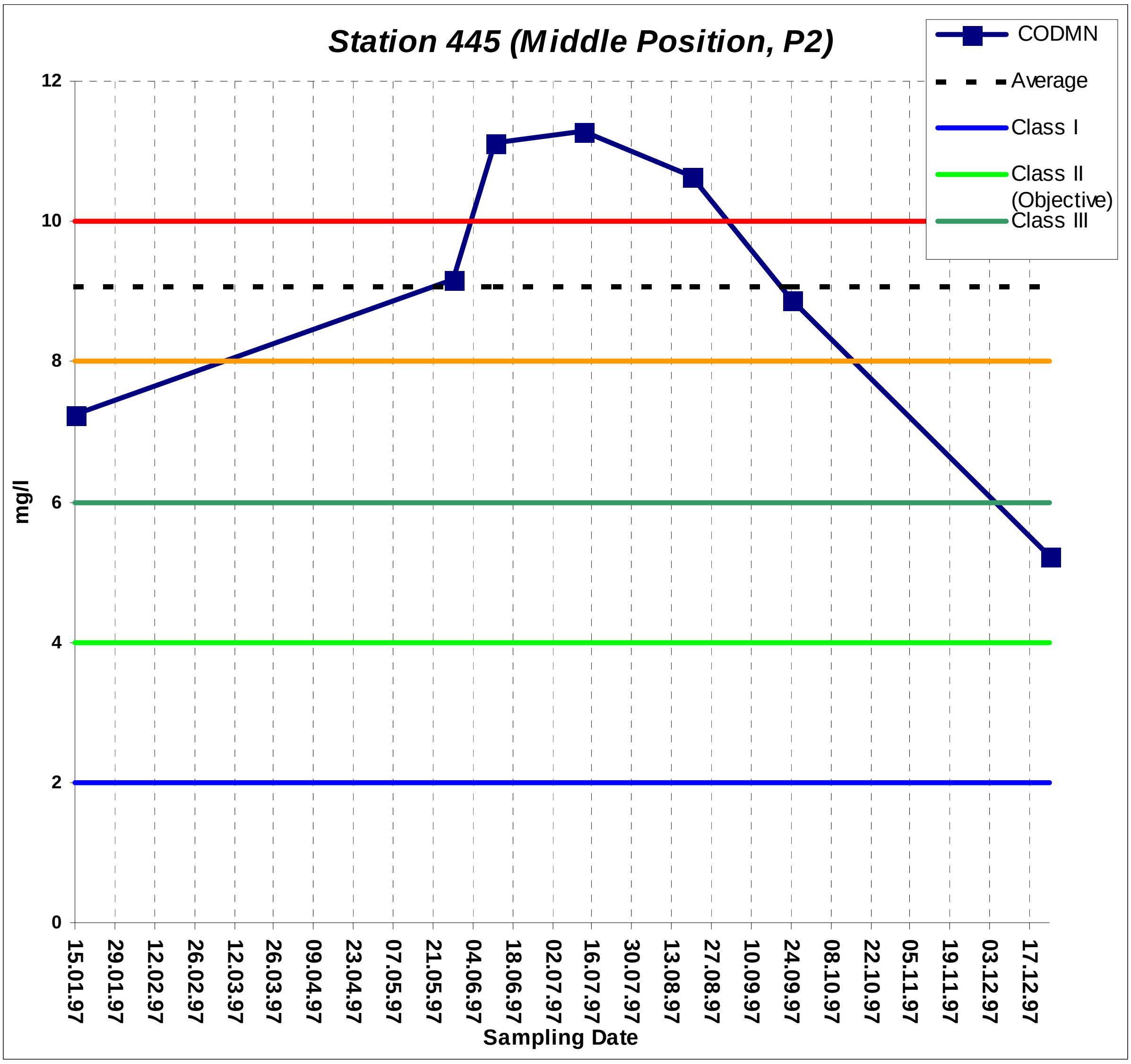

Figure 14: COD_{Mn} concentration at station 445, with the values from the five Chinese water classification classes indicated, as well as the concentration goal for this river stretch

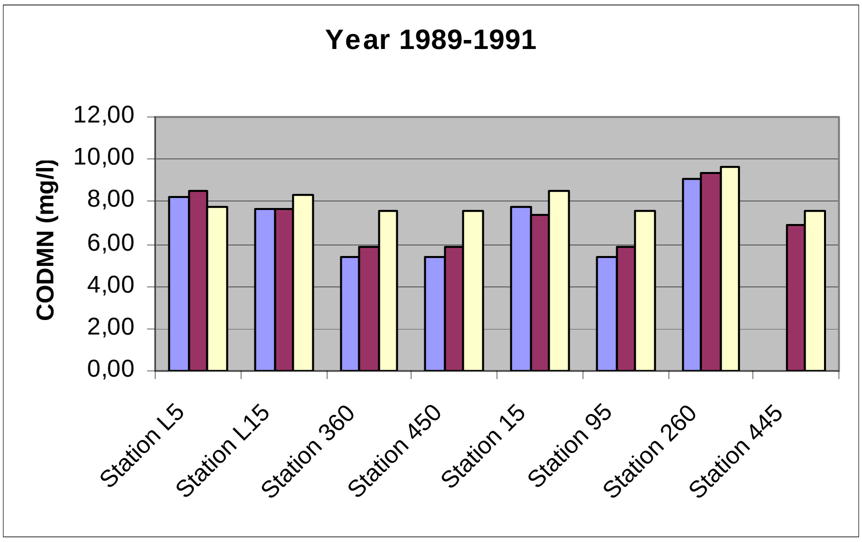

Figure 15: Yearly average COD_{Mn} concentrations for the period 1989-1991

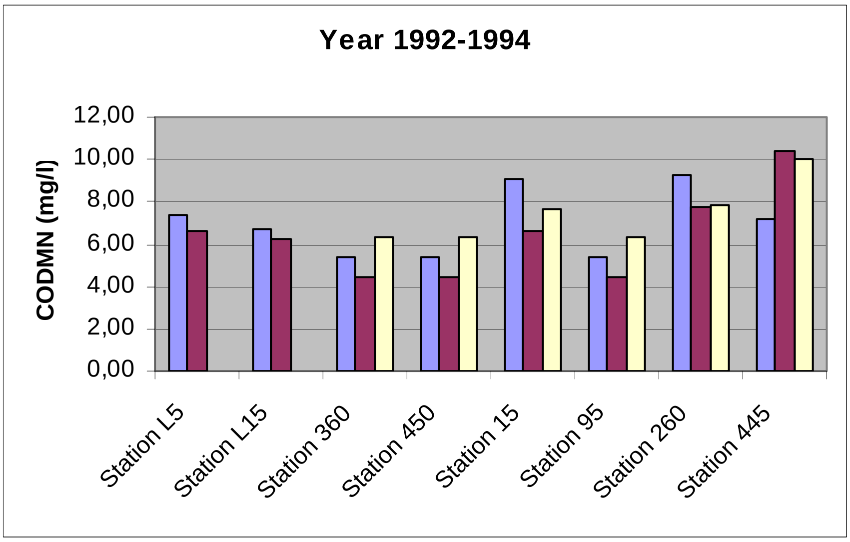

Figure 16: Yearly average COD_{Mn} concentrations for the period 1992-1994

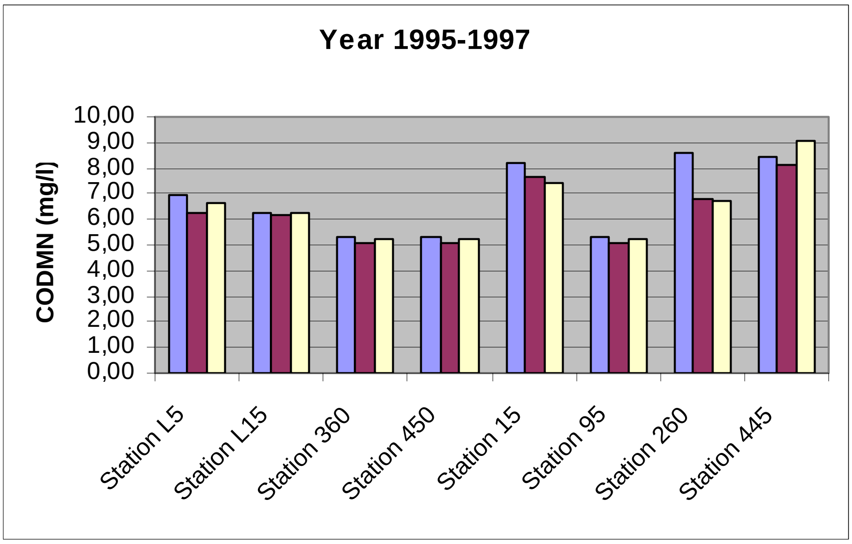

Figure 17: Yearly average COD_{Mn} concentrations for the period 1995-1997

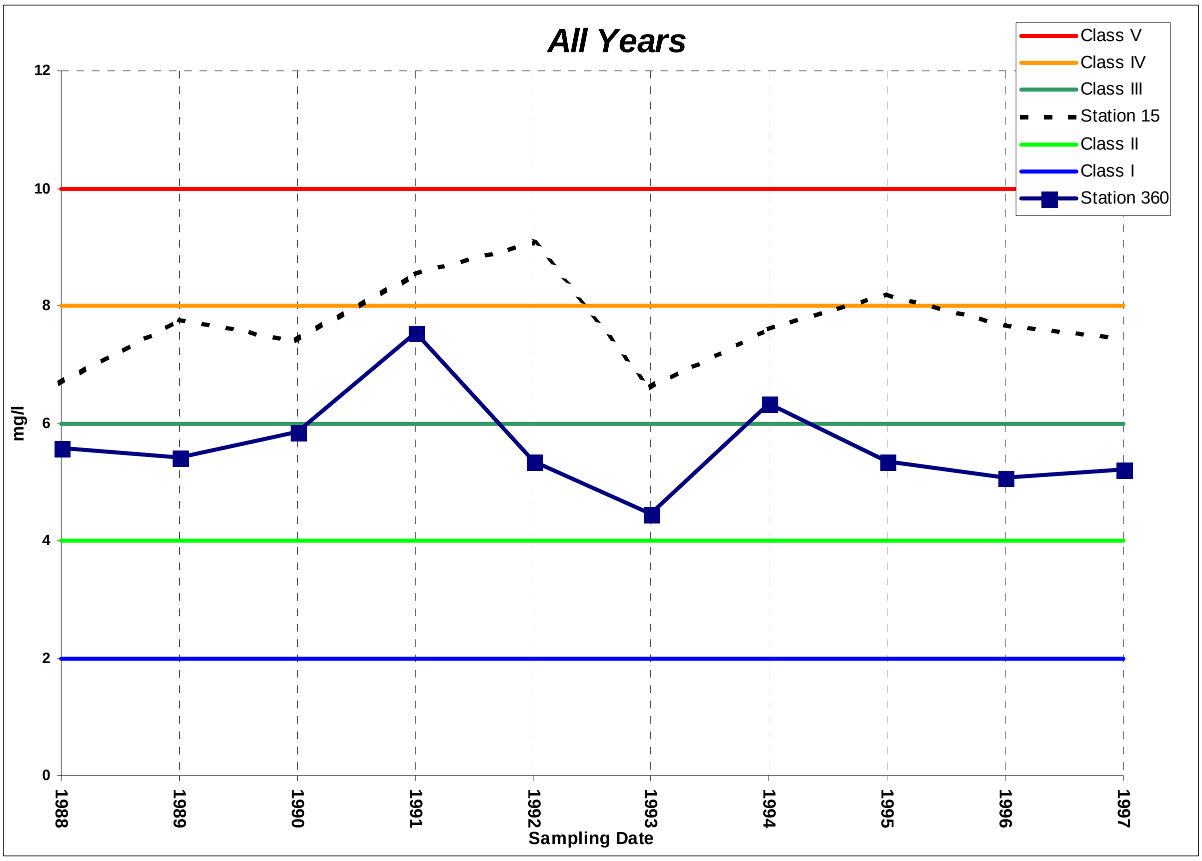

Figure 18: Yearly average of COD_{Mn} concentrations for stations 15 and 360 (Jin Bo Hu) for the period 1988-1997

5. Pollution sources

5.1 Industrial activities

5.1.1 General

There are 10 major industrial plants in the Mudanjiang river catchment with significant discharges to water of specific pollutants. The discharges from these plants represent about 80% of the total pollution load discharged to freshwater recipients. All these plants discharge currently their process and sanitary water directly to the Mudanjiang river or one of its tributaries (see Figure 7). The summary of industrial monitoring data is at section 2.

As regards measures already implemented to reduce the pollution load into the Mudanjiang river, a Fertilisation Control Plan is being applied and measures have been implemented related to small factories (shut down)

5.1.2 Pi Jiu chang

This brewery is located within the Mudanjiang city proper. It produces 150 000 tonnes of beer per year. The brewery discharges about 1650 tonnes/ day of wastewater into the Mudanjiang river (about 600 000 tonnes/year), with an average COD concentration of 1000 mg/l.

5.1.3 Zhao Zi chang

This pulp and paper mill is located the Mudanjiang city proper. On the basis of ’broad leave trees’, 14 000 tonnes of pulp and 25 000 tonnes of paper is being produced per year. The plant discharges 35 000 tonnes of wastewater per day into the Mudanjiang river, with a COD concentration of 5-800 mg/l and a concentration of suspended solids of 300-500 mg/l. The technology is currently based on chlorine bleaching.

5.1.4 Fa dian chang

This coal power plant is located the Mudanjiang city proper. About 1000 MW is being generated per year. 17 000 tonnes of cooling water is being discharged per hour into the nearby Mudanjiang river, but no ecological effects due to the temperature of the cooling water have been observed. Furthermore, it discharges sanitary water from 4000 people (1000 people staff and 3000 of family), with a COD concentration of 150 mg/l

There is a large number of minor sources, discharging about 20% of the total pollution load.

5.2 Waste water

The national criteria for wastewater are listed at Table 2 of Appendix B.

The basis for calculating the loads from wastewater is:

- A production coefficient for what one person discharges of phosphorus, nitrogen and organic matter per day
- The number of people connected to a sewerage system (or number of inhabitants multiplied adjusted for a percentage of people having water toilets)

An estimate of the number of people using public toilets, and how the waste is treated is also necessary.

More detailed information related to data collection and municipal wastewater:

- The Mudanjiang urban area has a sewerage system, but outside the urban areas, there is mostly no piping system
- It appears that there is no current practice in China as regards production coefficients for nutrients. European figures will therefore be applied. Suggested values are:
  N: 12.5 g /person/day
  P[1]: 1.7-2.5 g/person/day

5.3 Agriculture

Pollution from agriculture are often divided into two categories, diffuse pollution from runoff from the areas, and direct (point) sources from manure tanks etc.

The latter can be quantified on the background of the number of animals, type of animals, number of months a year they are inside the barn, and the type of manure tanks in use.

There is no information about the application of manure applied. The animal density (animal units per area) will therefor be used 'European figures' for run-off coefficients per crop type will be applied

The diffuse sources from the crop areas are more difficult to estimate. Soil losses are often calculated using a version of USLE (Universal Soil Loss Equation) calibrated for the conditions in the country or region in question. The equation takes into account the soil erodibility the slope length, the slope steepness and the cultivation system (crop type, fertiliser use)

Based on soil losses, losses of particulate P by surface run-off can be calculated when the P-content in soil is known and some enrichment is taken into account. Thus the soil losses calculated by USLE can be used as a basis for the calculation of P-losses.

The load from the agricultural areas can also be estimated on the basis of empirical data (monitoring data from different fields.

[1] Will depend on the extent of the use of P-containing detergents

6. Pollution load quantification

6.1 General

Apart from the information about discharges at source, retention considerations and monitoring in lakes and rives of chemical parameters, data on the water flow in the river are crucial for the quantification of the load of the various relevant parameters.

There are two hydrological stations in the Mudanjiang river. The available information is summarised in Table 6.

Table 6: Hydrological data for the Mudanjiang and Changjiangtun monitoring stations

Mudanjiang(14)						**Changjiangtun(15)**				
Year Month	1995	1996	1997	1998	Average for some years	1995	1996	1997	1998	Average for some years
1	47	55	21	38	57	71	49	141	92	56
2	33	42	8	44	57	50	43	155	89	52
3	45	35	39	60	59	64	48	199	83	68
4	66	110	233	107	109	153	115	166	48	209
5	139	231	329	142	152	226	216	257	87	275
6	161	165	603	119	226	244	161	320	184	351
7	171	285	135	334	294	254	296	296	262	417
8	359	987	351	434	427	431	885	77	214	680
9	212	225	238	369	277	320	30	68	370	404
10	133	140	79	164	149	273	16	69	137	220
11	80	109	42	141	97	146	9	74	193	125
12	42	46	9	55	66	55	36	96	129	76
Average/ annual	124	203	174	167	163	191	159	160	157	244

6.2 Sewage

'Households not connected to public sewerage systems' include both scattered dwellings and households within urban areas that are not connected. The diffuse anthropogenic nitrogen and phosphorus losses from households encompass the phosphorus and nitrogen losses from sanitary wastewater.

Technical solutions for treatment of wastewater from households not connected to sewerage are highly variable and the distance from the households to the inlet into surface waters will influence the quantity of the nitrogen and phosphorus losses into surface waters.

In many densely populated catchments in Europe, the quantity of wastewater from scattered dwellings is insignificant when compared with the discharge from wastewater treatment plants. However, these areas may have a significant portion of the households that are not connected to public sewerage. In addition, there are catchments with fewer infrastructures, where the proportion of the nitrogen and phosphorus losses from scattered dwellings may be relatively high. The procedures for quantifying the nitrogen and phosphorus losses from households not connected to sewerage are based on theoretical approximations, using national statistics. However, the situation is very different in China, where the construction of WWTPs has not come so far.

The nitrogen and phosphorus loss quantification should be based on average specific loss figures of nitrogen and phosphorus into water bodies, taking account the level of water consuming equipment, treatment methods, ways of discharge and distance from the water bodies.

Where there are flow data but no water quality data, the examples of typical water quality data in Table 7 may be used to estimate loads.

Table 7: Examples of typical water quality data in sewage

	SPM **(mg/l)**	**Total N** **(mg N/l)**	**Total P** **(mg P/l)**	**BOD** **(mg O/l)**
Crude sewage	350	55	15	*350*
Partially treated sewage	100	40	10	*100*
Treated sewage	30	30	7	*20*
Treated sewage with nutrient removal	10	8-10	0,5-1	*15*

Where only population data is available for estimating crude (untreated) sewage discharges, the following per capita loads based on the above water quality data and a flow of 180 1/person/day may be used to estimate nutrient load (less in China):

SPM	0,063 kg/person/day
Total N	0,009 kg N/person/day
Total P	0,0027 kg P/person/day
BOD	0,063 kg O/person/day

6.3 Total loads

Tables with loads of e.g. organic matter (expressed as COD), suspended solids, phosphorus and nitrogen discharged to different sections (sub-catchments) and sources should be developed in order to facilitate the choice of measures to be applied at the various points in the river catchment, e.g.:

Table 8: Possible summary tables per substance, source and river stretch/section

Sections	*Industry*	*Municipal Wastewater*	*Agriculture*
Upstream Jin Bo lake			
Jin Bo lake			
Mudanjiang (M.J.) river from Jin Bo lake to M.J. city proper			
Hailin river			
M.J. river from M.J. city proper to border of Harbin county			
M.J. river from border of Harbin county until it flows into the Songhua			
TOTAL			

6.4 Retention

Retention is, *inter alia*, a function of temperature, physical characteristics of rivers and lakes, such as residence time (lakes) and specific runoff, hydraulic load and bottom characteristics (rivers). Many of these parameters are difficult to measure, and therefore difficult to implement in calculation procedures. In general, nitrogen retention is more influenced by biological processes than the phosphorus retention, whereas the phosphorus retention is more influenced by sedimentation processes than the nitrogen retention.

Parameters influencing nitrogen and phosphorus retention are, *inter alia*, renewal time in lakes, input of nitrogen and phosphorus to freshwater systems, trophic level, oxygen condition, volumes of lakes, temperature, nitrogen fixation, general water chemistry, water vegetation and human activity in the catchment.

In most cases, nitrogen and phosphorus retention is quantified on the basis of the mass balance of investigated lakes and rivers. The different methods may be divided into the following categories:

- Models of nitrogen and phosphorus retention based, on the mass balances of river systems (including both rivers and lakes)
- Models of nitrogen and phosphorus retention based on mass balances of lakes and transformation of these findings related to the whole river system,
- In-situ measurements or other types of measurements that provide retention coefficients for nitrogen removal in streams and rivers.

The following factors are considered to be important when quantifying the retention of nitrogen and phosphorus in a river catchment:

- The portion of lakes, river stretches and wetland in each catchment;
- The hydrological and morphological conditions within the river system; and
- The development of retention coefficients or methods f6r both nitrogen and phosphorus should be based on national and/or international research on retention in different freshwater systems.

7. Water quality and objectives

7.1 Chinese water classification system

The water quality criteria adopted by P.R. of China (Environmental Standards for Surface Waters, GB 3838-88) divides the water quality into five categories (see also Appendix B, Table 1). The relevant categories for the Mudan Jiang catchment are categories II, III and IV.

Category I: Water resources and nationally protected water bodies.

Category II comprises water bodies that are “drinking water resource class 1 protection areas”, high value fish protection areas, spawning habitats for fish and shrimps”.

Category III comprises water bodies that are “ drinking water resource class 2 protection areas, general fish protection areas and swimming areas.

Category IV comprises water bodies that are “ for industrial and no human body touching recreational use”.

Category V comprises water bodies that are for “agricultural and general scenic amenity”.

7.2 Current water quality classification

According to Mudanjiang Environmental Authorities, the pollution due to organic matter is perceived as the main problem in the Mudanjiang river and its tributaries. It is shown by high values of COD.

In order to get a good picture of the organic matter problem in the river and the lake, the monitoring scheme in Table 9 could be applied:

Table 9: Proposed monitoring scheme to monitor organic matter in the Mudanjiang river

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.

7.3 Objectives for improving the water quality in the river

The goals for user interests are set by HEPB and thereafter approved by the Heilongjiang government. The Mudanjiang river is currently categorised as class 2 in the upper part, class 3 in the middle part and class 4 in the lower part (according to the Chinese National Water Classification System), see also Figure 18.

The current objectives concerning the water quality of the Mudanjiang are as follows:

- To reach water quality class II for the river stretch down to Mudanjiang city, including the Jin Bo Hu that has already water quality class II;
- To reach water quality class III for the river stretch from Mudanjiang city to Hailang gong, the site where the Mudanjiang river flows into the Song Hua Jiang,

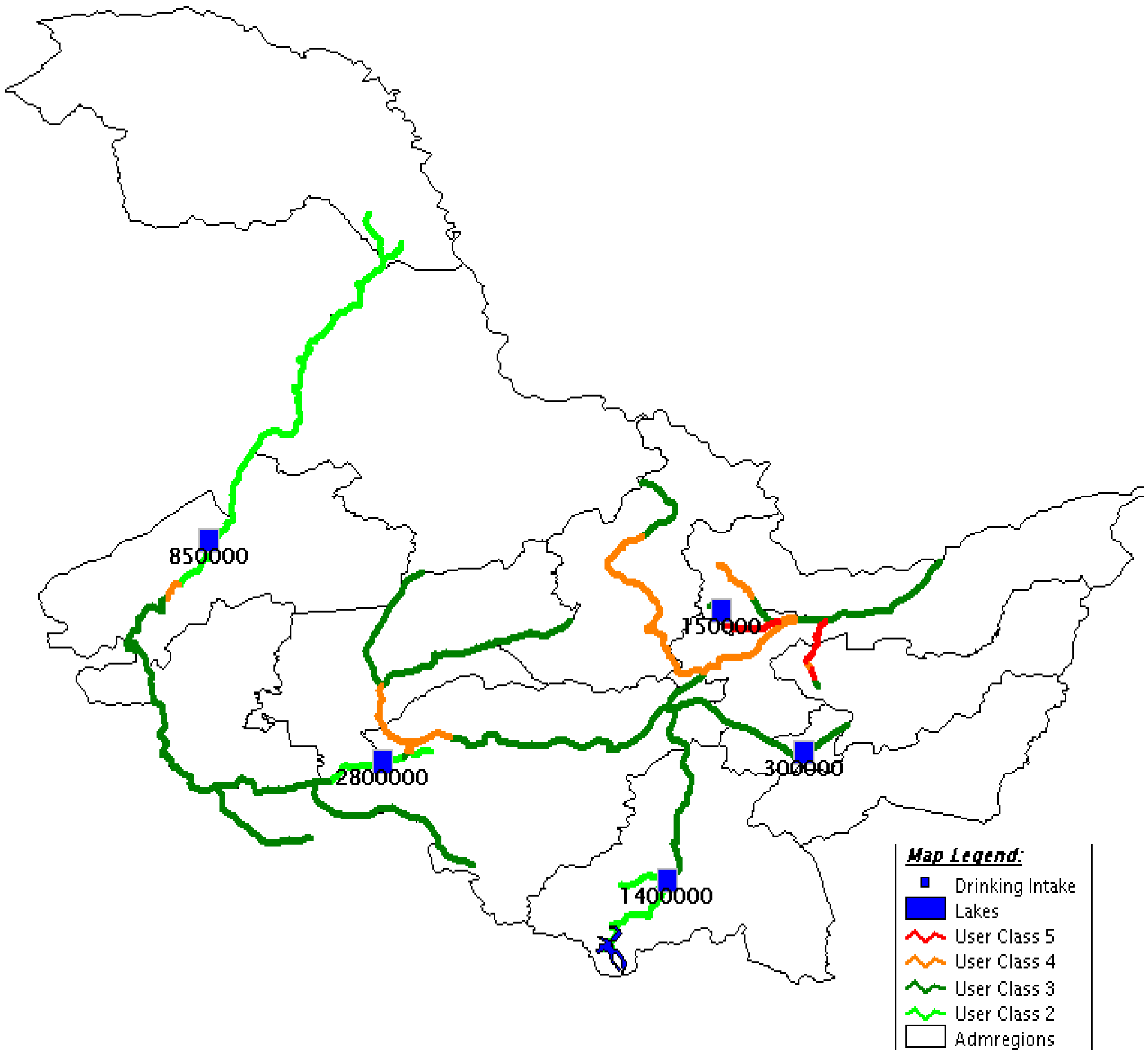

Figure 18: Number of p.e. connected to main drinking water supplies, with water quality goals, classified according to the Chinese Water Quality Classification System

7.4 Lessons learned and Recommendations

7.4.1 Lessons learned

It is important to take account cultural/linguistic issues when preparing for such a Sino-Norwegian a project. Elements to take account of are *i.a.*:

1. Preparatory work- set aside sufficient time prior to the actual project tasks are being addressed
2. Definition of objectives- mutual understanding
3. Linguistic aspects- working environment
4. Mapping of parties involved or to be involved
5. Data requirements- working procedures
6. Technical challenges

When planning a project it is important to have a common understanding of the task/the problems to be solved, and to clearly define the objectives of the project. It is easy to be trapped by different understandings of the defined tasks. The linguistic related potential problems should not be neglected, as they concern not only the direct communication between the involved scientific people, but also the foreign people's access to the necessary documentation. The availability of highly competent interpreters and translators is therefore an issue that should be given priority in any future projects.

There may also be differences in data availability, restrictions on documents that from the onset may appear strange to a foreign party.

It is important to establish a good dialogue between the scientific environment and local and regional decision-makers. It may happen that there are more 'interested' parties in the project than it appears from the onset of the project. It is therefore important to make a thorough survey of potentially interested parties at an early stage. This will benefit the project to a large extent.

It should also be borne in mind that the growing public awareness towards environmental issues may require the taking into account of 'user interests as regards the water bodies involved.

Reliable and sufficient background (historical) information is of importance. The data compilation phase should therefore be carried out carefully. The holistic approach as regards data collection and compilation when dealing with abatement strategies for example (consider all sources of the environmental problem identified, take account of all user interests) may still appear 'strange' to some communities. It is important to explain why the data is necessary, i.e. for which purpose, how will the data be used. The value of such a project is therefore not only result-based, but also very much related to the principles and methods applied.

NIVA considers such bilateral projects between China and Norway to be stimulating both with regard to the technical and scientific challenges, and the social aspects. When such projects are carried out on the basis of good preparatory work, with the knowledge that not only the working methods may be different, but also the socio-economic background may vary considerably, they are highly recommended and likely to be beneficial for all parties.

An early awareness of possible/potential cultural and/or technical problems is of utmost importance. The preparatory phase should be carefully and thoroughly carried out-a successful project may be decided at that stage, during such preparations It is necessary to be prepared to revise the objectives during the project period due to unforeseen events; however good preparatory work will reduce the risk for this happening. It is important to ensure that the Chinese partners have acquired necessary knowledge/skills of any equipment/procedures/methods required to make use of the results of the project after the finalisation of co-operation project. An inception meeting with all parties involved should be held in order to provide parties with a feeling of 'ownership' in the project

7.4.2 General recommendations

Due to a lack of data for many of the main aspects of a completely developed Abatement Strategy, it is necessary to pursue the work on data collection. This concerns both the collection of background data (e.g. from agricultural activities) and monitoring data (industry and river/lake monitoring) in order to establish a sufficiently complete pollution load for the Mudanjiang river catchment and the sub-catchments. On the basis of this pollution load quantification, and the local/regional/national water quality goals (that take user interest into account), it will be possible to quantify the reductions necessary to reach the set goals. In detail, this means:

1. It is recommended that the classification in water quality criteria take account of the suitability of the water for different uses, such as swimming, fishing, irrigation and drinking.

2. In areas or situations where unsatisfactory conditions have been identified**,** an action plan for mitigation should be suggested. The plan should be developed in harmony with any national/regional/local environmental goals for the areas in question. Relevant international guidelines on mitigation measures should be addressed.

3. A plan for generating supplementary information should be developed for areas where the existing information is insufficient to describe the environmental conditions, or to form the basis for development of remedial actions. This concerns for example:

- More information about discharges from a higher number of industrial plants
- Additional information about domestic wastewater (e.g. discharges points from cities, scattered dwellings)
- Diffuse losses of organic matter
- In areas where preventive or mitigating actions are to be conducted, a plan for monitoring the effects of such actions should be developed.

4. Total phosphorus should be included in the regular monitoring programme. This could be particularly important for studies to be undertaken at the Jin Bo Hu that clearly has a eutrophication problem with regular algal-blooms (blue-green algae?).

5. Upgrading of laboratory performances to international standards of analytical quality and sensitivity should be carried out, wherever necessary; possibly on the basis of results of already carried out (NIVA exercise) and new intercomparison exercises.

6. A dialogue should be launched between province authorities (catchment based approach) to advise environmental authorities on strategies for the management of water resources based on the above-mentioned principles. Advice should be given on how to organise the planning process and how to prepare cost-effective pollution abatement strategies.

7. The abatement plan should be catchment based.

7.4.3 Monitoring

General

8. Sampling site choice: The site should be an area where the water is well mixed (such as at or immediately downstream of a weir) and hence of uniform quality. Otherwise it would be necessary to establish the relationship between the concentration at the sampling point and at a representative number of sampling points over the whole river cross section (established by weighting the concentrations at each sampling point by the volume of water per unit time at that point).

7.4.4 Industry

9. Ideally, all industrial plants that discharge polluting substances should have a monitoring programme. Practically it is necessary to ensure that at least the most important industrial plants as regards the substances of concern have an adequate monitoring programme. Practical difficulties will arise when there are small plants with small discharges. It will therefore, in many cases, be necessary to agree on a 'discharge limit figure' for the purpose of distinguishing between significant and less significant annual discharges. The ultimate aim is that the catchment/national figures should provide comparable and transparent reports, and that the reported figures are as complete as practically possible.

9. The sampling strategy should, for each plant and sector, be sufficient to ensure a reliable quantification of the total discharges of the substances of concern. Where the production and/or wastewater discharges vary significantly over the year, the sampling frequency and methods of assessment should be adjusted correspondingly.

7.4.5 Wastewater

10. Monitoring should be carried out (for larger plants) or theoretical quantification, in the case of smaller plants. Scenarios on population pattern/number e.g. for 2010-2020 should be made in support for abatement strategies.

11. Ensure that national statistics are sufficient to enable the quantification of losses from households not connected to treatment plants. The national statistics should be as up to date as possible, providing information on:

- The number of households not connected to sewerage systems; and of
- The number of people living in the households, taking account the 'part of the year inhabitants' (e.g. offices, shops, hotels, tourist accommodations and secondary houses).

12. General statistics should provide information about:

- The waste-water treatment methods and water consuming devices in the households; and
- Location of the households in relation to watercourses (if available) and soil conditions (the part of the load actually reaches the surface waters).

7.4.6 Diffuse sources

13. Spatially accurate land cover and/or land use data is a prerequisite for assessing diffuse losses of nitrogen and phosphorus to surface waters. Land cover data, from for example satellite imagery, identifies areas of forest, grass and arable land, although satellite imagery has limitations because it is not possible to discriminate whether grassland belongs to agricultural land or amenities. Land use data from, for example national census, provides a more detailed classification of the nature of agricultural

practices (e.g. stocking density, areas of different arable crops). This level of detail can be important as for example diffuse N and P losses may vary with arable crop type.

User interests

14. It is necessary to further develop a user interest map" (swimming, fishing, irrigation, others) for all rivers and the main lakes.

15. To carry out an evaluation on whether the main uses of the various water bodies are possible on the basis of the current water quality.

8. Implemented or planned measures

8.1 Effect of measures

8.2 Three WWTPs to be constructed

8.2.1 Mudanjiang city

A wastewater treatment plant for the city is under construction. It will have a capacity of 100 000 tonnes of sewage/day (domestic (25%) and industrial sewage (75%)). It is planned that 75 % of the discharges from industrial plants in Mudanjiang will be connected to the wastewater treatment plant and 25 % of the households in Mudanjiang will be connected.

8.2.2 Hai Lin city

A wastewater treatment plant for the city is under construction. It will have a capacity of 30 000 tonnes/day (domestic and industrial sewage). It is planned that 60% of the discharges from industrial plants in Hai lin city will be connected to the wastewater treatment plant and 40 % of the households in Hai lin city will be connected.

8.2.3 Ning jan

A wastewater treatment plant for the city is under construction. It will have a capacity of 30 000 tonnes/day) (domestic and industrial sewage). It is planned that 60% of the discharges from industrial plants in Nin jan city will be connected to the wastewater treatment plant and 40 % of the households in Ninjan city will be connected.

8.3 Pulp and paper mill

There is a proposal to improve the technology applied at the Chai He paperboard mill (10 July 1998).

The Zhao zi chang pulp and paper plant in Mudanjiang city proper. The technology is currently based on chlorine bleaching, but will move to ozone bleaching by the year 2000. An internal treatment plant is being built and, when it is operation by the year 2000, the COD concentration in the wastewater will be reduced to 350 mg/l and the concentration of suspended solids to 200 mg/l.

8.4 The Pi Jiu chang brewery

The brewery is located in the Mudanjiang city proper. When the planned municipal wastewater treatment plant in Mudanjiang is operational, the wastewater will be connected to that plant.

9. Possible measures to be undertaken to reach the set objectives

Below are listed some large-scale measures to be implemented in order to improve the water quality of surface waters in the Mudanjiang river catchment. It is important to ensure that the identification of 'what are the main problems in the catchment' has been carried out taking all main user interests into account. This identification will determine which substances represent the main problems, and thereby also which parameters should be monitored. It is therefore also important to identify the most important sources for the identified water related problem.

The next steps in the abatement strategy planning will be to make the list more exhaustive, to prioritise amongst the possible measures (cost-effectiveness analysis) and to propose timetables for implementing the selected measures.

Municipal wastewater treatment plants
It is evident that the construction of a sufficient number of wastewater treatment plants in the Mudanjiang catchment is of utmost importance. This in order to reach the water quality goals set by HEPB and thereby improve the possibilities for the public to take advantage of the river/lake for swimming/fishing/irrigation to a much larger extent.

It is also important to develop detailed plans for connecting industrial plants to the said wastewater treatment plants to be constructed.

Treatment of industrial wastewater on-site
An additional measure to be undertaken is improved process water treatment at many of the most polluting industries in the catchment.

Industrial sources
It is important to get as more complete picture of the industrial discharges that contribute to the identified main environmental problems in the watershed, i.e. effects of a high the organic load

Diffuse sources
It is important to get as more complete picture of the diffuse losses that contribute to the identified main environmental problems in the watershed, i.e. effects of a high the organic load

10. Proposed future project activities

10.1 Objectives

Improve the water quality of the identified main water bodies in the Mudanjiang watershed by means of better field and 'in-house' equipment, improved monitoring performance, improved laboratory performance, improved knowledge of user interests, improved knowledge of the actual environmental problems in the catchment, improved implementation of cost-effective measures.

10.2 Equipment

A number of chemical/biological instruments could be purchased (according to a priority list) in order to improve performance both at provincial and central environmental monitoring centres. The prioritisation should be made on the basis of 'which instruments are needed to efficiently control and facilitate the main aquatic problems in the catchment', i.e. per today organic matter.

10.3 Jing Bo Hu

It would be very important to intensify the studies of the nutrient-rich in Jing Bo Hu. The size and importance of this lake clearly shows that it should be given high priority in future project developments. The lake faces repeated annual algal blooms, and there are several important issues to be further developed, such as:

- A complete input-output budget of the lake with regard to nutrients and organic matter
- Inventory of sources of nutrients and organic matter
- Plans for 'inter-provincial' co-operation on a catchment scale
- Biological monitoring, i.e. chlorophyll concentrations, phytoplankton biomass, algae species studies (toxins, identification of species' succession)
- User interests
- Development of list of possible measures to improve the water quality
- Cost-effectiveness analysis of measures

Wastewater treatment

Provide a detailed plan of construction and investment for the treatment of domestic and industrial wastewater in the Mudanjiang river catchment.

11. Literature

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Appendix A. ENSIS

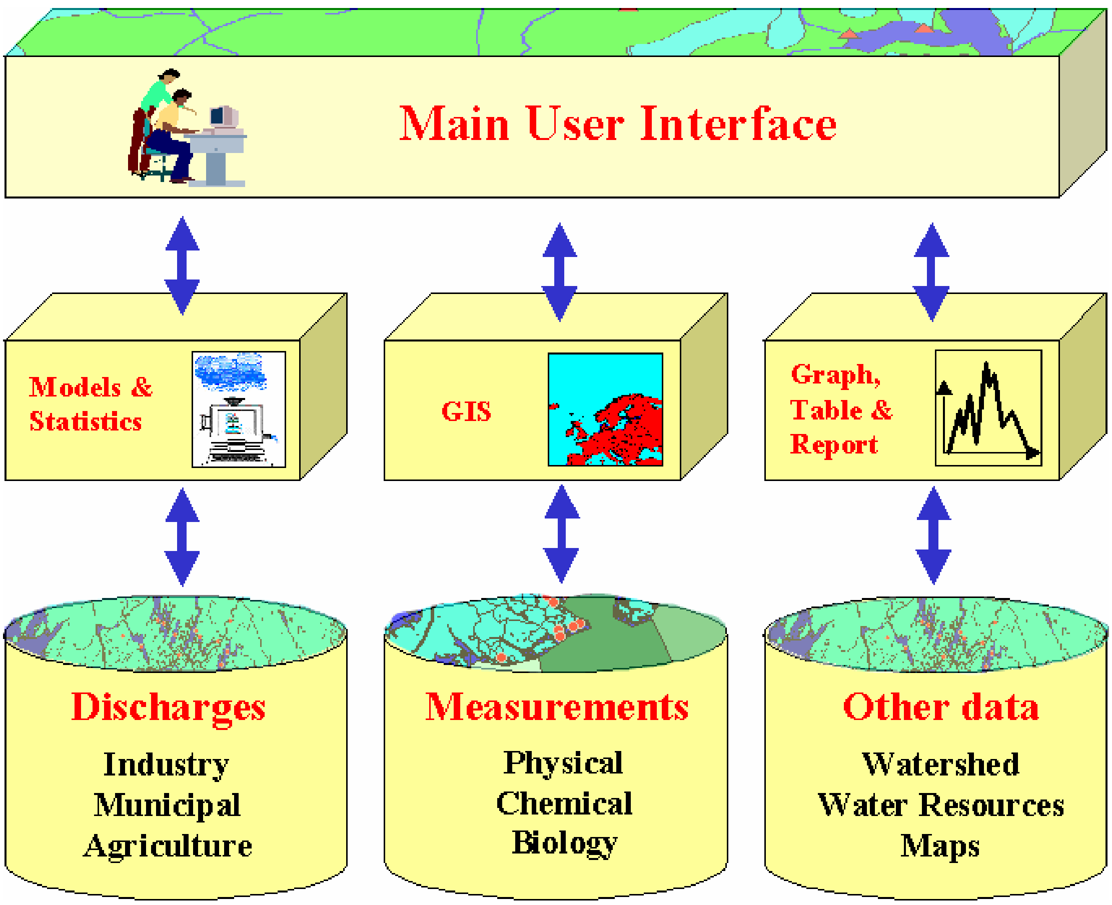
ENSIS

An Environmental Surveillance and Information System

What is ENSIS?

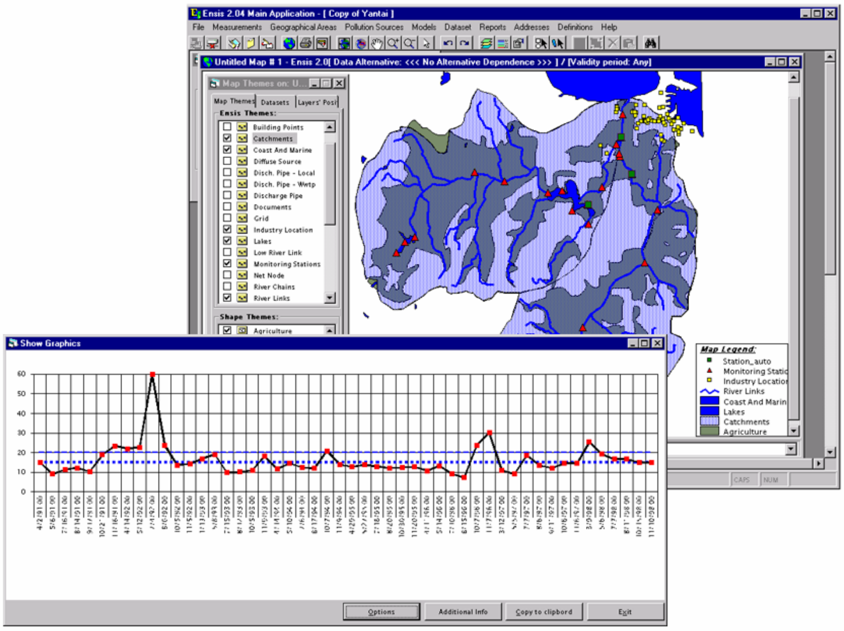
ENSIS consists of ENSIS WaterQuis, ENSIS Airquis, and a basic module. ENSIS WaterQUIS is a management and decision support system for the environmental protection of water resources. WaterQUIS provides a geographic information system interface (GIS) for the integration and display of water quality monitoring and modelling results. The system can be used as a management tool for planners, an information tool for the public and an expert system for specialists.

ENSIS AirQuis is a similar tool, and can provide information on the air quality in an area and the pollution levels to which the population is exposed.



ENSIS is developed as a joint co-operation between the Norwegian Institute for Water Research (NIVA), the Norwegian Institute for Air Research (NILU) and the IT-company Norgit.

Geographical Information System (GIS)
The geographical information system (GIS) is a major part of ENSIS. All geographical defined elements such as monitoring stations, wastewater treatment plants, industries, rivers, lakes, coastal areas can be created, selected, inspected and edited through the GIS interface. The elements displayed through GIS are all directly connected to standard registration dialogues where data are entered and edited. The registration forms can also be reached via the pull-down menu system.



The ENSIS database
The ENSIS database is prepared to receive and store a wide range of environmental information, such as monitoring data to asses the status of the environment, data about the pollution sources that causes pressure to human beings and the environment, and information related to the water resources. Search for data can be done through the GIS interface or by using alphanumerical criteria available from standard graphical forms. Search criteria are tailor-made for the type of data in question, and can for instance be geographical location, measured component, time period for the measurements, or type of industry.

ENSIS on the Web
A web-interface to the ENSIS database has been developed. This gives the general public access to information about environmental quality via the World Wide Web. It will enhance public awareness of environmental issues, and increase the participation in the decision-making process.

Thin client technology
ENSIS can also be used as a central database solution with use of "thin client" technology. This allows sharing of data, and all the built-in tools in ENSIS, over long distances, even though the network capabilities might be limited.

Features of ENSIS Basic and ENSIS WaterQuis

Features of ENSIS Basic
Geographical information system (GIS) Description and registration of monitoring data Storage of physical and chemical data Manual data acquisition system Automatically data acquisition system Import and export from/to external data sources Search of data by geographical and numerical criteria Graphical presentation of data Numerical presentation of data Statistical processing of data Tools for quality control of data Report generator System for document handling and storage of images ENSIS accessible with use of Thin client technology Access to the ENSIS database via World Wide Web

Features of WaterQUIS
Definition and registration of information and data about catchments, rivers and lakes Definition and registration of coastal information Registration of discharge from domestic waste water Registration of discharge from industry Registration of pollution from diffuse sources Environmental classification system for water quality Model for calculation of pollution load

Technical Highlights
The ENSIS software is running on Windows NT platform, and is developed for an Oracle database. The GIS is programmed with MapObjects from ESRI, which makes it compatible with ArcView and ArcInfo.

Appendix B. Summary of the Chinese Water Classification System

Table 1. National Water Quality Criteria for Surface Waters[2]
Unit: mg/ if not stated otherwise

Class Parameter	1	2	3	4	5
Total –P	0,02	0,1	0,1	0,2	0,2
COD_{Cr}	15	15	15	20	25
COD_{Mn}	2	4	6	8	10
BOD_5	3	3	4	6	10
Total Kjeldal N	0,5	0,5	1	1	2
Nitrate	10	10	20	20	25
Nitrite	0,06	0,1	0,15	1,0	1,0
Ammonia	0,02	0,02	0,02	0,2	0,2
DO	90%	6	5	3	2
T. Coliforme Bacteria			10 000		
Cadmium	0,001	0,005	0,005	0,005	0,01
Chromium $^{+VI}$	0,01	0,05	0,05	0 ,05	0,1
Lead	0,01	0,05	0,05	0,05	0,1
Mercury	0,00005	0,00005	0,0001	0,001	0,001
Dissolved iron	0,3	0,3	0,5	0,5	1,0
Phenols	0,002	0,002	0,005	0,01	0,1
Oil	0,05	0,05	0,05	0,5	1,0

Table 2. National criteria for waste water

Chemical parameter	**Class I (mg/l)**		**Class 2 (mg/l)**		**Class III (mg/l)**
	New	Current	New	Current	
pH	6-9	6-9	6-9	6-9	
BOD_5	30	60	60	80	300
Oil	10	15	10	20	30
Ammonia	15	25	25	40	-
COD_{Cr}	100	150	150	200	500
Phosphorus	0,5	1,0	1,0	2,0	-

The concentrations represent the maximum concentrations of the specific pollutants for discharges to water.
'New' means new factories or reconstructed factories.

[2] Only parameters that may be of relevance for the Mudanjiang river catchment are listed.

Appendix C. Norwegian Water Classification System[3]

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.

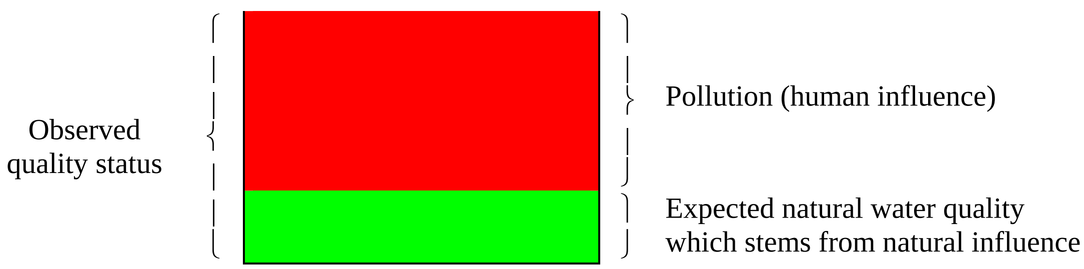
System structure and limitations

Table 1 shows the classification of environmental *quality status* and *suitability* related to adequate usage of the watercourse.

Table 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.



[3] *This section is based on* SFT-guideline 97:04, ISBN 82-7655-368-0

Figure 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 south-eastern part of Norway.

Table 2: *A typical shallow lake in the south-eastern 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 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 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 4 shows the classification of the water *quality status*. The key parameters are listed in Italics.

Table 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

Appendix D. Intercomparison results

The Analytical Results (2000, HEMCS)

Item	Sample	Concentration	Method
pH	B	5.76	Glass electrode method
	D	5.36	
Ammonium-nitrogen (mg/L)	B	0.025	Nessler's reagent colorimetric
	D	0.558	
Total Phosphorous (mg/L)	B	0.047	Nitrogen-alkaline potassium persulfate spectrophotometric method with stannous chloride
	C	0.268	
COD_{Mn} (mg/L)	B	2.47	Acid potassium permanganate
	D	7.16	
Conductivity (ms/m)	B	2.30	Conductivity gauge method
	D	3.90	
Nitrate (mg/L)	B	0.05	Spectrophotometric method with phenol disulfonic acid
	C	1.28	
Sulphate (mg/L)	B	<0.1	IC
	D	<0.1	
Chloride (mg/L)	B	0.271	IC
	D	1.151	

After the report on the intercomaprison exercise was finished, Ms Chen Aifeng realised there were some mistakes in the results sent to NIVA, and used as basis for the report. On 2000/8/21 the following mail was sent to Norwegian experts to correct the analytical results:

"Mr. Havard Hovind,

I have received the report on the intercomparison of chemical analyses, 1999, between four laboratories in China and NIVA Norway. I am the laboratory no.3. There are some mistakes in the results of analyses I wrote to you before. I correct the mistakes to be right, now.

1.There are mistakes on the instruments the results of conductivity are not right. The results are blank out.

2.There are mistakes with the calculation of COD, the right results are 0.25 mg/l (sample B) and 0.72 mg/l (sample D).

3.It's the right results of nitrate, 0.765 mg/l (sample C) with IC method, and 0.75 mg/l (sample C) and 1.28 mg/l (sample D) with spectrophotometric method with phenol disulfonic acid."

The analytical results, 1999, Mudanjiang

Item	A	B	C	D
pH	6.80	6.45	5.59	5.22
Ammonium-nitrogen mg/L	<0.05	<0.05	0.379	0.474
TP mg/L	0.05	0.05	0.27	0.23
COD_{Mn} mg/L			0.78	0.67
Conductivity μs/cm	4.02	3.96	23.6	25.5

Report on the intercomparison of chemical analyses, 1999, between four laboratories in China and NIVA in Norway.

Mr. Håvard Hovind, Norwegian Institute for Water Research (NIVA), Oslo, Norway

1. General

1.1. Introduction

Through years of experience with projects in different countries, with the organisation and evaluation of intercomparisons, we have learned that different laboratories very often use different analytical methods, or use different versions of the same analytical method for chemical analysis of water samples (as well as for sediments and biological materials). There may be different reasons for the laboratories' choice of analytical method, but once a method works on a routine basis, our experience is that there is very little willingness to change the method.

All analysts working with chemical methods know that different methods or different versions of methods, may lead to different analytical results. Therefore, when comparing chemical data from several laboratories, it is very important to have a documentation of the comparability between laboratories. One way to obtain such documentation of the comparability between two or more laboratories in a simple way, is to perform parallel analysis or intercomparison tests.

Intercomparisons of analytical methods are easily carried out by analysing sample aliquots taken from the same sample and sent to all the participating laboratories. If only two laboratories are involved in the comparison, it is usually called parallel analysis. The best way to select samples is to take a series of samples from the water bodies in the monitoring area. Therefore, such a set of samples should be sent to the laboratories involved in the intercomparison test. However, if this is difficult to organise samples may, as an alternative, be sent from the organising laboratory, which endeavours to select samples being comparable with the samples in the relevant water bodies.

1.2. Intercomparison of analytical methods

The analytical variables to be determined in the intercomparison should be the same as the ones included in the respective monitoring programmes. There are different ways to handle the results however, for water samples the most commonly used method is to produce one analytical result for each variable in each sample.

2. Current Project

2.1 Background

As an introduction to a more comprehensive intercomparison exercise in the future for the analytical programmes connected to the NORAD projects in China, the NIVA laboratory together with four laboratories in China, performed an intercomparison exercise in 1999. The results of this intercomparison will be a good basis for the proposed future exercises. The 1999 intercomparison exercise was partly funded by NIVA.

2.2. Preparation of samples

Stock solutions were prepared by weighing exact quantities of stoichiometric compounds into volumetric flasks, dissolving the compounds and diluting to the mark. Given volumes of these stock solutions were pipetted into 5 litre volumetric flasks and diluted to the mark with deionised water. The concentration of these synthetic samples were calculated from the weighed amount of compound and the dilution factors. These "true values" are given in the tables on the following pages, together with the results received from the participating laboratories. The samples were mailed to the laboratories 15. November 1999.

2.3. Treatment of data

The analytical results were sent to NIVA, which recorded all the results for statistical calculations. For water samples where only one result is reported for each variable and sample, and three or more laboratories are participating, it is normal to calculate the median value, the arithmetic mean and the standard deviation between the laboratories. For some of the analytical variables it is possible to calculate the true value from the weighed amount of material and the volume of the stock solution used for the preparation of the samples. As the exact true value of some other of the analytical variables are not known, it is suggested that the median value is used as basis for the comparability tests, as this value is normally less affected by outliers than the mean value. However, whenever only three laboratories have sent results for some of the analytical variables, this is not the case, and the problem needs to be discussed.

Some plots of the results have been made as bar diagrams, where the analytical results of the participating laboratories are plotted along the y-axis, and the sample number A -D along the x-axis. For each sample the laboratories are represented by a column, visualised by different column shadings. The Figures 1 - 8 illustrates the comparability between the laboratories. When only three laboratories are compared, it is possible to prepare correlation plots between two and two laboratories. However, this type of plot is more valuable if several samples, with varying concentration of the determinant, have been analysed at the laboratories involved.

It creates a problem that one of the laboratories, number 3, has returned results only for one sample in a sample set. That means that there are reported results for sample B in sample set AB and for sample D in sample set CD, and not for the other sample in the sample set.

Some time after this compilation of data, a meeting should be organised for the participating laboratories to discuss the results and try to explain the varying results. Criteria to be used for establishing acceptance limits for comparability should also be discussed.

2.4. Analytical results from the participating laboratories

The analytical results reported by the participating laboratories are compiled in the following tables, together with the calculated median value, the mean value, the standard deviation and the calculated "true value" of the synthetic samples for the analytical variables where this is possible. In cases where the results from one laboratory are strongly deviating from the other two laboratories, the results from this laboratory normally is excluded from the calculation of the mean value. Because very few laboratories participated in this intercomparison, this is not done here.

2.4.1. pH

There are some differences between the three laboratories as regards reported pH values. For the samples A and B, and partly C, laboratory no. 2 has reported much higher results than the other two laboratories. For sample D the results from the three laboratories are much more comparable. It should also be noticed that the samples were analysed at rather different periods of the month at the three laboratories, and this different storage time may have affected the pH determination. However, the similarity in composition between the samples indicates that there should not be expected any differences in the comparability from one sample to another, any systematic deviation should more likely be the same for all four samples. Differences between samples indicates that the error affecting the results is random.

2.4.2 Conductivity

For conductivity, the comparability is good between two laboratories, however, one laboratory (no. 3) has reported a very low result for sample D. This analytical variable is greatly affected by the temperature in the solution during measurement. Thus the conductivity is increasing with about 2 % per degree at room temperature. However, this does not explain the very low result of laboratory no. 3, which should check their instrument and electrode for malfunctioning.

2.4.3. Phosphate-phosphorous, mg/l

Three laboratories reported results for phosphate in the samples A - D. There is very good comparability between the laboratories for sample A, which has a low content of phosphate. For sample B, laboratory no. 4 has reported a slightly too high result compared to the two other laboratories. The results for the samples C and D are of acceptable comparability. The median and mean values are close to the calculated theoretical values.

2.4.4. Total phosphorous, mg/l

For total phosphorous the comparability is good for the results of the samples C and D, which had the highest concentrations of phosphorous. The results of the samples A and B are differing much more. Thus laboratories no. 2 and 3 reported results being too high compared with the other laboratories, which results are close to the calculated value for total phosphorous. This difference at low concentrations may be caused by problems with the blank values, which is dependent on the calibration of the instrument, or there may be problems with contamination from the reagents or the surroundings.

2.4.5. Nitrate-nitrogen, mg/l

For this analytical variable, laboratory number 4 has reported too high values for all four samples, both when the comparison is made with the other laboratories, and with the calculated values. The result from laboratory no. 3 is slightly too low for sample B, when compared to the calculated value for nitrate. For sample C the result from laboratory no. 3 is missing, but the comparability between laboratories 1 and 3 is very good for sample D, and the reported values are very close to the calculated ones. To find a reasonable explanation for the observed differences, more detailed information about the methods used for the determination of nitrate is necessary.

2.4.6. Ammonium-nitrogen, mg/l

For this analytical variable, the comparability of the results is varying considerably from one sample to another. For samples C and D the comparability of the reported results may be considered acceptable. This analytical variable is rather difficult to determine with high precision at very low concentrations, because from experience at many laboratories that contamination may represent a severe problem in the very low concentration range.

2.4.7. Total nitrogen, mg/l

Three laboratories reported results for total nitrogen, however, the comparability was rather varying. Laboratory no. 4 reported far too high results for all four samples when compared to the calculated value. The difference compared with the other laboratories is visualised very clearly in Figure 7. The comparability between the other laboratories is good, taking into consideration the extremely low concentrations of nitrogen in samples A and B.

2.4.8. Chemical oxygen demand, COD-Mn

It appears as if the permanganate oxidation is performed under rather different conditions at the participating laboratories, as the results are varying considerably. The calculated values for total organic carbon is 0,83, 1,03, 6,16, and 5,13 mg/l, respectively, and it was expected that the COD results should correlate in a simple manner to these values. One complicating factor is the fact that the concentrations are very low at least in two of the samples, i.e. A and B. In addition to this, the use of potassium phthalate as a carbon source may represent some problems as it is not always completely digested during the oxidation process. The oxidation degree is strongly dependent on the reaction conditions. In the future it is necessary to use another organic compound which is more easily digested as carbon source.

3. Conclusions

The preparation of this report was strongly delayed because of the difficulties to get all the results from the participating laboratories. This problem led to a situation where we have written the report from the intercomparison, without letting the participants have the possibility to comment on a draft report. In the future, the participating laboratories must comply with the planned time schedule.

It appears obvious that there are different analytical method used at the participating laboratories. This is shown in the table of results for phosphorous and ammonium, when considering the different detection limits used. This fact may partly explain the relatively great variations in the reported results at the low concentration ranges. In addition to this there may also be a problem in controlling the contamination risk when performing analyses at low concentrations, especially for analytical variables such as ammonia and phosphate.

The relative deviation (%) from the calculated theoretical value for phosphorous and nitrogen compounds.

		Laboratory number				
Analytical variable	**Sample**	**1**	**2**	**3**	**4**	**5**
PO4-P	A	4,3			- 4,3	4,3
	B	- 2,9			**46**	7,9
	C	- 0,3			- 6,6	2,8
	D	0,4			- 17,3	4,3
TOT-P	A	0	**54**		<	4,3
	B	0	**43**	**34**	<	5,7
	C	- 0,3	- 6,6	- 7,3	- 10,0	3,1
	D	- 0,4	- 0,4		- 13,4	4,3
NO3-N	A	- 1,6			**163**	
	B	1,3		**35**	**381**	
	C	- 1,7		**66**	**185**	
	D	0,2			**90**	
NH4-N	A	0	<		**- 47**	
	B	- 5,0	<	**- 25**	**280**	
	C	- 1,7	- 6,0		- 0,7	
	D	0,2	- 5,4	10,9	2,2	
TOT-N	A	- 0,6			**139**	-15,7
	B	2,0			**375**	**- 55,6**
	C	0,3			**129**	- 1,4
	D	3,3			**63**	- 1,7

In the table above the relative deviation from the calculated theoretical value is given for each analytical variable. Internationally it is very common to use as a general rule, that when a deviation from the "true" value is less than ± 20 %, the analytical result reported is considered as acceptable. Using this rule as a basis for the evaluation of the reported results, the deviation being greater than ± 20 % is given in bold letters in the table. In these cases the laboratory should check the analytical routine to find an explanation of the great deviation, and perform corrective actions to avoid such errors in the future.

An important following-up step should be an evaluation meeting between representatives of the participating laboratories involved. At such a meeting the results should be discussed, and emphasis should be put on explaining the discrepancies in the results. For this purpose it is necessary to have a detailed description of the analytical methods used at each of the participating laboratories.

On this basis, it would be valuable to carry out a more comprehensive intercomparison, including all the major components, such as conductivity, alkalinity, chloride, sulphate, calcium, magnesium, sodium, and potassium, and possibly some metals such as iron, aluminium, manganese, lead, copper, zinc, cadmium, and mercury. The samples should cover a wider range of concentrations, because this gives better information about the reasons for observed differences, and because the water quality of the water bodies in the monitoring programme may vary considerably.

Appendix E. Summarised comments on the samples and COD_{Mn} analysis for all stations for the period 1988-1997

This Appendix provides summarised information about the Classification system used, the number of water quality samples per year, the code classification of the water (station) based on the analytical results, according to the Chinese water quality classification system, the water quality class ‘name’, also according to the Chinese water quality classification system, the standard deviation and the number of samples above or below the concentration limits.

It comprises the period 1988-1997 and concerns Chemical oxygen depletion (COD_{Mn}).

Year 1988

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1988**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	4		
Classified Value:	6,68 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,87		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	4		
Classified Value:	11,11 [mg/l]		
Water Quality Class Code:	---		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	4,85		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	4		
Classified Value:	11,44 [mg/l]		
Water Quality Class Code:	---		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	2,54		
Count of observations above limit:	3 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	4		
Classified Value:	6,46 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,51		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	12		
Water Quality Class Code:	---		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	2,43		
Count of observations above limit:	6 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	5		
Classified Value:	5,58 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,01		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		

Year 1989

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1989**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,77 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,05		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	14,05 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	3,24		
Count of observations above limit:	8 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,03 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,15		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	6,94 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,17		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	2		
Classified Value:	11,38 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	5,69		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	5,42 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	2,98		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	5 observations less than [4]		

Year 1990

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1990**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,41 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,44		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	11,18 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	3,48		
Count of observations above limit:	4 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,33 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,58		
Count of observations above limit:	3 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,51 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,29		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	6,92 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	2,08		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	5,86 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,57		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [0]		

Year 1991

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	1, river_national		
Selected time period:	1991		
Parameter:	156, CODMN (20, Water Sample_R)		
Statistical method used:	Averaging		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	8,54 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	1,88		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	11,45 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	2,54		
Count of observations above limit:	6 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,65 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	1,88		
Count of observations above limit:	4 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	8,33 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	1,77		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	7,56 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,35		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Classified Value:	7,02 [mg/l] from 8 WQ samples		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	2,64		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	1 observations less than [4]		

Year 1992

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1992**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,07 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,56		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	13,30 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	6,49		
Count of observations above limit:	4 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,23 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,8		
Count of observations above limit:	3 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Classified Value:	7,75 [mg/l] from 7 WQ samples		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,95		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	7,16 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,33		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Classified Value:	5,44 [mg/l] from 8 WQ samples		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,22		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		

Year 1993

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1993**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	6,62 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,76		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	9,42 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	5,11		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,78 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,81		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	6,84 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	2,12		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	9		
Classified Value:	10,38 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	9,12		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Classified Value:	4,46 [mg/l] from 8 WQ samples		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,41		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	2 observations less than [4]		

Year 1994

Area of Interest:	**230400107, MDJ Catchment**	**Position Used**	**Sampling Method Used**
Classification System:	**1, river_national**		
Selected time period:	**1994**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,61 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,74		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	10,51 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	3,05		
Count of observations above limit:	3 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,87 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,9		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,01 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	1,98		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	7		
Classified Value:	9,99 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,82		
Count of observations above limit:	4 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	6,33 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	2,12		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	2 observations less than [4]		

Year 1995

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	1, river_national		
Selected time period:	1995		
Parameter:	156, CODMN (20, Water Sample_R)		
Statistical method used:	Averaging		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	8,19 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	3,08		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	11,43 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	3,23		
Count of observations above limit:	6 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	8,61 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,49		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	6,01 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,69		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Classified Value:	8,45 [mg/l] from 8 WQ samples		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	1,23		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	5,35 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,47		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	1 observations less than [4]		

Year 1996

Area of Interest:	230400107, MDJ Catchment	Position Used	Sampling Method Used
Classification System:	**1, river_national**		
Selected time period:	**1996**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	9		
Classified Value:	7,69 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,98		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	9		
Classified Value:	13,20 [mg/l]		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	3,45		
Count of observations above limit:	8 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	9		
Classified Value:	6,80 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	2,3		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**74, 360**	**P1**	**6**
Number of WQ samples:	7		
Classified Value:	6,71 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,91		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	8,15 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	1,66		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	5,07 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	1,4		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	2 observations less than [4]		

Year 1997

Area of Interest:	**230400107, MDJ Catchment**	**Position Used**	**Sampling Method Used**
Classification System:	**1, river_national**		
Selected time period:	**1997**		
Parameter:	**156, CODMN (20, Water Sample_R)**		
Statistical method used:	**Averaging**		
Station:	**72, 15**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	7,46 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	3,91		
Count of observations above limit:	2 observations greater than [10]		
Count of observations below limit:	1 observations less than [4]		
Station:	**79, 95**	**P1**	**6**
Number of WQ samples:	8		
Classified Value:	13,82 [mg/l]		
Water Quality Class Code:	---		
Water Quality Class Name:	<<< Outside QC System bounds >>>		
Standard Deviation:	9,46		
Count of observations above limit:	4 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**47, 260**	**P1**	**6**
Number of WQ samples:	5		
Classified Value:	6,71 [mg/l]		
Water Quality Class Code:	4		
Water Quality Class Name:	bad		
Standard Deviation:	0,67		
Count of observations above limit:	0 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**40, 445**	**P2**	**6**
Number of WQ samples:	7		
Classified Value:	9,08 [mg/l]		
Water Quality Class Code:	5		
Water Quality Class Name:	very bad		
Standard Deviation:	2,22		
Count of observations above limit:	3 observations greater than [10]		
Count of observations below limit:	0 observations less than [4]		
Station:	**73, 450**	**P2**	**6**
Number of WQ samples:	8		
Classified Value:	5,20 [mg/l]		
Water Quality Class Code:	3		
Water Quality Class Name:	fair		
Standard Deviation:	2,45		
Count of observations above limit:	1 observations greater than [10]		
Count of observations below limit:	3 observations less than [4]		