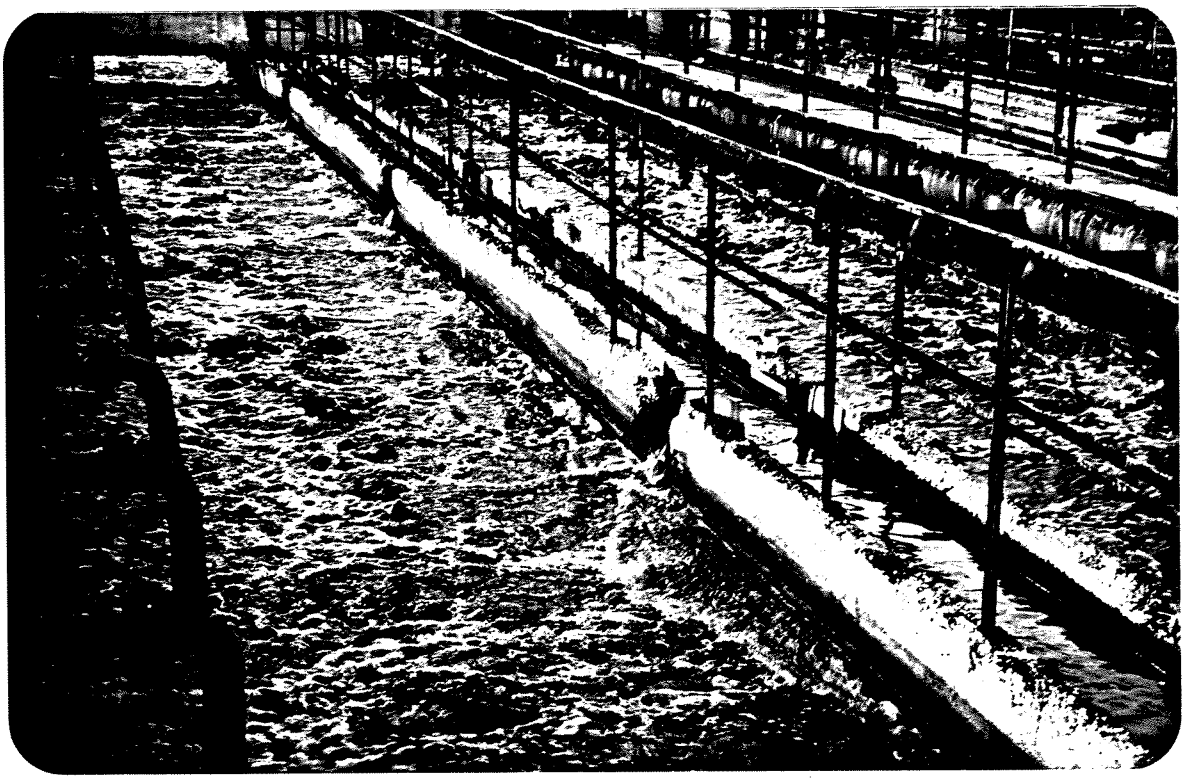
Upgrading of Wastewater Treatment Plants in Poland

PHASE I



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Abstract:

In order to identify operation problems and to improve treatment efficiency, diagnostic studies have been carried out at selected treatment plants. Recommendations are made how to improve the situation. Chemical precipitation is one of the solutions considered.

4 keywords, Norwegian	4 keywords, English
1. Kjemisk felling	1. Chemical precipitation
2. Rensing av avløpsvann	2. Wastewater treatment
3. Evaluering	3. Evaluation
4. Drift og vedlikehold	4. Operation & Maintenance

Project leader

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Municipal Engineering Centre

UPGRADING OF WASTEWATER TREATMENT PLANTS IN POLAND
PHASE I

Oslo, March 1993

Svein Stene-Johansen
Project Manager

PREFACE

With reference to the Programme of Cooperation between the Norwegian Ministry of Environment and the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland for the period 1991 - 1992, the Steering Committee agreed to initiate the Project UPGRADING OF EXISTING TREATMENT PLANTS IN POLAND in its first meeting in Oslo, 17th. - 19 th. of June, 1991.

The project was proposed by the Norwegian Institute for Water Research, NIVA, who later on signed a contract with the Norwegian Ministry of Environment to execute the project. The Polish Ministry appointed Centrum Techniki Budownictwa Komunalnego (CTBK) as NIVA's Polish cooperation partner.

To strengthen NIVA's team NIVA appointed Aquateam A/S as partner.

The first meeting between CTBK and NIVA took place in Warsaw in August 1991. The field investigations were carried out in November 1992 as a joint project team representing the two countries.

The team has visited the following towns:

Lomza
Minsk Maz.
Plonsk
Grajewo
Lapy
Pruszkow

The team would like to thank the staff at all the treatment plants visited as well as the local authorities which gave us full support.

The project manager would also like to thank the team members who consisted of

Mr. Leslaw Borzym	CTBK
Mrs.Elisabeth Kwapiszewska	CTBK
Mr. Bjarne Paulsrud	Aquateam
Mrs.Grazyna Englund	NIVA
Mr. Johan Ahlfors	NIVA

Particular thanks to director of CTBK, Mr. jan Zambrzycki and Mr. Andrzej Braun, who have kindly commented on this report.

Oslo, March 1993

Svein Stene-Johansen
Project Manager

LIST OF CONTENT

1. INTRODUCTION

1.1 The Present Water Pollution Situation in Poland

Bad quality of surface water is caused by water pollutants introduced to watercourses with municipal and industrial wastewaters, pollutants deriving from surface runoff from agricultural land, municipal and rural areas, and transportation routes as well as deposition of air pollution.

According to the statistics of 1987, water quality class I accounted for 0.9 percent of the total river course length, water of quality class II for 1.9 percent, class III for 18.4 percent, whereas substandard waters represented 78.8 percent of the rivers examined.

Serious threat is observed with regards to lakes, where water of quality class I is lacking totally, and substandard lake waters constitute 16 percent of the lakes examined, whereas lakes of quality class II constitute some 47 percent, and class III 37 percent

In 1987, about 12000 mill. m^3 municipal and industrial wastewater were produced, including 65 percent power station cooling water. The quantity of wastewater requiring treatment (4500 mill. m^3) included 34 percent subject to mechanical, 5.6 percent to chemical, and 21.9 percent to biological treatment. The low percentage of wastewater under full treatment is due, first of all, to an insufficient number of wastewater treatment plants, as well as to the bad functioning of the majority of the existing treatment plants.

Poland has approved of a set of priorities in the field of environmental protection, published in March 1990 and called "Strategic Goals of Environmental Protection in Poland"

For Water Protection the priorities are as follows:

1. Furnishing all towns with highly efficient municipal wastewater treatment plants with removal of biogenic compounds and full processing of sludge (about 360 new installations or retrofit of 400 existing plants).

2. Desalination of wastewater from hard coal mines.

3. Polish manufacturing of control equipment for wastewater treatment plants

1.2 The Objectives of the Project

About twenty years ago Norway had about 200 treatment plants based on "imported" design criteria and technology. About 60 percent of existing treatment plants were not operating according to standards and regulations. In order to solve the problem a major research and development programme with more than 60 subprojects was carried out. On this basis Norway made their own national treatment strategy and policy, and hundreds of millions of Norwegian crowns were saved annually.

Vel mye ?

One of the most successful following up project was a project called "Operation of treatment plant facilities". In a cost-effective way existing wastewater treatment facilities were upgraded. Intensive training programmes had to be initiated.

A similar project, but in a small scale has been initiated for Poland as a pilot project. The objectives are as follows:

- To increase wastewater treatment efficiency in existing mechanical and biological treatment plants in a cost-effective way.
- Through evaluation of existing treatment plant facilities, pilot plants and full scale experiments, obtain results which will give inputs to the development of a strategic plan and policy regarding wastewater treatment in Poland.
- To exchange knowledge between the two countries.

1.3 Scope of Work

The scope of work has been divided into different steps or activities and shown in Figure 1.1.

Step I: Selection

The selection of plants to be included in the projects is done by CTBK and based on the following selection criteria:

- There should be a need for upgrading/rehabilitation of the selected plant.
- The owners (local authority) and the management should be interested in the project and give full support.
- For practical reasons the plants should be located in one part of the country, not spread all over.
- Water quality laboratory capable of doing the required analyses should not be located too far away, max 1 hour drive.

Step II: Problem identification

The plant efficiency and the operational status of the plant should be established. The checklists in Appendix 1.1 have been used as a checklist.

Drawings, descriptions of mechanical equipment, physical data, biological and chemical water quality data, water and sludge quantity data, budget, etc. to be made available.

Step III: Verbal reports

The findings during step II will be discussed with the plant management and advice given to improve the situation.

Step IV: Diagnostic study

After the problems at the treatment plants have been identified, a limited number will be thoroughly investigated based on the checklist in Appendix 1.1. Jar-tests will be carried out.

Step V: Report phase I

The results obtained during step I - step II will be reported and the conclusions will be the base for the next steps.

Step VI: Full scale experiments

Full scale experiments will be carried out at a selected number of treatment plants for a limited period of time. Based on the results, the team will come up with recommendations for upgrading/rehabilitation and other improvements. Estimates for capital investments, operation and maintenance costs will be done.

Step VII: Draft report phase II

A draft report for phase II will be prepared.

Step VIII: Seminars

Seminars will be organized for wastewater treatment plant operators with the objective to increase the treatment efficiency in existing plants by improving operation performance and by introducing chemical treatment where appropriate.

The plants included in the programme should serve as demonstration plants.

Step IX: Conference

After the field work has been completed, evaluated and reported, the main findings and recommendations should be presented to the decision makers. A strategic plan to increase wastewater treatment efficiency should be presented.

Step X: Final report

The final report will be a summary of the reports from phase I and II with recommendation including comments from the conference.

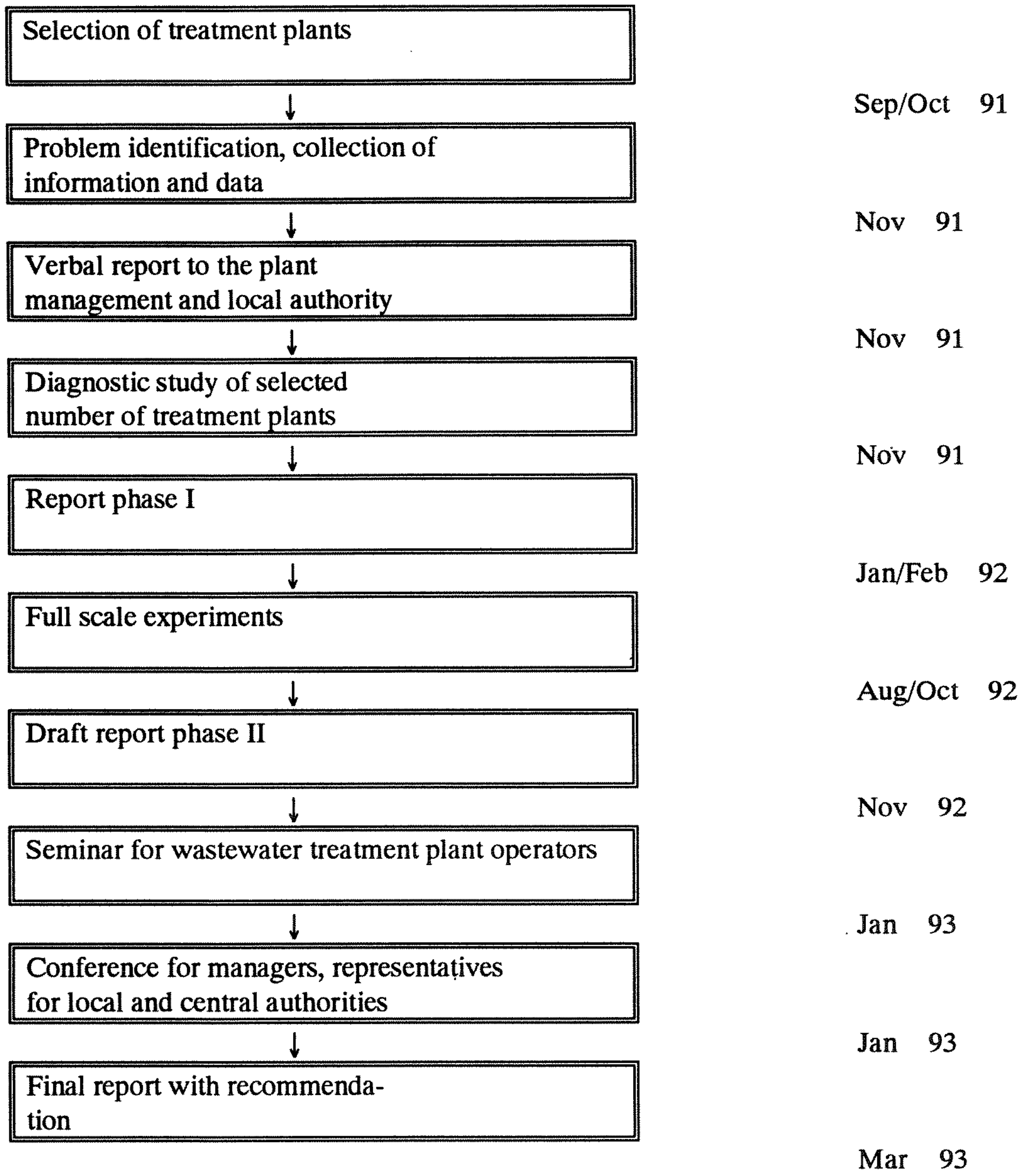

Fig 1.1 Scope of work and time schedule

2. CHEMICAL TREATMENT PROCESSES

2.1 General

Generally, chemical treatment processes consist of a mixing stage, in which the coagulant is mixed with water, followed by a flocculation stage, during which settleable flocs form, finally to be removed in a separation stage, normally by sedimentation.

The following methods of precipitation are relevant:

* Pre-precipitation
* Simultaneous precipitation
* Direct precipitation
* Post-precipitation.

They are briefly described below.

2.2 Pre-precipitation

Pre-precipitation consists of chemical precipitation, followed by a biological stage.In order to reduce the loading on the biological stage, many treatment plants have pre-precipitation. The precipitant can be introduced at a turbulent point to ensure good mixing before primary sedimentation. Rebuilding is thus not required.

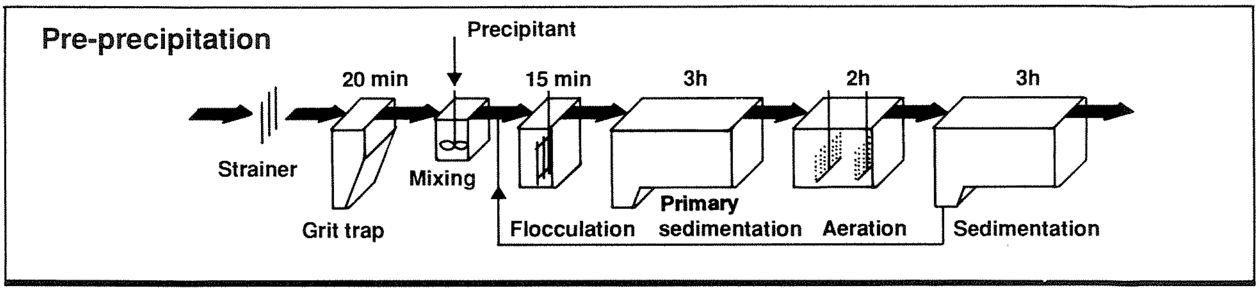

Figure 2.1 Pre-precipitation

This method achieves good phosphorus removal and a high reduction of organic material which reduces the loading on the biological stage. The activated sludge production will be reduced and also the energy costs for biological treatment.

The effectiveness of conventional biological treatment is shown in Figure 2.2. About 30 percent of the influent organic pollution separates in the primary sedimentation stage, 10 percent is leaving with the treated effluent, and about 60 percent separates in the biological stage.

Figure 2.2 shows how the addition of pre-precipitation changes the distribution of organic substances removal. About 75 percent can now be removed in primary sedimentation and only about 15 percent in the biological treatment stage. This means that the biological stage can be made very compact.

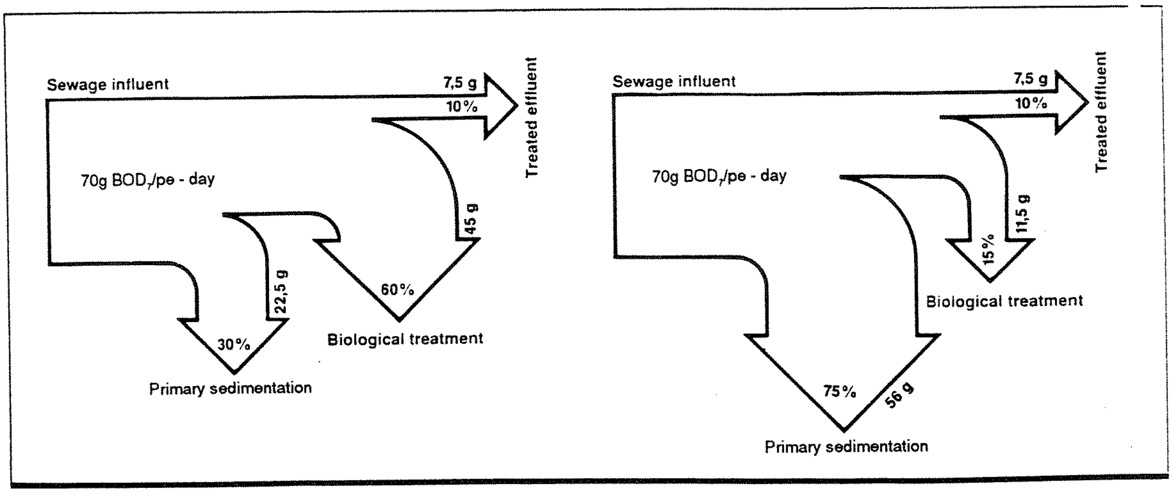

Figure 2.2 Removal of organic substances in conventional treatment and pre-precipitation.

The proportion of organic material in sludge is increased by more than 30 percent giving a corresponding increase in digester gas production from anaerobic sludge stabilization.

The total quantity of sludge after stabilization is approximately the same as for conventional treatment.

Key figures:

Reduction	
SS	>90 percent
BOD	>90 percent
Ptot	>90 percent
Ntot	=25 percent

Total hydraulic retention time:
about 9 hours

2.3 Simultaneous Precipitation

When the phosphorus is chemically precipitated at the same time as the biological treatment in an activated sludge process, the process is simultaneously. The biological stage serves as a flocculation tank with both chemical and biological sludge separated in a subsequent stage.

The flocculant results in increased separation of organic substances.

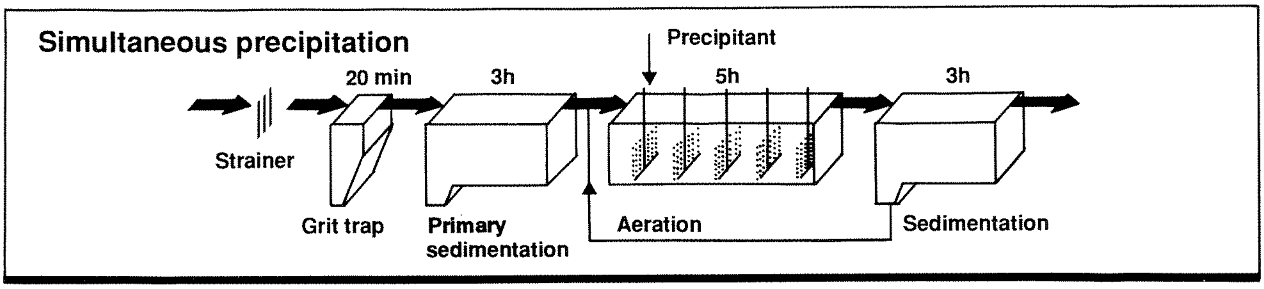

Figure 2.3 Simultaneous precipitation

The chemical flocculant is normally added to either the inlet or discharge of the activated sludge stage. Sludge production increases, reducing the age of the sludge and thereby making nitrification more difficult.

Key figures:

Reduction	Total hydraulic retention time:
SS = 90 percent BOD = 90 percent Ptot < 90 percent Ntot = 25 percent	about 11.5 hours

2.4 Direct Precipitation

The precipitation stage constitutes the only treatment stage after mechanical screening and the grit chamber, or in some cases proceeded by a primary sedimentation tank. The process is highly cost-effective with a reduction of phosphorus by more than 90 percent and organic substances by about 75 percent.

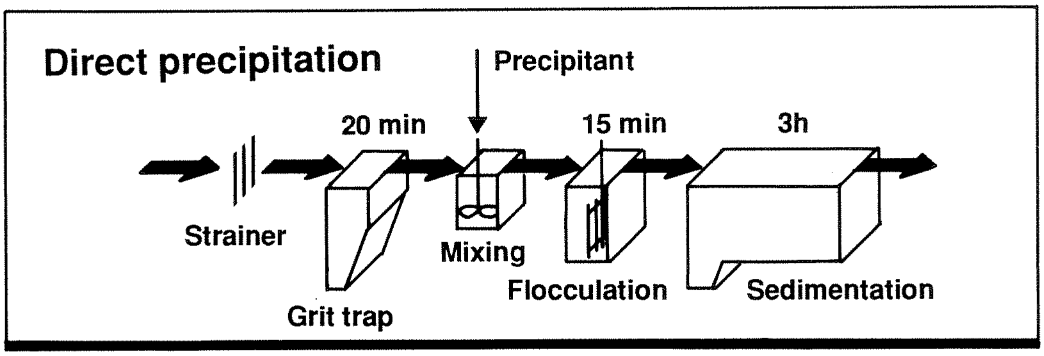

Figure 2.4 Direct precipitation

Very modest investments are required to expand existing mechanical treatment plants into efficient direct-precipitation treatment plants.

Key figures:

Reduction:		Total hydraulic retention time:
SS	> 90 percent	3 - 4 hours
BOD	= 75 percent	
Ptot	> 90 percent	
N tot= 25 percent		

2.5 Post-precipitation

Phosphorus is separated from biologically treated wastewater in a post-treatment stage. Instead of sedimentation process, the sludge can be separated by flotation or filtration.

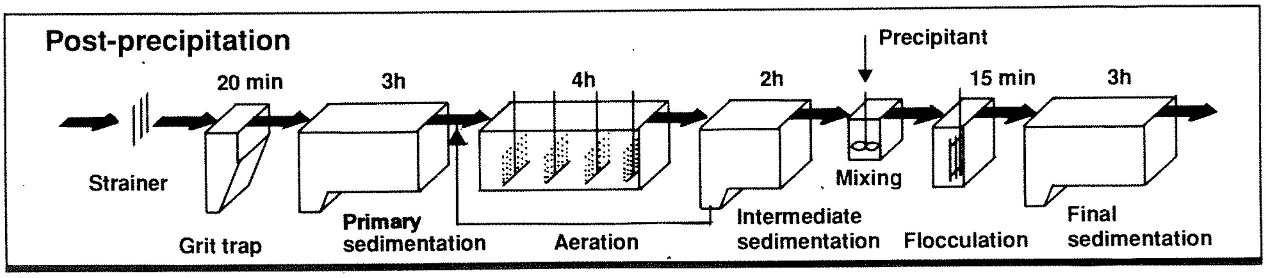

Figure 2.5 Post-precipitation

Post-precipitation may result in phosphorus levels below 0.5 mg P/l. If combined with filtration, the level may decrease below 0.1 mgP/l.

Recycling of chemical sludge to the primary sedimentation stage by post-precipitation, is quite common. The sludge will be more easily thickened and it leads to impoved separation of phosphorus and organic materials in the primary sedimentation tank.

During periods of high hydraulic loading, post-precipitation prevents the loss of sludge from the sensitive biological stage. An extra important security is achieved.

Key figures:

Reduction:		Total hydraulic retention time:
SS	> 90 percent	about 12 hours
BOD	> 90 percent	
Ptot	> 95 percent	
Ntot	= 25 percent	

3. LOMZA WASTEWATER TREATMENT PLANT

3.1 General Information

Lomza is the regional capital with a population of about 55 000. The town is situated about 120 km north-east of Warsaw.

About 90 percent of the population in Lomza are connected to the sewerage system. The remaining 10 percent have septic tanks which are regularly emptied into the sewerage system prior to the treatment plant.

About 80 percent are connected to the separate sewerage system, while the rest (old part of the town) are connected to a combined system with overflows. All sewage flows by gravity along a collector to the treatment plant.

According to the Statistical information on environmental protection,1991, the water consumption in 1990 from the water supply system for municipal purposes in Lomza district, was in the order of:

- total	8 300 000 m^3/y
- towns	6 400 000 m^3/y
- villages	1 900 000 m^3/y

and per person:

- total	23.9 m^3/y	or	65 l/p.d
- in towns	45.4 m^3/y	or	125 l/p.d
- in villages	9.2 m^3/y	or	25 l/p.d

Some industrial activities exist in the town, where a textile factory was the biggest (ca. 2 500 employees, but due to recession diminished to less than 1 000 last year). Other minor industries are dairy, brewery, mineral water production, bakery, abattoir, etc.

Total wastewater discharge by the municipal sewerage system is:

- in total	9 400 000 m^3/y
- households	5 900 000 m^3/y
- industry	2 500 000 m^3/y
- other sources	1 000 000 m^3/y

of which 6 800 000 m^3/y are treated mechanically-biologically, and 2 500 000 m^3/y are untreated.

The river Narew is passing through the Lomza region with its main tributaries Biebrza and Pisa. Between the conjunction of rivers Narew/Bug and the river Vistula, Warsaw has its major water supply intake.

The recipient for Lomza wastewater treatment plant is the river Narew with a total length of 450 km in Poland. It originates in White Russia. The pollution situation in the river in 1990 is described in Table 3.1 below.

Table 3.1 River classification

Physico - chemical classes % of km				Biological classes % of km			
I	II	III	IV	I	II	III	IV
-	72	19	9	-	25	17	58

3.2 Treatment Plant Facilities

The existing wastewater treatment plant is a conventional mech.- biological treatment plant with:

- aerated grit chamber
- primary sedimentation
- aeration tanks
- secondary sedimentation
- sludge lagoons and open fermentation basins

Design capacity:	14 500 m^3/d
Actual load:	14 000 m^3/d
Municipal wastewater:	10 000 m^3/d
Textile factory:	3-4 000 m^3/d

A new water supply with a capacity of 6 000 m^3/d will soon be in operation which will increase the total water consumption in the town.

The director and the deputy director are the employees of the Municipal Directory for Water and Sewerage System. At the treatment plant itself, there are about 28 employees divided in the following categories:

10	pump operators	3	guards
4	electricians	4	warning syst. operators
3	workshop mechanichs	3	chemists

A programme exists for modernization of the existing plant by application of a 2-stage biological system, where the first stage should be high loaded system and the second low loaded with intermittent sedimentation. Sludge would be treated by acid flotation (under pressure). The manager of the plant was very uncertain about this plan (very costly and especially as the acid flotation is not in use in technical scale, thus the system can cause many problems).

* Discharge requirements:

BOD_5 - 2 mg O_2/l
SS - 30 mg/l
pH - 6.5 - 9.0

* Loads allowed:
BOD_5 - 240 kg/d
SS - 600 kg/d
Dissolved subst. 20 000 kg/d

3.3 Operation Performance and Problems

Standard sampling procedures for the plant involved grab samples every working day at 08:00 a.m. from the influent and the effluent, as well as from the aeration tank and the return sludge. The influent and effluent samples were analyzed for BOD_5, COD, total solids, suspended solids, and pH, while the sludge samples were analyzed for total solids and dissolved oxygen. All analyses were performed in their own laboratory.

The process control of the activated sludge plant was based upon keeping a fairly constant sludge content (mixed liquor suspended solids) in the aeration tanks. This should be managed by varying the wasting of surplus activated sludge, but the flow meter for wasted sludge was not functioning, and no records were achieved for the total amount of sludge removed per day. In practice, the waste activated sludge valve in the return sludge line is opened to a certain degree for a given period based upon experience, but in this way, the process control is rather unreliable.

Another factor causing operational problems was the blocked drainage system of the sludge drying beds. New sludge lagoons were under construction to cope with this. Also, the old sludge digester (which had never been in operation) was planned to be renovated, and the renovation programme had started with the gas tank.

Pumping of sludge from the primary clarifier was done only once a day, and this created a lot of floating sludge on the top of the clarifier with possibility for the sludge to escape with the presettled wastewater.

Results from samples taken by the regional environmental protection authorities indicated good plant performance during days with low discharge of wastewater from the textile factory. With larger peaks of textile wastewater discharged to the plant, the effluent quality deteriorated and given standards were exceeded. This was especially true for the discharge of dissolved solids. There is, however, a question about setting discharge limitations for dissolved solids in wastewater effluents, since several salts will influence the results, and the addition of chemicals for phosphorus and BOD- removal will be a problem.

3.4 Results of Investigations

During our visit, flow proportional daily composite samples were taken from both the influent (raw wastewater) and the effluent of the plant. Variations during the day in raw wastewater quality were determined by taking 2 hour composite samples. The wastewater flow was monitored continuously with a transportable flow-meter. Jar-tests were performed to obtain some information about the possibilities of reducing the organic load on the plant with pre-precipitation, either with Al- or Fe-compounds.

3.4.1 Wastewater Flow

The wastewater flow just after the inlet pumping station was continuously monitored during approximately two days (from 11:00 a.m. on Wednesday, November 13, to 08:00 on Friday, November 15). The results are presented in Figure 3.1. Due to the pumping station, the flow through the plant varied in three levels: No pumping (zero flow), 1 pump in operation (125-175 l/s), 2 pumps in operation (325-425 l/s). The high peaks during night-time clearly indicate the discharge of wastewater from the textile factory.

3.4.2 Wastewater Quality and Plant Removal Efficiency

All the results from our wastewater sampling programme are presented in Appendix 3.1. Uncertain values are marked with a *. The most interesting data are presented in Figure 3.2, which shows the variations in raw wastewater COD concentration during the two days. Comparing these results with the flow variations in Figure 3.1 lead to the conclusion that the industrial peak flows during these two nights did not represent a major organic load on the plant.

The results from the daily composite samples of influent and effluent wastewater are presented in Table 3.2. Both influent and effluent samples are collected during the same 24 hours, ignoring the wastewater detention time through the plant. In our experience, this will not significantly influence the calculated removal efficiency.

Table 3.2 Removal of COD, BOD_5, and suspended solids (SS) in Lomza sewage treatment plant during November 13-15, 1991.

	Influent (mg/l)		Effluent (mg/l)		Percent removal	
	13-14 Nov.	14-15 Nov.	13-14 Nov.	14-15 Nov.	13-14 Nov.	14-15 Nov.
COD	317	407	43	37	86	91
BOD_5	157	120	10	7	94	94
SS	221	199	20	26	91	87

The results in Table 3.2 prove that the plant functioned very well during our visit. This is, however, not surprising, since the actual loading (both organic and hydraulic) was low in this period, with an average BOD-load of 0.1 kg BOD_5/kg MLSS·d, and a maximum overflow rate in secondary clarifier of 0.85 m^3/m^2 ·h (with 2 pumps in operation).

Lomza

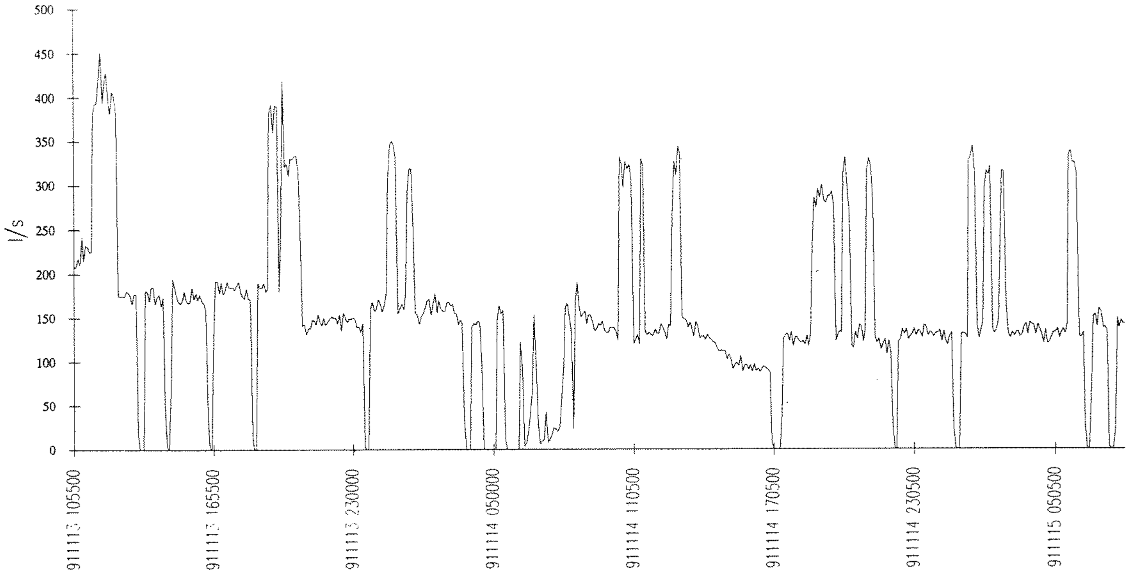

Figure 3.1 Wastewater flow during November 13-15, 1991

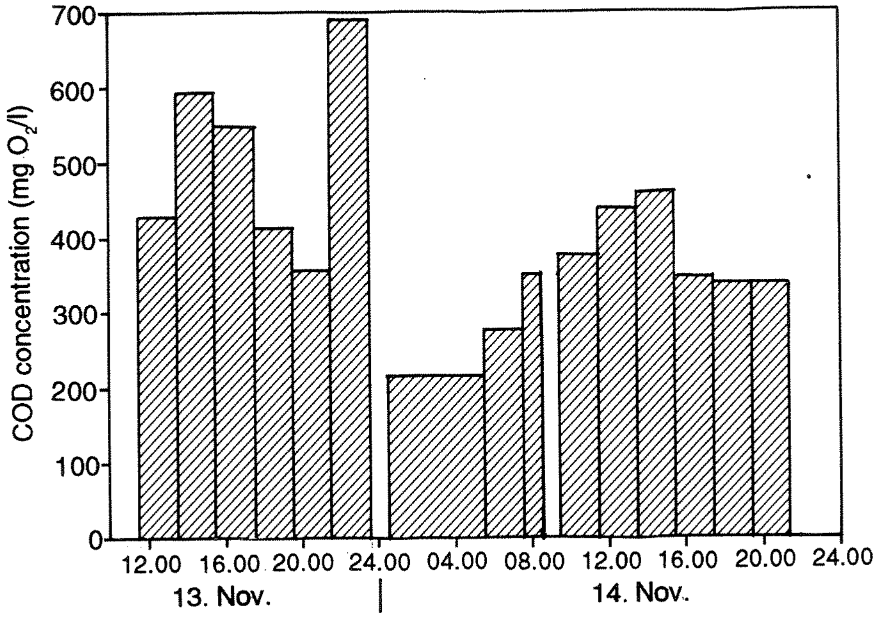

Figure 3.2 Variation in raw wastewater COD-concentration during November 13-14, 1991

3.4.3 Jar-tests

The results from the two jar-tests are summarized in Appendix 3.2, and Figures 3.3 and 3.4 present the COD and PO_4-P concentrations in the supernatant as a function of chemical dosage.

In the first jar-test with Al-sulphate, the raw wastewater was rather diluted (COD = 219 mg/l), and a good removal of COD (82 percent) was achieved with only 150 g/m³ of Al-sulphate. With this dosage, the orthophosphate concentration was reduced to below 1 mg/l PO_4-P.

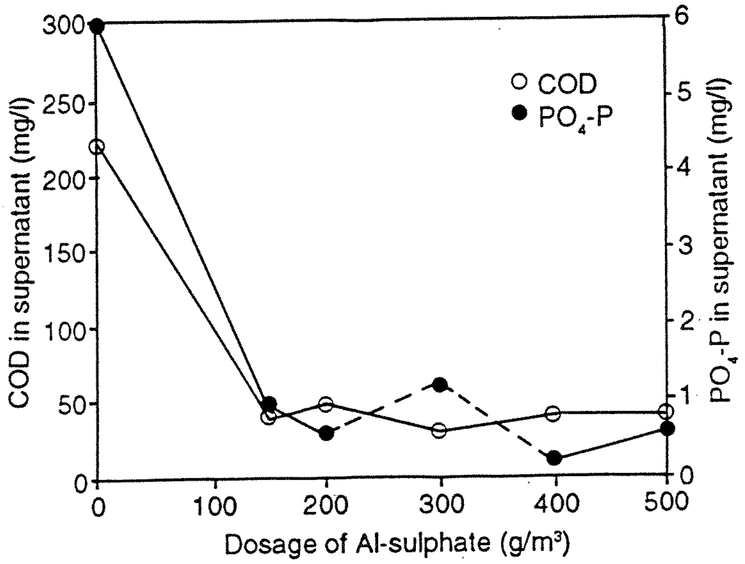

Figure 3.3 Results from jar-tests with Al-sulphate

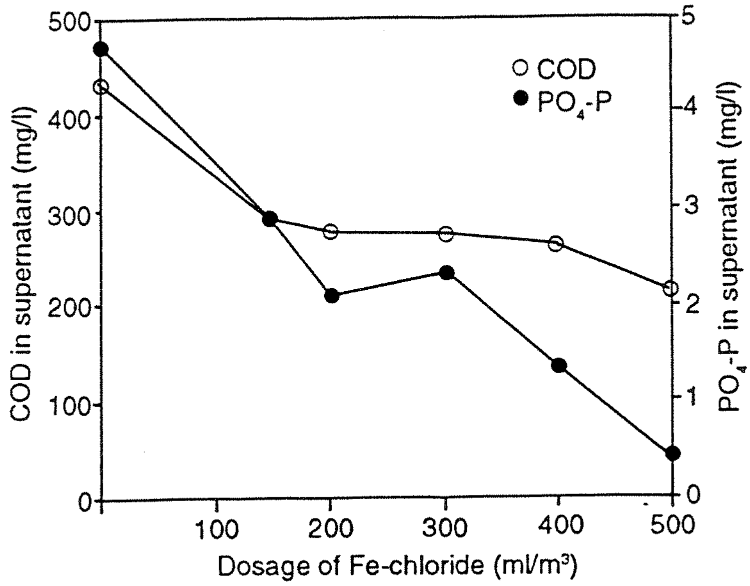

Figure 3.4 Results from jar-tests with Fe-chloride

There was no significant increase in COD or PO_4-removal with increasing chemical dosage.

In the second jar-test with Fe-chloride, the raw wastewater had a higher COD-concentration (432 mg O_2/l), and the COD removal was only 33 percent with 150 ml/m^3 Fe-chloride, increasing to 52 percent COD-removal with a dosage of 500 ml/m^3 Fe-chloride. The removal of orthophosphate was also less than in the first jar-test.

From these two jar-tests it is not possible to claim that Al- sulphate is a better coagulant than Fe-chloride for Lomza, since the raw wastewater characteristics were quite different in the two tests. More tests at different times during the day, and with varying discharge of textile wastewater will be necessary prior to full scale testing of chemical precipitation at this plant.

3.5 Conclusion and Recommendation for Further Actions

The Lomza sewage treatment plant functions well as long as the discharge of wastewater from the textile industry is moderate (3,000-4,000 m^3/d). Both the organic and hydraulic loads on the plant are then below acceptable limits for biological wastewater treatment. There are, however, several actions that should be taken to achieve a more stable and reliable operation of the plant:

- Put into operation the waste activated sludge flow meter to facilitate a better process control based on a constant sludge age in the aeration tanks.

- Establish a "tailor-made" record system for all the data from measurements and analyses performed at the plant.

- Improve the operators' manual for the plant and run a course in sewage treatment plant operation and maintenance for operators and the management.

- Increase the frequency of sludge pumping from the primary clarifier to reduce the amount of floating sludge.

With increasing discharge of textile wastewater (up to 9,000 m^3/d), actions need to be taken at the factory. First of all, the neutralization and equalization tanks should be emptied in a controlled way by pumping the wastewater to the municipal sewer network, instead of flushing the system by just opening a valve at the bottom of the tanks. With a more even distribution of the wastewater discharge, the increased organic load could be handled by introducing pre-precipitation at the municipal treatment plant (See chapter 3.6).

3.6 Proposal for Full Scale Testing of Chemical Precipitation

3.6.1 Objective

The main purpose of chemical precipitation at this treatment plant is to reduce the organic load on the biological treatment step due to the discharge of industrial wastewater (textile factory) and septage addition. An additional effect of chemical precipitation will be a reduced discharge of phosphorus to the river Narew.

3.6.2 Test Programme

3.6.2.1 General

The programme proposed here is based on the data achieved in Nov. 1991 during our first visit to the treatment plant. At that time the contribution of wastewater from the textile factory was relatively small, and the results from our jar tests with chemical precipitation of raw wastewater (pre-precipitation) may not represent the situation with more industrial wastewater discharged to the plant. New jar tests just before starting the full scale testing are therefore recommended.

In November 1991 both aluminium-sulphate and ferric-chloride were tested with fairly good results in respect of COD-reduction, but the data for the P-reduction are difficult to interprete due to analytical errors. For full scale testing we recommend to use the chemical which is cheapest and easiest to obtain in Poland.

3.6.2.2 Dosing point

The chemicals should be added to the incoming wastewater after the pumping station and at a point with good mixing conditions. After initial mixing there should be minor turbulence to achieve larger flocs of the precipitates which can easily be removed in the primary sedimentation tanks. In any case there should be possibilities for changing the chemical dosing point by using a flexible hose from the dosing pump.

3.6.2.3 Dosing rate and chemical consumption

Based upon the previous jar tests, a chemical dosing rate of approx. 200 g/m^3 (Al-sulphate) or 200 ml/m^3 (Fe-chloride) should be appropriate to start with, but a higher contribution of the textile wastewater may require even higher dosing rates. Great variations in raw wastewater alkalinity and pH can create severe problems for the chemical precipitation process.

With an average wastewater flow of 14000 m^3/d, the daily chemical consumption will be approx. 2800 kg Al-sulphate or 2800 litres Fe-chloride.

A chemical storage tank of approx. 20 m^3 will be necessary.

3.6.2.4 Monitoring, sampling and analyses

The effect of chemical precipitation should be determined by taking composite samples at three different places:

1. The influent (raw wastewater) before any return streams (surplus activated sludge etc.) are mixed with the wastewater.

2. The influent to the aeration tank (after primary sedimentation).

3. The effluent from the plant (after secondary sedimentation).

Automatic samplers (controlled by a timer) should be installed at the three places and for each of them 3 samples should be collected every week; one covering Monday and Tuesday (48 hours composite sample), one covering Wednesday and Thursday (48 hours composite sample) and the last one covering Friday through Monday (72 hours composite sample).

The samples should be analysed for:

- BOD_5
- COD
- Suspended solids
- Total phosphorus
- Orthophosphate

In addition the pH-value should be measured every day in the influent to the aeration tank and in the effluent from the plant. These pH-measurements should be done at the plant and not in the laboratory.

3.6.2.5 Test period

The total test period should be 3-4 weeks in order to achieve some experience with the effects of reduced loadings on the biological treatment step.

3.6.2.6 Side effect of chemical precipitation

With the pre-precipitation system, there will be an increased amount of sludge that has to be removed from the primary sedimentation basins. The sludge pumping capacity and the capacity of succeeding sludge treatment units should therefore be checked during the test period.

Addition of Al- or Fe-compounds will not reduce the sludge value as an organic fertilizer for agricultural use, but there will be an increase in effluent dissolved solids resulting in values higher than the existing effluent standards. This problem should be addressed to the water pollution control authorities.

4. MINSK MAZOWIECKI SEWAGE TREATMENT PLANT

4.1 General Information

Minsk Mazowiecki is one of the 13 towns in the Siedlce region with a population of about 35 000. The town is situated about 40 km south-east of Warsaw.

About 75 percent of the population are connected to the sewerage system. The remaining 25 percent have septic tanks or other individual solutions. The tanks are regularly emptied and the septages are discharged to the treatment plant.

About 70 percent are connected to the combined sewerage system with overflows while the rest (5 percent) are connected to the separate system .

According to the Statistical Information on Environmental Protection, 1991, the water used in 1990 from the water supply systems in the whole Siedlce region, was in the order of:

- total	10 800 000 m^3/y
- towns	8 500 000 m^3/y
- villages	2 300 000 m^3/y

and per person:

- total	16.6 m^3/y	or 45 l/pd
- towns	40.9 m^3/y	or 112 l/pd
- villages	5.2 m^3/y	or 14 l/pd

Some industrial activities exist in the town, where the main input to the treatment plant is from a dairy (800 - 1 000 m^3/d). Other industrial activities are of minor influence on the operation of the plant. There are machinery industry, reparation of railways, workshops for reparation of pumps, tractors and machinery for agriculture.

The wastewater discharge by the municipal sewerage system is:

- total	17 600 000 m^3/y	or 2 009 m^3/h
- town	7 700 000 m^3/y	or 879 m^3/h
- industry	7 800 000 m^3/y	or 890 m^3/h
- other sources	2 100 000 m^3/y	or 240 m^3/h

of which 1 400 000 m^3/y are treated mechanically, 13 600 m^3/y are treated mechanically-biologically, and 2 600 000 m^3/y are untreated.

There are 13 towns in the Siedlce region of which 10 are connected to sewerage systems. 8 towns (about 135 000 people) have biological treatment plants.

4.2 Treatment Plant Facilities

The existing wastewater treatment plant is a conventional mechanical-biological treatment plant with:

- grit chamber
- primary sedimentation
- aeration tanks
- secondary sedimentation
- Imhof tank and drying beds
- Fermentation Basin

Design capacity: 10 110 m^3/d
Actual load : 6 000 - 8 000 m^3/d (the plant is overloaded by organic materials)

The effluent from the plant is discharged into the small river Srebrna classified at the II class. The effluents standards are 25 mg/l $BOD_{5,}$ 30 mg/l SS and pH=7.8.

The director is an employee of the Municipal Directory for Water and Sewerage System. At the treatment plant itself, there are employed about 15 persons, divided into the following categories:

1 manager	1 electrician
4 plant operators	2 drivers
5 attendantts	3 chemists

4.3 Operation Performance and Problems

According to the plant management, the plant is overloaded by organic matter discharged from a dairy near by. This overloading causes high BOD, COD and suspended solids concentrations in the effluent, and the discharge permit is exceeded regularly. There was, however, some confusion about the wastewater discharge from the dairy, and several questions were still unanswered after a visit to the dairy.

The treatment plant staff operated a rather comprehensive sampling and analysis programme five days a week, based on grab samples taken between 08:00 and 10:00 a.m. Samples were taken of the incoming municipal wastewater just after mixing of dairy wastewater and municipal wastewater, in the effluent from the primary settling tank, and in the plant effluent. Once a month a grab sample was taken from the incoming dairy wastewater. All the samples mentioned above were analyzed for BOD_5, suspended solids, permanganate value, pH, and temperature. Moreover, grab samples were taken daily from the aeration tanks and the return sludge line with analyses for mixed liquid suspended solids (MLSS), sludge volume (after 30 min.), O_2-concentration, pH, and temperature. Microscopic examination of the activated sludge was also performed regularly.

The process control of the plant was based upon keeping the MLSS concentration in the aeration tanks as constant as possible by varying the wasting of surplus activated sludge. However, with no flowmeter for measuring the amount of wasted sludge, it is hard to achieve a good process control.

The most distinctive problem was the lack of sludge dewatering equipment, since the drainage system of the existing drying beds was blocked, and 11,000 m^2 of drying beds were completely filled with liquid sludge that would not dewater.

Another marked problem was the malfunction of the sludge scrapers in both the primary and secondary settling tanks. Settled sludge was not completely removed by the scrapers, and after a while, clusters of rotten sludge floated to the surface and was discharged with the treated wastewater.

During peak organic loads, the oxygenation capacity of the aeration system was too low, resulting in a low level of dissolved oxygen in the aeration tank. This situation represents good growth conditions for the filamentous bacteria, with a poor settling sludge as the result.

4.4 Results of Investigations

During our visit, flow proportional daily composite samples were taken from both the influent (raw wastewater) and the effluent of the plant. Variations during the day in raw wastewater quality were determined by taking 2 hour composite samples. The wastewater flow through the plant was monitored continuously with a transportable flow-meter. Jar-tests were performed to obtain some information about the possibilities of reducing the organic load on the plant with pre-precipitation, either with Al- or Fe-compounds.

4.4.1 Wastewater Flow

The wastewater flow just after mixing of municipal and dairy wastewater was monitored continuously for approximately three days (from 11:00 a.m. on Saturday, November 16 to 09:00 a.m. on Tuesday, November 19). The results are presented in Figure 4.1. The diurnal variations shown here are quite normal, but all the short-time peaks (to some extent also during night-time) are difficult to explain, unless there is a pumping station at the dairy for discharge of wastewater to the sewage treatment plant. A visit to the dairy did not give any answer to this question.

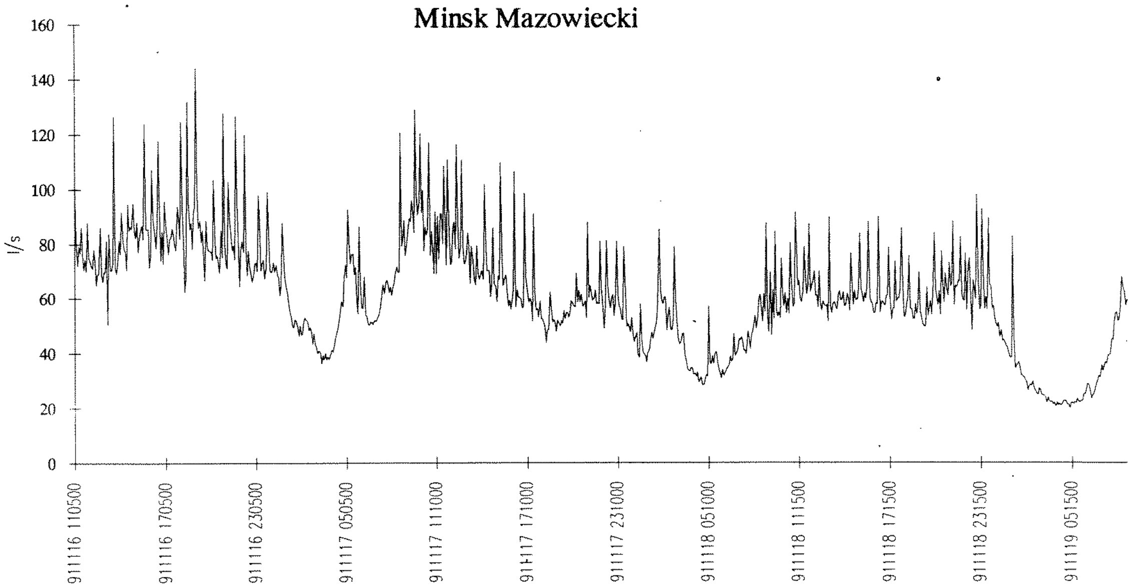

Figure 4.1 Wastewater flow during November 16-19, 1991

4.4.2 Wastewater Quality and Plant Removal Efficiency

All the results from our wastewater sampling programme are presented in Appendix 4.1. Uncertain values are marked with an *. The most interesting data are presented in Figures 4.2 and Figure 4.3, which show the variations in COD in raw wastewater during two days, and in the primary clarifier effluent during the third day. The first day of sampling was a Saturday, and there were marked peaks in the raw wastewater COD-concentration during normal working hours corresponding to a minor increase in the wastewater flow. On Sunday, the COD concentration in raw wastewater was considerably lower with about the same wastewater flow. The data clearly indicate the discharge of relatively small volumes of highly concentrated wastewater on working days, and according to the treatment plant management, the dairy is the source for this contribution of organic matter.

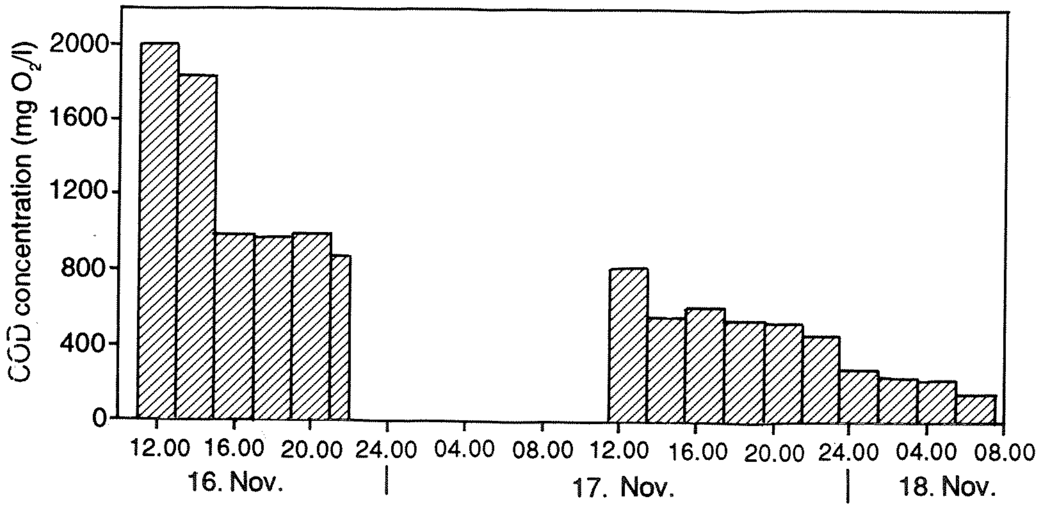

Figure 4.2 Variation in raw waste wate,. COD-concentration during November 16-18, 1991.

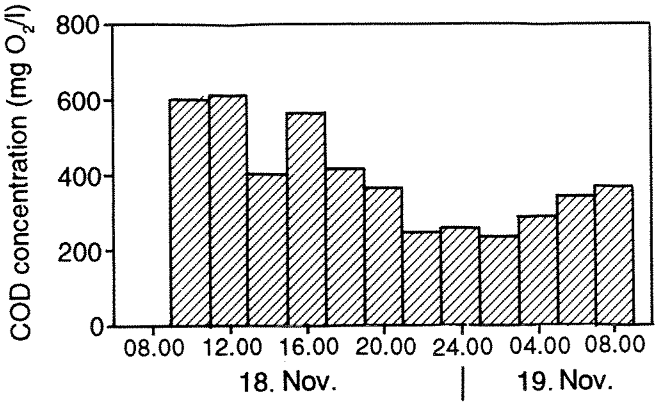

Figure 4.3 Variation in COD-concentration of primary settled wastewater during November 18-19, 1991

The results from the daily composite samples of influent and effluent wastewater are presented in Table 4.1. Both influent and effluent samples are collected during the same 24 hours, ignoring the wastewater detention time through the plant. In our experience, this will not significantly influence the calculated removal efficiency.

Table 4.1. Removal of COD, BOD_5, and suspended solids (SS) in Minsk Mazowiecki sewage treatment plant during November 16-19, 1991.

	Influent (mg/l)			Effluent (mg/l)			Percent removal		
	16-17 Nov.	17-18 Nov.	18-19* Nov.	16-17 Nov.	17-18 Nov.	18-19 Nov.	16-17 Nov.	17-18 Nov.	18-19* Nov.
COD	605	429	509	210	143	204	65	67	60
BOD_5	400	297	345	36	40	48	91	87	86
SS	203	150	131	101	62	75	50	59	43

* This composite sample was taken after the primary clarifier to obtain some information about the activated sludge plant loading. The percent removal for this day is for the activated sludge system alone, and not for the overall plant.

The results in Table 4.1 prove that the plant is not functioning properly, with high concentrations of organic matter and suspended solids in the effluent. There are at least two obvious explanations for this situation:

1. The organic loading of the plant is so high during peak loads (~0.5 kg BOD_5/kg MLSS d) that oxygen deficiency occurs in the aeration tank, resulting in poor settling sludge.
2. Malfunctioning sludge scrapers in secondary settling tank.

4.4.3 Jar-tests

The results from four jar-tests are summarized in Appendix 4.2, and Figures 4.4, 4.5, 4.6 and 4.7 present the COD and PO_4-P concentrations in the supernatant as a function of the chemical dosage.

In the first jar-tests with a raw wastewater sample taken on Saturday morning, a significant removal of COD (~50 percent) was obtained with only 150 mg/l of Al-sulphate, and increased Al- dosage gave no further COD-removal. The orthophosphate removal was nearly complete with a dosage of 200 g/m^3 of Al-sulphate. (see Figure 4.4)

The next jar-test, with ferric chloride as a coagulant, was performed a few hours later, with a slightly different raw wastewater quality. In this case, the COD-removal was about 37 percent with a dosage of 150 ml/m^3 Fe-chloride, increasing to 53 percent removal with a 300 ml/m^3 dosage. The PO_4-removal was acceptable with a dosage of 200 ml/m^3 (see Figure 4.5).

Similar jar-tests were also performed on Monday morning (see Figures 4.6 and 4.7) with a raw wastewater with somewhat higher COD- concentrations. Acceptable COD-removal (~60 percent and ~50 percent) was achieved for Al-sulphate and Fe-chloride dosages of 150 g/m^3 and 300 ml/m^3, respectively. However, the dosages should be increased to 300 g/m^3 (ml/m^3) to obtain good PO$_4$-removal.

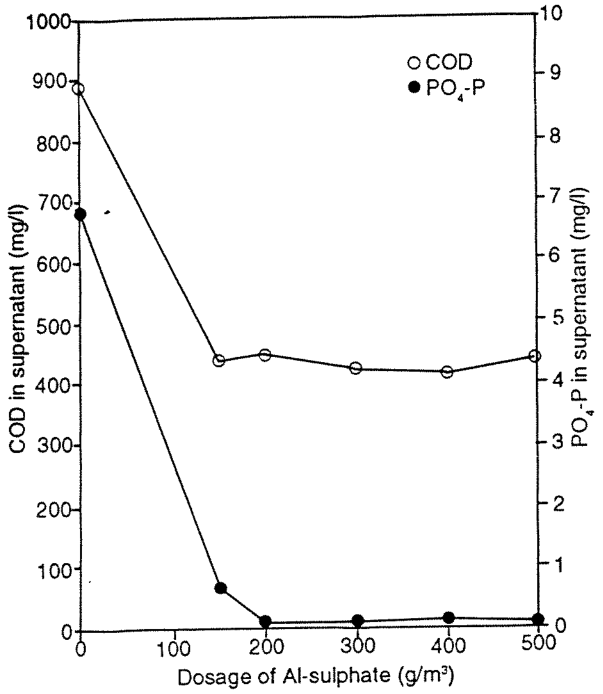

Figure 4.4 Results from jar-tests with Al-sulphate, November 16, 1991

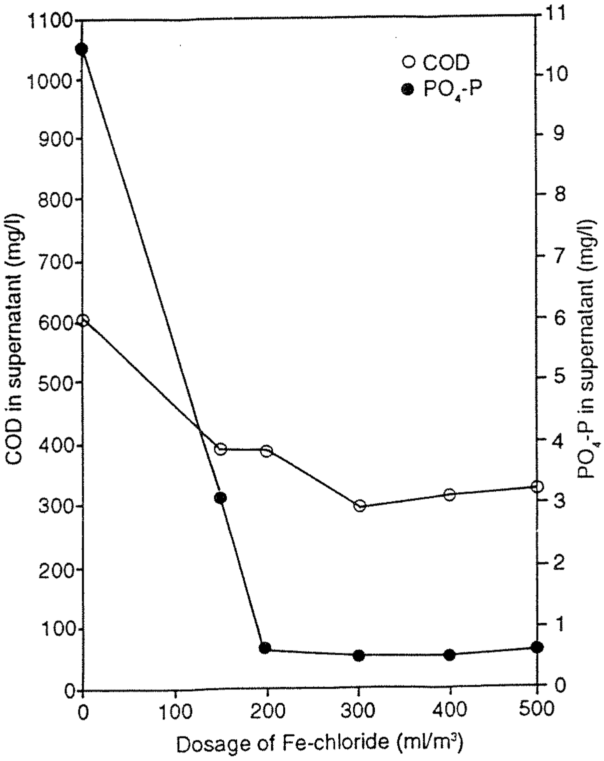

Figure 4.5 Results from jar-tests with Fe-chloride, November 16, 1991

4.5 Conclusion and Recommendation for Further Action

The Minsk Mazowiecki sewage treatment plant is not functioning properly, and the discharge permits are exceeded regularly. The major reason for this seems to be the discharge of wastewater from a dairy, resulting in organic overloading of the plant. The lack of sludge dewatering equipment is also a serious problem for the treatment plant.

The high organic loading on the plant could be managed by investing in pre-treatment facilities at the dairy, or an enlargement of the sewage treatment plant itself. Another solution without major investments may be to reduce the organic loading by introducing pre-precipitation with Al- or Fe-compounds at the sewage treatment plant. This alternative will also include a major reduction in the discharge of phosphorus to the recipient (see chapter 4.6). One important side-effect with pre-precipitation is the increase in sludge production, but the sludge handling problem has to be solved in any case, either by establishing a provisional dewatering lagoon or investing in mechanical dewatering equipment.

There are also several other actions to be taken for a general improvement of the plant operation and maintenance programme:

- Repairing the sludge scrapers in both primary and secondary settling tanks.
- Putting into operation all non-functioning flow meters for wastewater and sludge streams to facilitate a better process control.
- Establishing a "tailor-made" record system for all the data from measurements and analyses performed at the plant.
- Improving the operators' manual for the plant and run a course in sewage treatment plant operation and maintenance for operators and the management.

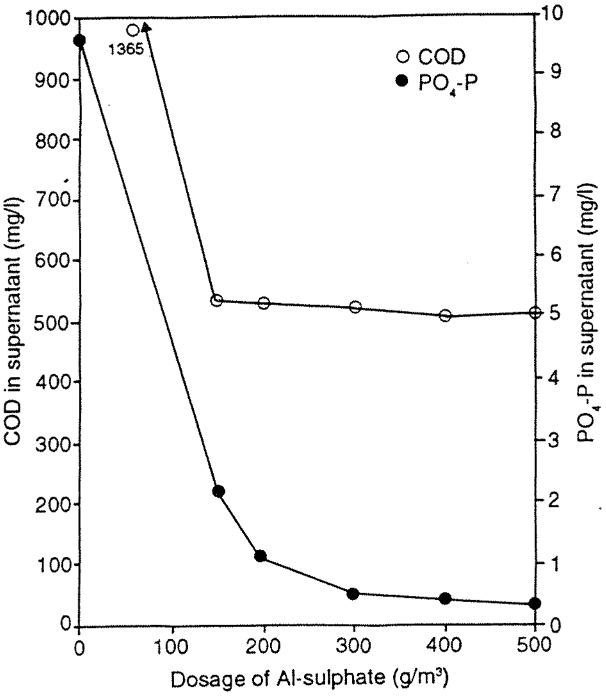

Figure 4.6 Results from jar-tests with Al-sulphate, November 18, 1991

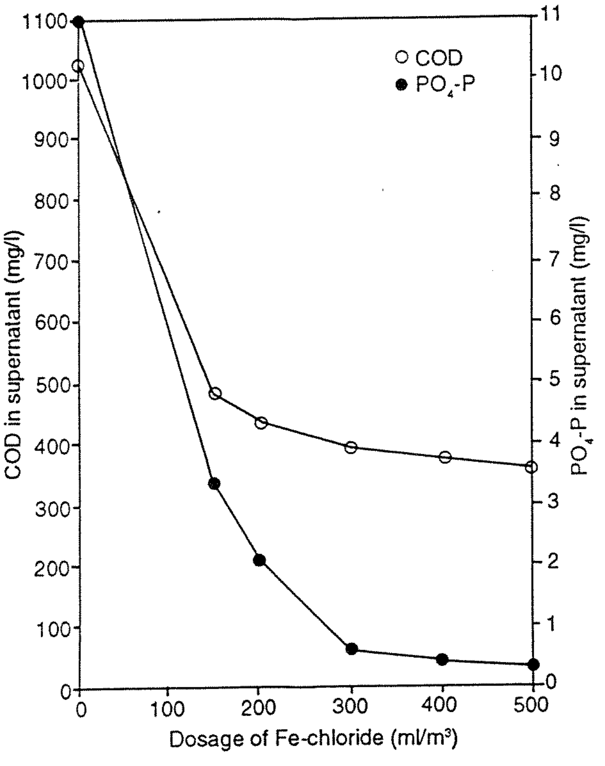

Figure 4.7 Results from jar-tests with Fe-chloride, November 18,1991

4.6. Proposal for Full Scale Testing of Chemical Precipitation

4.6.1 Objective

The main purpose of chemical precipitation at this treatment plant is to reduce the organic load on the biological treatment step due to the discharge of wastewater from the dairy. An additional effect of chemical precipitation will be a reduced discharge of phosphorus to the rivers Srebrna and Vistula.

4.6.2 Test programme

4.6.2.1 General

The programme proposed here is based on the data achieved in November 1991 during our first visit to the treatment plant. At that time we did not know the amount of wastewater coming from the dairy, and the results from our jar tests with chemical precipitation of raw wastewater (pre-precipitation) may not represent the worst situation with more industrial wastewater discharged to the plant. New jar tests just before starting the full scale testing are therefore recommended.

In Nov. 1991 both aluminium-sulphate and ferric-chloride were tested with good results. These tests indicated that there were small differences between the two chemicals. For full scale testing we therefore recommend the chemical which is cheapest and easiest to obtain in Poland.

4.6.2.2 Dosing point

The chemical should be added to the incoming wastewater after the pumping station and at a point with good mixing conditions. After initial mixing there should be minor turbulence to achieve larger flocs of the precipitates which can easily be removed in the primary sedimentation tank.

The Minsk Mazowiecki plant has a recirculation of surplus activated sludge to the inlet pumping station, and we should preferably dose the chemical upstream the mixing point of activated sludge and incoming sewage. The return of surplus activated sludge to the pumping station means a problem for the chemical precipitation, and this has to be discussed with the plant management. In any case there should be possibilities for changing the chemical dosing point by using a flexible hose from the dosing pump.

4.6.2.3 Dosing rate and chemical consumption

Based upon the previous jar tests, a chemical dosing rate of approx. 300 g/m^3 (Al- sulphate) or 300 ml/m^3 (Fe-chloride) should be appropriate to start with, but a higher contribution of dairy-wastewater may need even higher dosing rates.

With an average wastewater flow of 7000 m^3/d, the daily chemical consumption will be approx. 2100 kg Al-sulphate or 2100 litres Fe-chloride.

A chemical storage tank of approx. 15 m^3 will be necessary.

4.6.2.4 Monitoring, sampling and analyses

The effect of chemical precipitation should be determined by taking composite samples at three different places:

1. The influent (raw wastewater) before any return streams (surplus activated sludge etc.) are mixed with the wastewater.
2. The influent to the aeration tank (after primary sedimentation).
3. The effluent from the plant (after secondary sedimentation).

Automatic samplers (controlled by a timer) should be installed at the three places, and for each of them 3 samples should be collected every week; one covering Monday and Tuesday (48 hours composite sample), one covering Wednesday and Thursday (48 hours composite sample) and the last one covering Friday through Monday (72 hours composite sample).

The samples should be analysed for:

- BOD_5
- COD
- Suspended solids
- Total phosphorus
- Orthophosphate

In addition the pH-value should be measured every day in the influent to the aeration tank and in the effluent from the plant. These pH-measurements should be done at the plant and not in the laboratory.

4.6.2.5 Test period

The total test period should be 3-4 weeks in order to achieve some experience with the effects of reduced loadings on the biological treatment step.

4.6.2.6 Side effects of chemical precipitation

With the pre-precipitation system, there will be an increased amount of sludge that has to be removed from the primary sedimentation basin. The sludge pumping capacity and the capacity of succeeding sludge treatment units should therefore be checked during the test period.

Addition of Al- or Fe-compounds will not reduce the sludge value as an organic fertilizer for agricultural use.

5. PLONSK SEWAGE TREATMENT PLANT

5.1 General Information

Plonsk is a town in the Ciechanow region with a population of about 21 000. The town is situated about 65 km north-west of Warsaw.

About 86 percent of the population are connected to the municipal sewerage system. The rest have septic tanks and the septage are emptied and discharged to the main collector to the treatment plant or have other individual solutions.

According to the Statistical Information on Environmental Protection, 1991, the water used in 1990 from the water supply systems in the whole Ciechanow region, was in the order of:

- total	10 900 000 m^3/y	or	1 244 m^3/h
- towns	7 300 000 m^3/y	or	833 m^3/h
- villages	3 600 000 m^3/y	or	410 m^3/h

and per persons:

- total	25.5 m^3/y	or	70 l/pd
- towns	49.9 m^3/y	or	138 l/pd
- villages	13.4 m^3/y	or	38 l/pd

Some industrial activities exist in the town. The biggest is a fruit processing factory, Hortex, working in the season from the middle of June to the middle of November), and WEDEL (chocolate factory).

The wastewater discharged by the municipal sewerage system is:

- total	9 700 000 m^3/y
- households	6 000 000 m^3/y
- industry	1 700 000 m^3/y
- other sources	2 000 000 m^3/y

of which 5 400 000 m^3/y are treated mechanically, 3 000 000 m^3/y are treated mechanically-biologically, and 1 300 000 m^3/y are untreated.

All the 9 towns in the district have sewerage systems, 5 are connected to the mechanical treatment plants and 4 to the mechanical-biological treatment plants.

5.2 Treatment Plant Facilities

The existing wastewater treatment plant is a conventional mechanical-biological treatment plant with:

- grit chamber
- primary sedimentation (2)
- aeration tanks
- secondary sedimentation (2)
- open fermentation basins (2) and drying beds (32)

The actual load of the plant is depending on whether the fruit processing factory is operating or not.

Load when fruit factory in operation:	7 000 m^3/d
Load when fruit factory not in operation:	5 000 m^3/d

where about 250 - 300 m^3/d origin from the septic tanks.

Table 5.1 The loading of the plant.

Parameters	Influent concentrations in season	 out of season	Effluent standards
BOD (mg/l)	700-1200	300 - 700	32
COD (mg/l)	1000-3000	700 -1200	150
SS (mg/l)	600-1000	300-500	55

The treatment plant is discharging to river Plonka which is connected further to river Vistula via river Wkra.

The manager of the plant is directly under the Water and Sewerage Directory which is under the management of the municipality.

There are 25 employees at the treatment plant divided into the following categories:

1 manager
1 foreman
8 plant operators
4 sludge operators

3 chemists
4 mechanics
4 electricians

5.3 Operation Performance and Problems

According to the plant management, the plant is operating fairy well outside the season for fruit and vegetables processing at the Hortex company (from mid-November to mid-June). The results from our own investigations (November 19-20) confirm this statement (see Chapter 5.4.2).

During the summer and early autumn, the discharge of wastewater from Hortex increases the organic load on the plant to such an extent that problems occur in the activated sludge system. The most distinctive problem is sludge bulking, resulting in uncontrolled sludge wasting from the secondary settling tank and reduced biomass in the aeration tank to oxidize the incoming organic matter.

Another factor causing problems is the insufficient capacity of the sludge drying beds due to high sludge production and low dewatering rate.

5.4 Results of Investigations

During our visit, flow proportional daily composite samples were taken from both the influent (raw wastewater) and the effluent of the plant. Variations during the day in raw wastewater quality were determined by taking 2 hour composite samples. The wastewater flow was monitored continuously with a transportable flow-meter. Jar-tests were performed to obtain some information about the possibilities of reducing the organic load on the plant with pre-precipitation, either with Al- or Fe-compounds.

5.4.1 Wastewater Flow

The wastewater flow after the grit chamber (and the inlet pumping station) was monitored continuously for approximately one day (from 1:40 p.m. on Tuesday, November 19, to 11:40 a.m. on Wednesday, November 20). The results are presented in Figure 5.1. Due to the inlet pumping station, the flow through the plant was nearly constant at 140 l/s whenever the pump was in operation, and the variations in wastewater flow during 24 hours can be seen from a somewhat longer period of no pumping during the night- time.

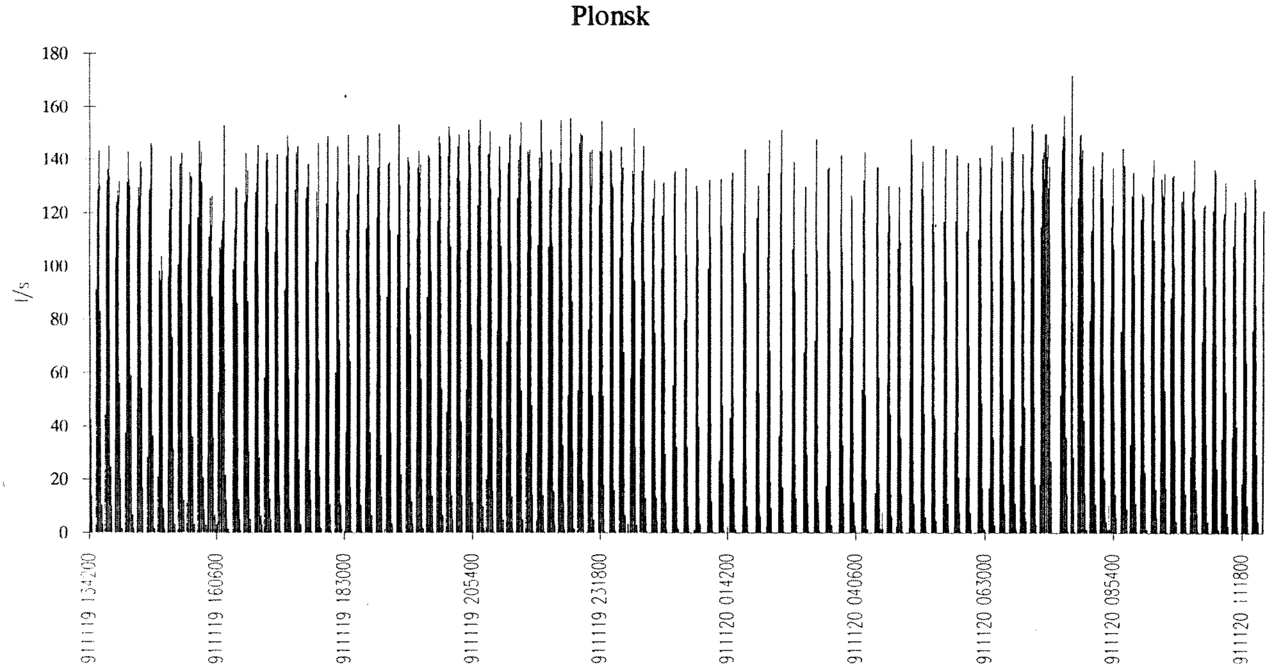

Figure 5.1 Wastewater flow during November 19-20, 1991

5.4.2 Wastewater Quality and Plant Removal Efficiency

The results from our sampling programme are presented in Appendix 5.1. Unfortunately, most of the BOD-data had to be rejected, since the given values were higher than the corresponding COD- values. Figure 5.2 shows the variations in raw wastewater COD- concentration, and this diagram indicates that there is minor influence of industrial wastewater during the day of investigation.

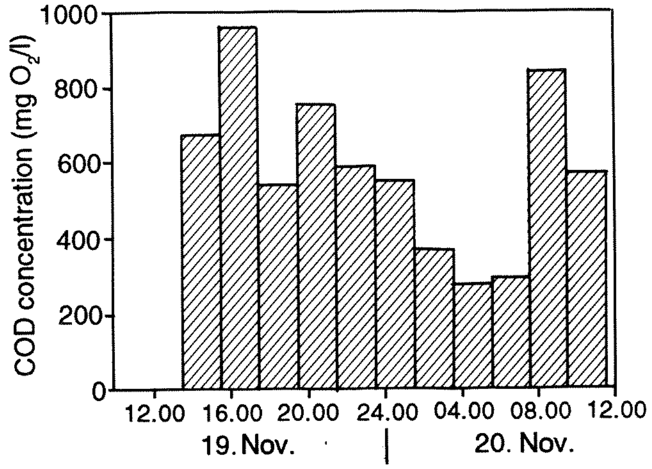

Figure 5.2 Variation in raw wastewater COD-concentration during November 19-20, 1991

The results from the composite samples of influent and effluent wastewater are presented in Table 5.2.

Table 5.2 Removal of COD, BOD_5, and suspended solids (SS) in Plonsk sewage treatment plant during November 19-20, 1991.

	Influent (mg/l)	Effluent (mg/l)	Percent removal
COD	392	43	89
BOD_5	---	10	--
SS	243	3	99

The results in Table 5.2 prove that the plant functioned very well during our visit. This is, however, not surprising, since the actual loading (both organic and hydraulic) was quite normal in this period, with an estimated average BOD-load of 0.2 kg BOD_5/kg MLSS d, and a maximum overflow rate in secondary clarifier of 0.1 m^3/m^2 h.

5.4.3 Jar-tests

The results from the two jar-tests are summarized in Appendix 5.2, and Figures 5.3 and 5.4 present the COD and PO_4-P concentrations in the supernatant as a function of the chemical dosage.

In the first jar-test with Al-sulphate, about 50 percent COD removal was obtained with a dosage of 200 g/m^3 of Al-sulphate, and the orthophosphate concentration was reduced to 0.3 mg P/l.

With Fe-chloride, even better results were obtained (60 percent COD- removal) with a dosage of 200 ml/m^3 of Fe-chloride. For this dosage, the orthophosphate concentration was reduced to 0.7 mg P/l, and further reduction was possible with increasing chemical dosage.

5.5 Conclusions and Recommendations for Further Actions

The Plonsk sewage treatment plant is not functioning properly during about 6 months a year. The major reason for this seems to be the discharge of wastewater from a fruit and vegetable processing industry ("Hortex"), resulting in organic overloading of the plant. The lack of sludge dewatering equipment is also a serious problem for the treatment plant.

The high organic loading on the plant could be managed by investing in pre-treatment facilities at the Hortex factory, or an enlargement of the sewage treatment plant itself. Another solution without major investments may be to reduce the organic loading by introducing pre-precipitation with Al- or Fe-compounds at the sewage treatment plant. This alternative will also include a major reduction in the discharge of phosphorus to the recipient (see Chapter 5.6). One important side-effect with pre-precipitation is the increase in sludge production, but the sludge handling problem has to be solved in any case, either by establishing a provisional dewatering lagoon or investing in mechanical dewatering equipment.

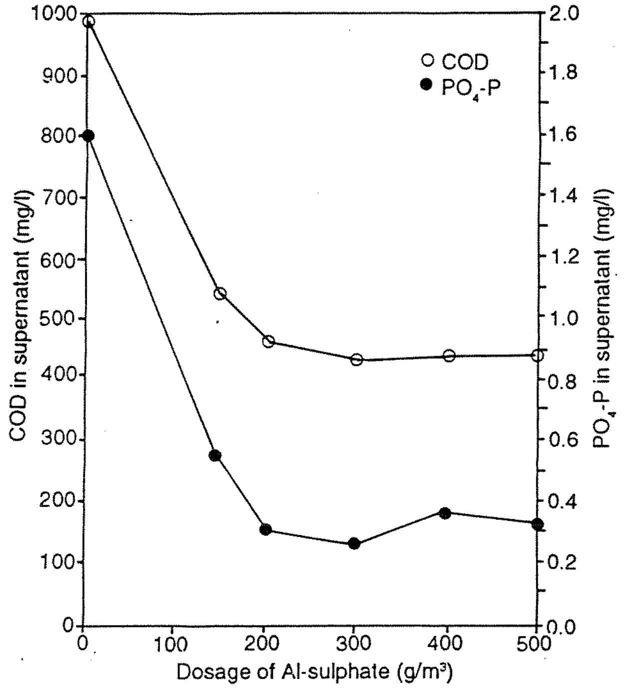

Figure 5.3 Results from jar-tests with Al-sulphate

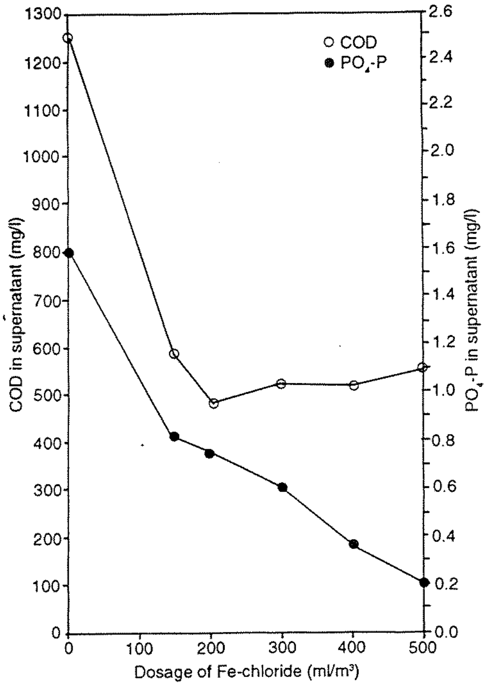

Figure 5.4 Results from jar-tests with Fe-chloride

There are also some other actions to be taken for a general improvement of the plant operation and maintenance program:

- Put into operation all non-functioning flow meters for wastewater and sludge streams to facilitate a better process control.
- Establish a "tailor-made" record system for all the data from measurements and analyses performed at the plant.
- Improve the operators' manual for the plant and run a course in sewage treatment plant operation and maintenance for operators and the management.

5.6 Proposal for Full Scale Testing of Chemical Precipitation

5.6.1 Objective

The main purpose of chemical precipitation at this treatment plant is to reduce the excessive organic load on the biological treatment step due to the seasonal discharge of industrial wastewater. An additional effect of chemical precipitation will be a reduced discharge of phosphorus to the river Plonka.

5.6.2. Test program

5.6.2.1 General

The programme proposed here is based on the data achieved in Nov. 1991 during our first visit to the treatment plant. At that time the contribution of wastewater from the "Hortex" company was small, and the results from our jar tests with chemical precipitation of raw wastewater (pre-precipitation) may not represent the situation with more industrial wastewater discharged to the plant. New jar tests just before starting the full scale testing are therefore recommended.

In Nov. 1991 both aluminium-sulphate and ferric-chloride were tested with good results. These tests indicated that ferric-chloride gave the best COD-reduction and aluminium-sulphate the best P-reduction, but the differences were small. For full scale testing we therefore recommend to use the chemical which is cheapest and easiest to obtain in Poland.

5.6.2.2 Dosing point

The chemicals should be added to the wastewater at a point with good mixing conditions, but after initial mixing there should be minor turbulence to achieve larger flocs of the precipitates which can easily be removed in the primary sedimentation tank.

The Plonsk plant has a recirculation of surplus activated sludge to the grit chamber, and we should preferably dose the chemicals upstream the mixing point of activated sludge and incoming sewage. In any case there should be possibilities for changing the chemical dosing point by using a flexible hose from the dosing pump.

5.6.2.3 Dosing rate and chemical consumption

Based upon the previous jar tests, a chemical dosing rate of approx. 200 g/m^3 (Al- sulphate) or 200 ml/m^3 (Fe-chloride) should be appropriate to start with, but a higher contribution of "Hortex"-wastewater may need even higher dosing rates.

With an average wastewater flow of 7000 m^3/d, the daily chemical consumption will be approx. 1400 kg Al-sulphate or 1400 litres Fe-chloride.

A chemical storage tank of approx. 10 m^3 will be necessary.

5.6.2.4 Monitoring, sampling and analyses

The effect of chemical precipitation should be determined by taking composite samples at three different places:

1. The influent (raw wastewater) before any return streams (surplus activated sludge etc.) are mixed with the wastewater.

2. The influent to the aeration tank (after primary sedimentation).

3. The effluent from the plant (after secondary sedimentation).

Automatic samplers (controlled by a timer) should be installed at the three places and for each of them, 3 samples should be collected every week; one covering Monday and Tuesday (48 hours composite sample), one covering Wednesday and Thursday (48 hours composite sample) and the last one covering Friday through Monday (72 hours composite sample).

The samples should be analysed for:

- BOD_5
- COD
- Suspended solids
- Total phosphorus
- Orthophosphate

In addition the pH-value should be measured every day in the influent to the aeration tank and in the effluent from the plant. This pH-measurements should be done at the plant and not in the laboratory.

5.6.2.5 Test period

The total test period should be 3-4 weeks in order to achieve some experience with the effects of reduced loadings on the biological treatment step.

5.6.2.6 Side effects of chemical precipitation

With the pre-precipitation system, there will be an increased amount of sludge that has to be removed from the primary sedimentation basin. The sludge pumping capacity and the capacity of succeeding sludge treatment units should therefore be checked during the test period.

Addition of Al- or Fe-compounds will not reduce the sludge value as an organic fertilizer for agricultural use.

6. OTHER SEWAGE TREATMENT PLANTS VISITED

In addition to the three sewage treatment plants described above, the following sewage treatment plants have been visited:

- Grajewo sewage treatment plant
- Grajewo industrial wastewater treatment plant
- Lapy sewage treatment plant
- Pruszkow treatment plant.

The manager of the last one did not want to take part in any experiments. His problem was lack of funds to extend the plant according to his plans. Thus no information have been collected.

Grajewo industrial wastewater treatment plant was recently put into operation. The plant received wastewater mainly from a dairy and had no major operational problems. The operational capacity was in the order of 2 500 m^3 per day, the design capacity 2 700 m^3 per day.

The Grajewo and Lapy sewage treatment plants were investigated according to the checklists used in this project and the data made available by the plant managers. The checklists are presented in Appendix 1.1.

Based on an evaluation of all the plants visited, the plants mentioned in this chapter did not get priority for further investigation.

APPENDICES

APPENDIX 1.1

CHECKLISTS

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Registration of Treatment Plants

Name of plant Łomza	Location	Recipient River Narew	Evaluated by Stene-Johansen/ Paulsrud
Municipality Łomza	Head of operation	Education	Date of insp. 13.11.91

Treatment plant data

Type of plant Activated sludge plant with step Loading			Designed by
Start of operation	Design pe. 50.000	Actual pe.	Location for sludge disposal Sanitory Landfill
Sewerage system [✓ Comb.] [✓ Sep.] Both types	Evaluation		
Pumping [✓ Yes] No	Effect on treatment With 1 pump: Q ≈ 180 l/s, With 2 pump: Q ≈ 400 l/s		
Industry [✓ Yes] No	Type Textile industry		
Possibilities for changing the process, rehabilitation/upgrading			

Comments: Septic tank sludge is added to the treatment plant inlet (average amounts 1900 m³/month or 65 m³/day, but great variations during the year)

Treatment plant facilities

Overflow	Screen	Grit chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank Reactivation.	Settling tank 2	Flocculation	Settling tank 3	Chlorination
V	V	V	V			V		V			

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centrifuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
		Λ		Λ				Λ		Λ		

Symbols: V = indicate the existing facilities

Comments: Cold anaerobic digestion in open basins.
Storage in Lagoons.
Sludge disposal at sanitary Landfill due to high content of heavy metals in the sludge.

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Registration of Treatment Plants

Name of plant Minsk Mazowiecki	Location	Recipient River Srebrna	Evaluated by Stene - Johansen / Paulsrud
Municipality Minsk Mazowiecki	Head of operation	Education	Date of insp. 16.11.91

Treatment plant data

Type of plant Conventional activated sludge plant			Designed by CTBK
Start of operation 1987	Design ~~per~~ 10000 m^3/d	Actual ~~pe.~~ 6800 m^3/d	Location for sludge disposal
Sewerage system [✓ Comb.] 30%, [✓ Sep.] 70%	Evaluation		
Pumping [✓ Yes] No	Effect on treatment		
Industry [✓ Yes] No	Type Dairy + same workshops		
Possibilities for changing the process, rehabilitation/upgrading			
Comments:			

Treatment plant facilities

Overflow	Screen	Grit chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank Reactiv-ation.	Settling tank 2	Floccu-lation	Settling tank 3	Chlorination
	✓	✓	✓			✓		✓			

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centri-fuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
		✓		✓				✓	✓			

Symbols: V = indicate the existing facilities

Comments: Thickening takes place in the old Jmhofftank after anaerobic digestion.
Drying beds does not function at all, due to blocked drainage system.

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Registration of Treatment Plants

Name of plant Ptonsk	Location	Recipient River Ptonka	Evaluated by Stene-Johansen/ Paulsrud
Municipality Ptonsk	Head of operation	Education	Date of insp. 17.11.91

Treatment plant data

Type of plant Activated sludge plant			Designed by CTBK
Start of operation 1981	Design ~~pe.~~ 8760 m^3/d	Actual ~~pe.~~ ~ 7000 m^3/d	Location for sludge disposal Up to now some is stored at the plant and some at the sanitary landfill
Sewerage system Comb. [✓ Sep.]	Evaluation Rain water from some industrial areas is connected to the separate sewer system		
Pumping [✓ Yes] No	Effect on treatment		
Industry [✓ Yes] No	Type. Fruit and vegetables processing (june - november) + chocolate factory		
Possibilities for changing the process, rehabilitation/upgrading			

Comments: Fruits & vegetables factory has pretreatment:
Small Imhofftank with very little effect.

Treatment plant facilities

Overflow	Screen	Grit chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank Reactiv-ation.	Settling tank 2	Floccu-lation	Settling tank 3	Chlorination
	✓	✓	✓			✓		✓			✓

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centri-fuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
				✓				✓		✓		

Symbols: V = indicate the existing facilities

Comments: Surplus activated sludge are recirculated to the grit chamber and mixed with incomming sewage.
Mixed primary/activated sludge is removed from the primary clarifier. The inlet pumping station is outside the treatment plant area.

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Registration of Treatment Plants

Name of plant Grajewo municipal w.w.t.p.	Location	Recipient	Evaluated by Stene-Johansen/ Pawlowski
Municipality Grajewo	Head of operation	Education	Date of insp. 14.11.91

Treatment plant data

Type of plant Imhofftank + trickling filter			Designed by Project bureau in Warzaw
Start of operation 1961	Design ~~pe.~~ 4500 m^3/d	Actual pe. 15000-17000	Location for sludge disposal Sanitary Landfill
Sewerage system Comb. [✓ Sep.]	Evaluation		
Pumping [✓ Yes] No	Effect on treatment		
Industry Yes [✓ No]	Type Separate treatment for the diary wastewater		
Possibilities for changing the process, rehabilitation/upgrading			

Comments: Q_{actual} = 3250-5100 m^3/d. Flow measured 4-6 times per day by recording height in measuring channel. The plant normally don't exceed the effluent standards.

Treatment plant facilities

Overflow	Screen	Grit chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank	Settling tank 2	Floccu-lation	Settling tank 3	Chlorination
							Reactiv-ation.				
	✓	✓	✓	✓				✓			

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centri-fuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
		✓						✓		✓		

Symbols: V = indicate the existing facilities

Comments: Primary sedimentation is a Imhofftank with cold digestion of both primary sludge and humus sludge.
Working 3 shifts.
1 manager + 10 operators
No sampling, they had a laboratory earlier, but this was closed down.

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Registration of Treatment Plants

Name of plant Grajewo industrial w.w.p.t.	Location Grajewo	Recipient	Evaluated by Stene-Johansen / Paulsrud
Municipality Grajewo	Head of operation	Education	Date of insp. 14.11.91

Treatment plant data

Type of plant Activated sludge plant with Kessner brushes			Designed by
Start of operation 1981	Design ~~pe.~~ 2700 m^3/d	Actual ~~pe.~~ 2500 m^3/d	Location for sludge disposal Sanitary Landfill
Sewerage system Comb. [✓ Sep.]	Evaluation		
Pumping [✓ Yes] No	Effect on treatment		
Industry [✓ Yes] No	Type Diary		
Possibilities for changing the process, rehabilitation/upgrading			
Comments:			

Treatment plant facilities

Overflow	Screen	Grit, chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank Reactiv-ation.	Settling tank 2	Floccu-lation	Settling tank 3	Chlorination
	✓	✓				✓		✓			

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centri-fuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
								✓		✓		

Symbols: V = indicate the existing facilities

Comments:

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Registration of Treatment Plants

Name of plant łapy	Location	Recipient Awissa to river Narew	Evaluated by Steve-Johansen / Pawlsud
Municipality łapy	Head of operation	Education Technician	Date of insp. 15.11.91

Treatment plant data

Type of plant Activated sludge plant			Designed by Buro Projectow Budownictwa Komunalnego
Start of operation 1973	Design pe.	Actual.~~pe.~~ 6500 m^3/d	Location for sludge disposal City green areas
Sewerage system [✓ Comb.] [✓ Sep.] 50% 50%	Evaluation		
Pumping [✓ Yes] No	Effect on treatment None		
Industry [✓ Yes] No	Type Dairy production: milk, butter and cheese		

Possibilities for changing the process, rehabilitation/upgrading

No equalization or neutralization at the diary

Comments: 70% of the load is municipal wastewater
30% of the load is industrial wastewater (mainly from the dairy)

Amount of diary wastewater : Average 1000 - 1500 m^3/d

Treatment plant facilities

+ Lagoons for 1 line

Overflow	Screen	Grit chamber	Settling tank 1	Biofilter	Biodisc	Aeration tank	Cont.tank / Reactivation.	Settling tank 2	Floccu-lation	Settling tank 3	Chlorination
	✓	✓	✓			✓		✓			

Thickening	Stabilization		Storage		Dewatering				Sludge disposal			
	Aerobic	Anaerobic	With air	Without air	Centri-fuge	Belt press	Filter press	Drying bed	Lagoon	Landfill	Agricult.	Parks/ gardens
✓				✓				✓				✓

Symbols: V = indicate the existing facilities

Comments:
Storage in large tanks (½ year detention time with some digestion during summer)

APPENDIX 3.1

LOMZA - RESULTS OF THE WASTEWATER SAMPLING PROGRAMME

LOMZA - 13-14. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD$_5$ mgO$_2$/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 11.37 - 13.37	427		104	9,2	3,6	54		0,29
Raw sewage 13.37 - 15.37	595		411	13,3	5,3	37		0,21
Raw sewage 15.37 - 17.37	547			11,9	6,9	55		0,13
Raw sewage 17.37 - 19.37	413	210	48	11,5	6,0	45		0,26
Raw sewage 19.37 - 21.37	355		69	6,9	1,5	34		0,30
Raw sewage 21.37 - 23.37	691			13,1	7,8	23		0,15
Raw sewage 00.37 - 05.37	216		52	2,5 *	1,7	56		0,23
Raw sewage 05.37 - 07.37	278		106	3,2 *	2,7	45		0,23
Raw sewage 07.37 - 08.37	350			10,8	4,3	28		0,18
Raw sewage, composite sample	317	157	221	5,4 *	4,9	28		0,25
Treated effluent, composite sample	43	10	20	6,5	0,93 *			6,9

LOMZA - 14. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD_5 mgO_2/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 09.30 - 11.30	377	-	286	4,3*	4,0	56	52	0,31
Raw sewage 11.30 - 13.30	440	107	355	6,3	4,3	37	32	0,30
Raw sewage 13.30 - 15.30	460	107	288	7,7	5,9	50	48	0,25
Raw sewage 15.30 - 17.30	348	124	313	8,8	6,6	48	44	0,26
Raw sewage 17.30 - 19.30	339	107	252	8,4	4,9	42	39	0,27
Raw sewage 19.30 - 21.30	337	78	101	7,9	3,6	34	32	0,24
Raw sewage, composite sample	407	120	199	8,2	3,8	32	30	0,26
Treated effluent, composite sample	37	7	26	7,7	5,9	34*	30*	6,2*

APPENDIX 3.2

Lomza - Results of Jar-tests

14. Nov. 1991

Type of coagulant	Coagulant dosage (mg/l)	Orthophosphate (mgP/l)	Total phosphorus (mgP/l)	COD (mgO/l)	Suspended solids (mg/l)
$Al_2(SO_4)_3 \cdot 14\ H_2O$	0	5,9	8,0	219	
	150	0,89	1,2	39	
	200	0,59	0,98	47	
	300	1,2	1,5	29	
	400	0,20	1,1	38	
	500	0,52	0,92	40	
$FeCl_3 \cdot 7\ H_2O$	0	4,6	7,3	432	
	150	2,8	5,9	288	
	200	2,0	5,6	274	
	300	2,3	2,9	274	
	400	1,2	2,4	259	
	500	0,39	4,2	206	

APPENDIX 4.1

MINSK MAZOWIECKI - RESULTS OF THE WASTEWATER SAMPLING PROGRAMME

MINSK MAZOWIECKI 16. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD_5 mgO_2/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 11.05 - 13.05	2009	750	450	15,6	14,3	88*	40	1,6
Raw sewage 13.05 - 15.05	1833	710	393	16,2	10,0	60*	29	1,6
Raw sewage 15.05 - 17.05	985	420	374	15,9	9,0	61*	25	0,79
Raw sewage 17.05 - 19.05	975	380	378	9,0	8,4	86*	30	0,49
Raw sewage 19.05 - 21.05	985	360	290	10,1	7,6	167*	24	0,55
Raw sewage 21.05 - 22.05	780	380	216	21,5	8,1	77*	25	0,56
Raw sewage, composite sample	605*	400	203	19,6	8,5	106*	31	0,71
Treated effluent, composite sample	210	36	101	19,4	8,4	99*	26	0,64

MINSK MAZOWIECKI - 17-18. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD_5 mgO_2/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 11.30 - 13.30	814	660	389	30,2	7,4	97*	27	0,27
Raw sewage 13.30 - 15.30	560	480	327	18,0	6,0	93*	29	0,34
Raw sewage 15.30 - 17.30	605	490	283	19,1	7,5	104*	28	0,27
Raw sewage 17.30 - 19.30	536	450	268	21,2	7,8	139*	29	0,29
Raw sewage 19.30 - 21.30	532	390	133	25,5	7,8	131*	35	0,31
Raw sewage 21.30 - 23.30	465	280	173	18,6	7,2	129*	28	0,19
Raw sewage 23.30 - 01.30	282	200	186	13,5	6,5	99*	28	0,09
Raw sewage 01.30 - 03.30	234	209	58	12,7	5,6	48*	18	0,05
Raw sewage 03.30 - 05.30	224	195	119	13,8	4,9	47*	14	0,13
Raw sewage 05.30 - 07.30	146	139	100	18,6	14,4*	129*	30	0,25
Raw sewage, composite sample	429	297	150	15,9*	8,0*	111*	26	0,21
Treated effluent, composite sample	143	40	62	7,0	2,1	99*	22	0,2

MINSK MAZOWIECKI - 18-19. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD_5 mgO_2/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 09.00 - 11.00	600	500	216	19,3		150*	30	0,61
Raw sewage 11.00 - 13.00	607	450	140	20,4		240*	36	0,89
Raw sewage 13.00 - 15.00	400	350	200	21,5		240*	47	0,79
Raw sewage 15.00 - 17.00	558	410	198	24,2		163*	44	0,97
Raw sewage 17.00 - 19.00	412	345	101	26,8		198*	30	0,76
Raw sewage 19.00 - 21.00	364	270	109	31,3		201*	31	0,76
Raw sewage 21.00 - 23.00	243	190	104	29,7		202*	36	0,69
Raw sewage 23.00 - 01.00	257	210	200	24,4		203*	35	0,7
Raw sewage 01.00 - 03.00	230	170	175	40,8		203*	37	0,67
Raw sewage 03.00 - 05.00	279	230	154	33,0		197*	35	0,62
Raw sewage 05.00 - 07.00	339	280	163	19,1		193*	34	0,77
Raw sewage 07.00 - 09.00	364	300	180	23,1		182*	33	0,54
After primary sedimentation, composite sample	509*	345	131	52,5*		231*	36	0,9
Treated effluent, composite sample	204	48	75	22,5		183*	31	0,78

APPENDIX 4.2

Minsk Mazowiecki - Results of Jar-tests

16. Nov. 1991

Type of coagulant	Coagulant dosage (mg/l)	Orthophosphate (mgP/l)	Total phosphorus (mgP/l)	COD (mgO/l)	Suspended solids (mg/l)
$Al_2(SO_4)_3 \cdot 14H_2O$	0	6,9		894	529
	150	0,69		439	80
	200	0,08		449	37
	300	0,07		419	142
	400	0,08		410	100
	500	0,08		439	47
$FeCl_3 \cdot 7H_2O$	0	10,7		618	626
	150	3,1		390	1049 (fat)
	200	0,65		390	49
	300	0,49		293	180
	400	0,49		312	48
	500	0,52		321	153

18. Nov. 1991

Type of coagulant	Coagulant dosage (mg/l)	Orthophosphate (mgP/l)	Total phosphorus (mgP/l)	COD (mgO/l)	Suspended solids (mg/l)
$Al_2(SO_4)_3 \cdot 14H_2O$	0	9,7	16,7	1365	568
	150	2,1	7,4	536	18
	200	1,1	4,9	527	15
	300	0,49	8,3 •	517	14
	400	0,39	10,7 •	502	14
	500	0,33	3,3	507	17
$FeCl_3 \cdot 7H_2O$	0	11,0	53,6	1024	530
	150	3,3	31,8	488	19
	200	2,1	7,7	439	15
	300	0,59	8,5	390	16
	400	0,39	22,0 •	375	15
	500	0,29	5,3	360	14

APPENDIX 5.1

PLONSK - RESULTS OF THE WASTEWATER SAMPLING PROGRAMME

PLONSK - 19.-20. NOV. 1991

Sampling point and type of sample	COD mgO/l	BOD_5 mgO_2/l	Suspended Solids mg/l	Total phosphorus mgP/l	Orthophosphate mgP/l	Total nitrogen mgN/l	Ammonia nitrogen mgN/l	Nitrate nitrogen mgN/l
Raw sewage 13.40 - 15.40	666	800*	449	3,7	2,5	61	40	0,1
Raw sewage 15.40 - 17.40	960	1120*	313	4,1	1,8	38	18	0,2
Raw sewage 17.40 - 19.40	539	450	215	3,6	1,8	34	16	0,2
Raw sewage 19.40 - 21.40	755	380	174	2,9	2,4	37	19	0,2
Raw sewage 21.40 - 23.40	588	410	223	4,7	1,6	33	17	0,2
Raw sewage 23.40 - 01.40	549	800*	191	2,8	1,6	33	13	0,2
Raw sewage 01.40 - 03.40	372	840*	96	3,8	1,2	24	10	0,2
Raw sewage 03.40 - 05.40	274	500*	54	2,9	1,4	7*	7	0,2
Raw sewage 05.40 - 07.40	294	400*	105	2,5	1,3	21	10	0,2
Raw sewage 07.40 - 09.40	843	840*	314	4,1	2,4	59	34	0,1
Raw sewage 09.40 - 11.40	568	480*	185	3,2	1,8	46	19	0,1
Raw sewage, composite sample	392	480*	243	3,7	1,5	34	15	0,1
Treated effluent, composite sample	43	10*	3	2,4	0,49	2*	0,5*	0,7

APPENDIX 5.2

Plonsk - Results of Jar-tests

19. Nov. 1991

Type of coagulant	Coagulant dosage (mg/l)	Orthophos-phate (mgP/l)	Total phosphorus (mgP/l)	COD (mgO/l)	Suspended solids (mg/l)
$Al_2(SO_4)_3 \cdot$ 14 H_2O	0	1,6		986	501
	150	0,53		538	265
	200	0,31		459	269
	300	0,26		426	234
	400	0,36		436	252
	500	0,33		436	252
$FeCl_3 \cdot$ 7 H_2O	0	1,6		1254	552
	150	0,82		582	25
	200	0,75		481	14
	300	0,60		515	33
	400	0,35		515	29
	500	0,21		538	21