

Upgrading of Wastewater Treatment Plants in Poland

PHASE II



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Municipal
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Abstract:

During the first Phase, diagnostic studies have been carried out at selected treatment plants in order to identify problems and how to improve treatment efficiency (Report 1st. Phase).

The report in hand (2nd. Phase) gives recommendations for upgrading/rehabilitation and other improvements based on full scale experiments at selected treatment plants.

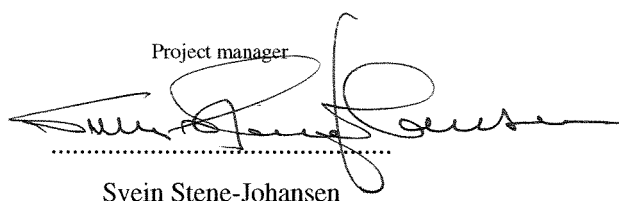
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UPGRADING OF WASTEWATER TREATMENT PLANTS IN POLAND PHASE II

Oslo, December 1994

**Svein Stene-Johansen
Project Manager**

Preface

The project described below is part of the Programme of Cooperation between the Norwegian Ministry of Environment and the Ministry of Environmental Protection, National Resources and Forestry in the Republic of Poland.

The project has been executed by the Norwegian Institute for Water Research, NIVA in cooperation with Aquateam A/S. As Polish cooperation partner, the Polish Ministry appointed Centrum Techniki Budownictwa Komunalnego (TBK).

The team engaged in the project consisted of the following members:

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

The project manager would especially like to thank the main author of this report, Mr. Bjarne Paulsrud, who also acted as project manager during my long time visit to India in 1993/94.

December 1994

Svein Stene-Johansen
Project Manager

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1 Introduction

This report summarizes the results obtained during Phase II of the joint Polish/Norwegian project "Upgrading of Wastewater Treatment Plants in Poland". In Phase I of this project three existing biological wastewater treatment plants were selected for full scale testing with chemical pre-precipitation. These plants were situated in Plonsk, Lomza and Minsk Mazowiecki. General information about the plants, results of preliminary jar tests and test programmes for the full scale trials were included in the Phase I-report.

In general, the main problem of the three plants was caused by periodically organic overloading, due to discharge of untreated and non-equalized industrial wastewaters. The normal way of handling such problems would be to install proper pretreatment of the industrial wastewater at the factories, but for economical reasons this could only be a long term solution. In the meantime the joint project wanted to demonstrate how pre-precipitation with ferric-sulphate (PIX) at the municipal wastewater treatment plant could reduce the negative effects of the industrial wastewater discharges. An additional effect of dosing coagulants will be a reduced discharge of phosphorus to the receiving waters.

For each plant the effect of chemical pre-precipitation was 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 pre-precipitation and primary sedimentation).
3. The effluent from the plant (after secondary sedimentation).

Automatic samplers (controlled by a timer) were installed at the three places and for each of them, 3 samples were 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 were analysed for

- BOD₅
- COD
- Suspended solids (TSS)
- Total phosphorus
- Orthophosphate

at laboratories in Lomza and Warsaw.

In addition pH-values were measured every day in the influent to the aeration tank and in the plant effluent.

2 Plonsk Wastewater Treatment Plant

2.1 General

Plonsk wastewater treatment plant is a conventional activated sludge plant with an average wastewater flow of about 5000 m³/d. The plant receives wastewater from a fruit and vegetables processing factory in the period June-November, and this increases the organic load of the plant to such an extent that sludge bulking occurs and causes loss of activated sludge in the plant effluent.

The full scale tests with pre-precipitation were performed during one month from October 16 to November 17, 1992 (at the end of the season for discharges of high organic industrial wastewater). The coagulant (ferric-sulphate) was mixed with incoming wastewater at the upper end of the grit chamber, and the dosage was controlled by the on-off switch of the inlet pumping station. The coagulant dosage (g/m³) was based upon previous jar tests.

2.2 Results

All the results from analyses and wastewater flow measurements are summarized in Appendix 1. The variations in BOD₅, COD and orthophosphate concentrations in raw wastewater, pre-precipitated wastewater and final effluent are presented in Figures 1-3 and the average pollutant loads and removal rates for each coagulant dosage are shown in Tables 1 and 2.

**Table 1. Plonsk wastewater treatment plant. Test period 16/10/92 - 30/10/92.
PIX-dosage = 300 g/m³**

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	1797	997	45	61	97
COD	7003	3160	55	275	96
TSS	1510	740	51	148	90
Ortho-P	20	1.5	93	0.58	97

**Table 2. Plonsk wastewater treatment plant. Test period 30/10/92 - 17/11/92.
PIX-dosage = 230 g/m³**

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	1496	848	43	49	97
COD	3793	1982	48	222	94
TSS	1705	940	45	143	92
Ortho-P	20	0.84	96	0.84	96

These results clearly demonstrate that pre-precipitation with ferric-sulphate has been very successful. Even with high BOD₅ and COD concentrations in the influent, the effluent concentrations have been constantly below effluent standards (BOD₅ = 32 mg O₂/l, COD = 150 mg O₂/l). The removal of phosphorus seems also very good, although there is a lack of total phosphorus data to fully support that statement.

Comparing the two periods with different coagulant dosage (Tables 1 and 2), the removal rates for both organic matter and phosphorus are quite similar. However, the organic loading was much higher in the first test period, and there are no reason to believe that the same results could have been achieved with the lowest coagulant dosage (230 g/m³) in this period. The optimum PIX-dosage will change with the varying characteristics of the incoming wastewater, and should be controlled according to experiences from continued testing in the actual plant.

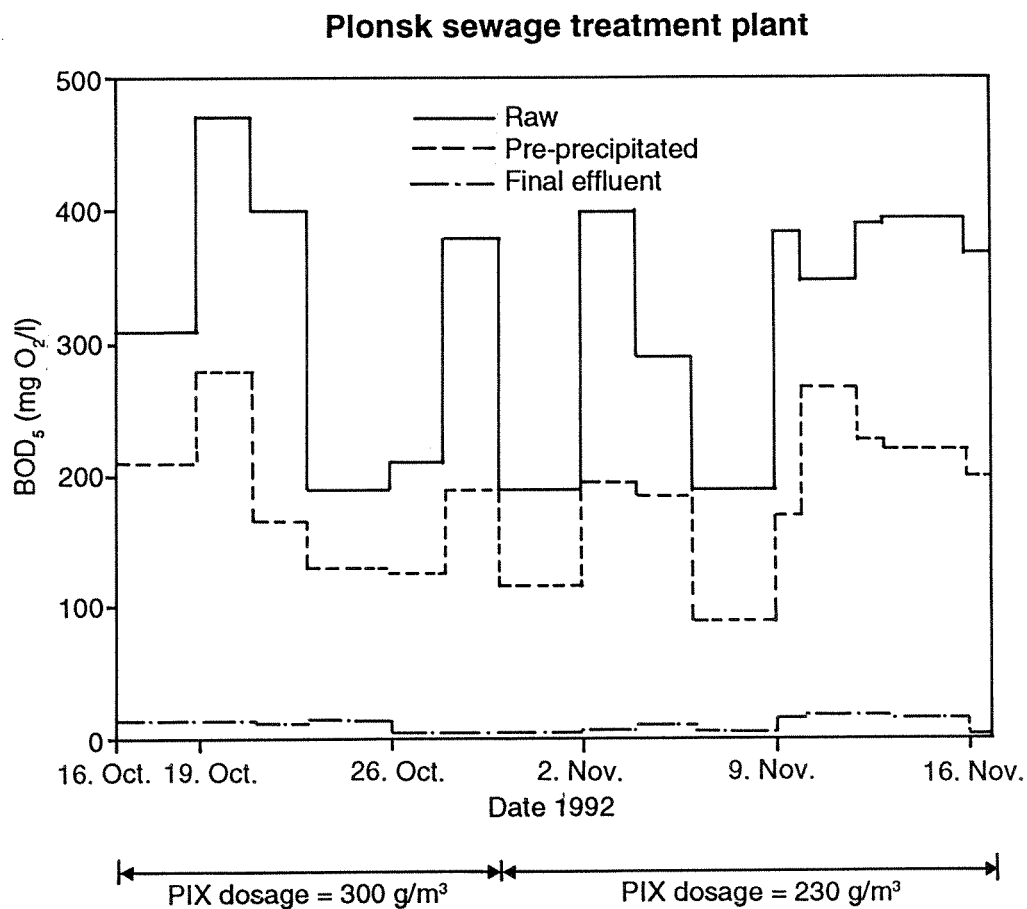


Fig. 1. Variations in BOD₅ concentrations of raw wastewater, pre-precipitated wastewater and final effluent

Plonsk sewage treatment plant

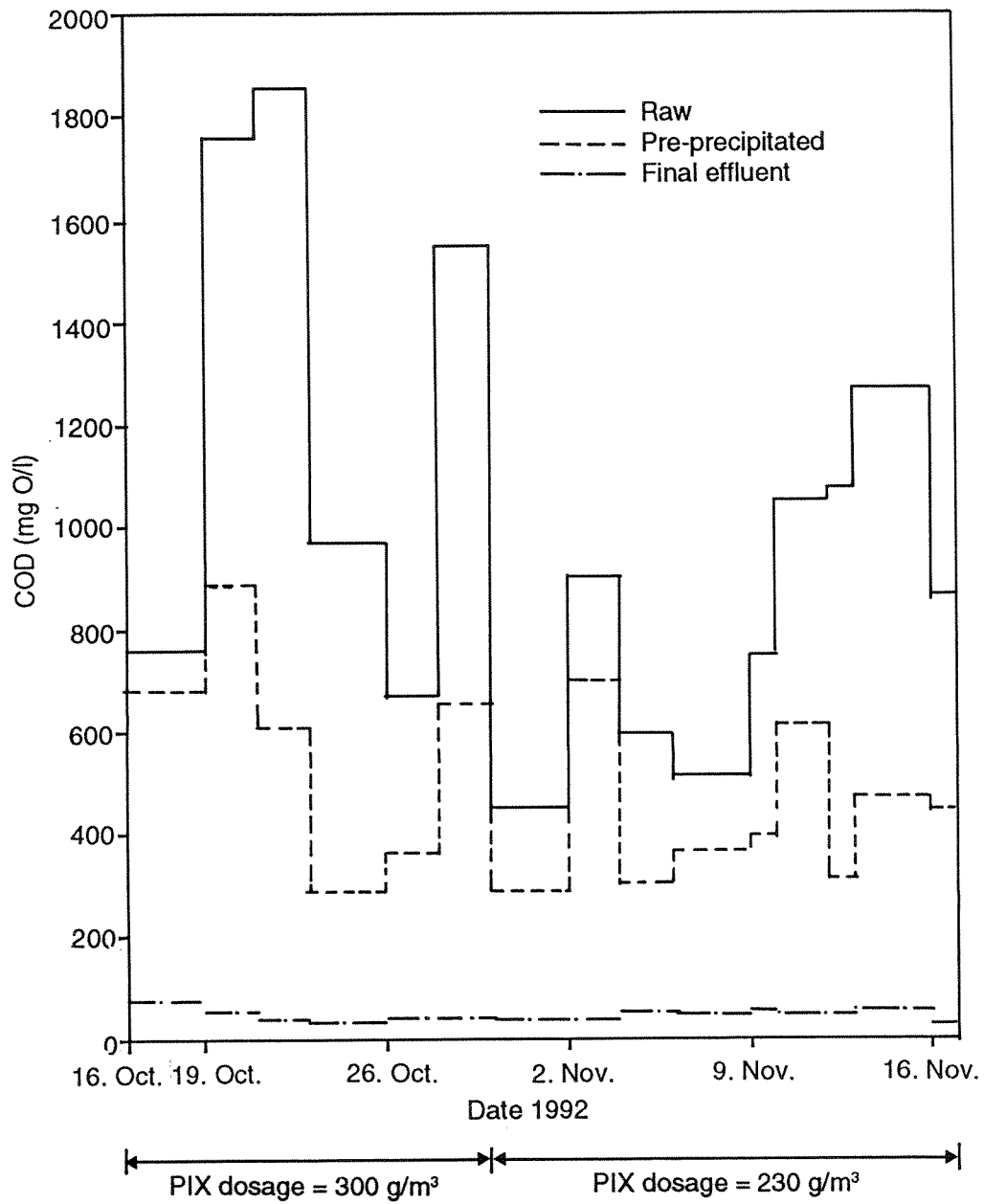


Fig. 2. Variations in COD concentration of raw wastewater, pre-precipitated wastewater and final effluent

Plonsk sewage treatment plant

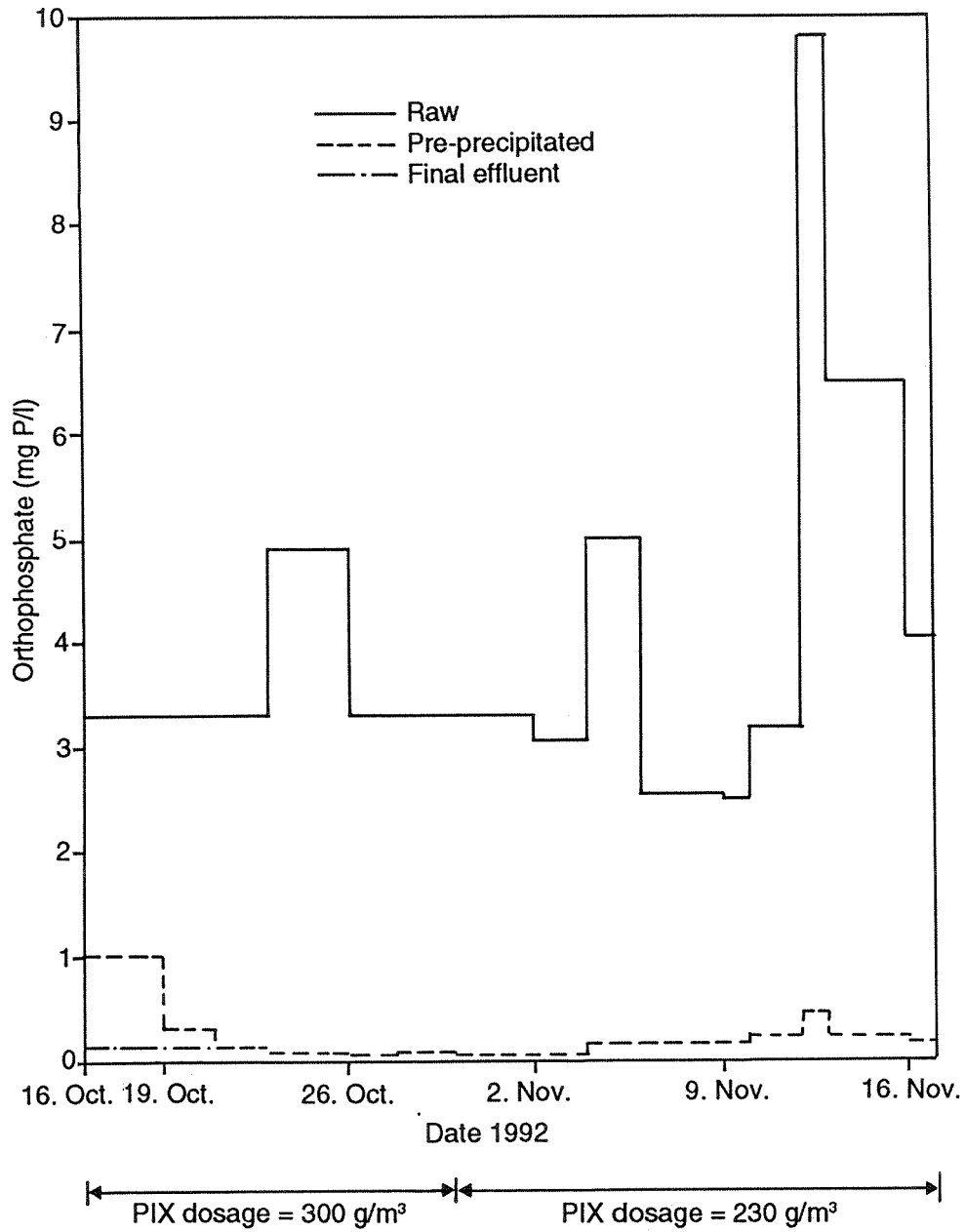


Fig. 3. Variations in orthophosphate concentration of raw wastewater, pre-precipitated wastewater and final effluent

3 Lomza Wastewater Treatment Plant

3.1 General

Lomza wastewater treatment plant is a conventional activated sludge plant with an average wastewater flow of about 15.000 m³/d. The plant receives wastewater from a large textile factory which under normal operation discharges 3000-4000 m³/d to the municipal sewer network. The industrial wastewater represents an extra organic load on the plant that often creates operational problems. However, during the test period the discharge of industrial wastewater was reduced due to low activity at the factory (economical problems).

The full scale tests with pre-precipitation were performed for about 3 weeks from November 24 to December 16, 1992. The coagulant (ferric sulphate) was mixed with incoming wastewater after the inlet pumping station, and the dosage was controlled by the on-off switch of the pumps. The coagulant dosage (g/m³) was based upon previous jar tests.

3.2 Results

All the results from analyses and wastewater flow measurements are summarized in Appendix 2. The variations in BOD₅, COD, ortho-P and total-P concentrations in raw wastewater, pre-precipitated wastewater and final effluent are presented in Figures 4-7.

The average pollutant loads and removal rates for each coagulant dosage are shown in Tables 3 and 4.

Table 3. Lomza wastewater treatment plant. Test period 24/11/92 - 07/12/92. PIX dosage = 150 g/m³

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	1723	1049	39	224	87
COD	6440	3535	45	814	87
TSS	1872	429	77	85	96
Ortho-P	51	6	88	3.3	94
Total-P	74	12	84	12	84

Table 4. Lomza wastewater treatment plant. Test period 08/12-92 - 16/12/92. PIX dosage = 200 g/m³

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	1857	968	48	252	86
COD	6128	3702	40	1108	82
TSS	2149	772	64	301	86
Ortho-P	78	7	91	5.5	93
Total-P	109	31	72	13	88

Figures 4 and 5 show that in the test period the incoming wastewater had a concentration of organic matter (BOD and COD) that is quite normal for municipal wastewater, and the discharges from the textile factory must have been small. There was an increase in the influent phosphorus concentration throughout the test period (Figures 6 and 7), but the reason for this is unknown.

With PIX-dosages of 150-200 g/m³, the removal of organic matter (BOD₅) over the pre-precipitation step has been 39-48 percent, and the overall BOD₅-removal was 86-87 percent. The average effluent concentration of BOD₅ was 16 mg/l. The removal of total phosphorus was acceptable with an average effluent concentration of 0.85 mg P/l, corresponding to an overall P-removal of 84-88 percent. In the second part of the test period the PIX-dosage was increased from 150 g/m³ to 200 g/m³ to compensate for the higher influent phosphorus concentration. With higher coagulant dosages we would have expected even better P-removals.

Lomza Sewage Treatment Plant

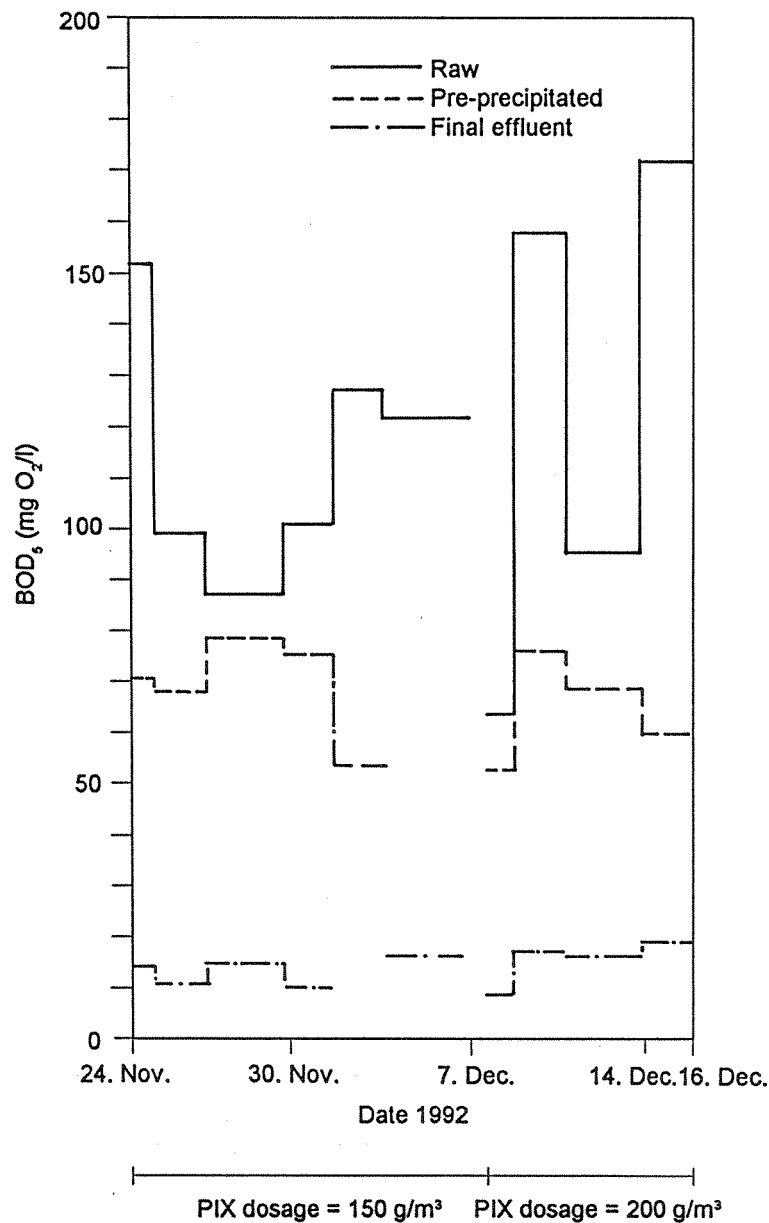


Fig. 4. Variations in BOD₅ concentrations of raw wastewater, pre-precipitated wastewater and final effluent

Lomza Sewage Treatment Plant

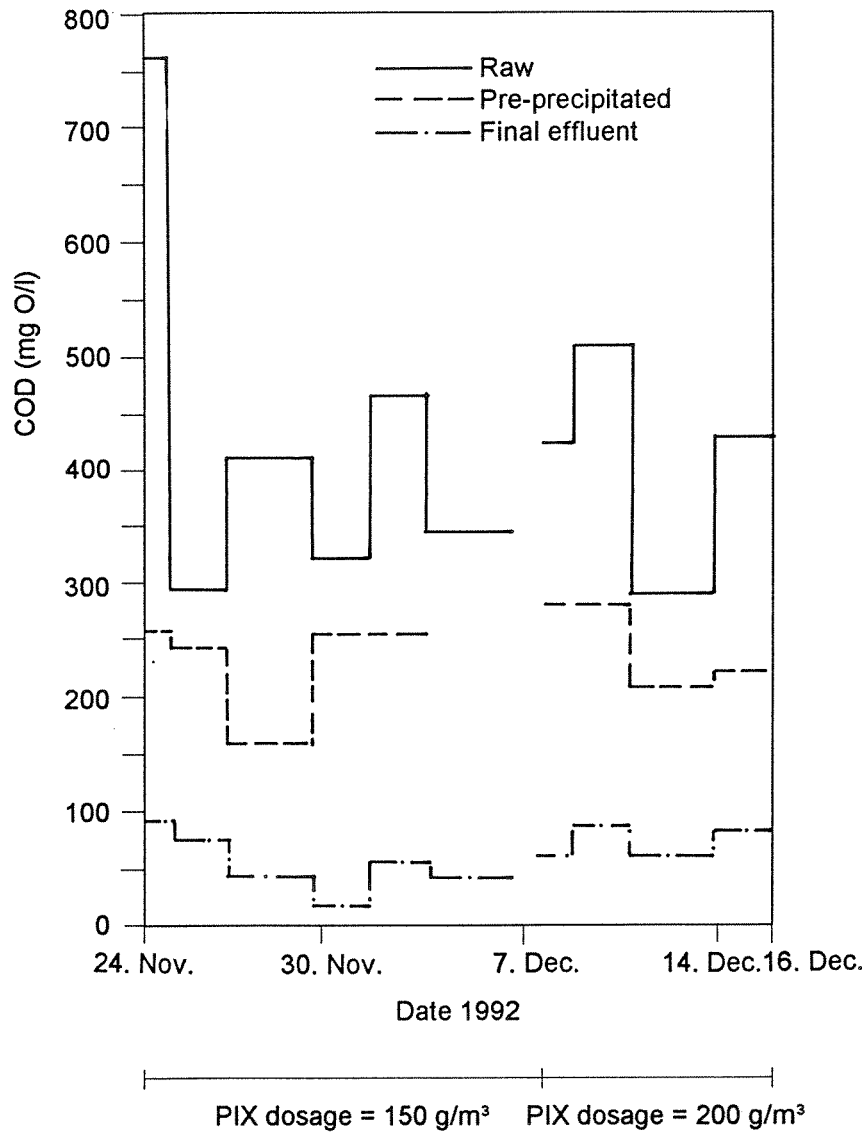


Fig. 5. Variations in COD concentration of raw wastewater, pre-precipitated wastewater and final effluent

Lomza Sewage Treatment Plant

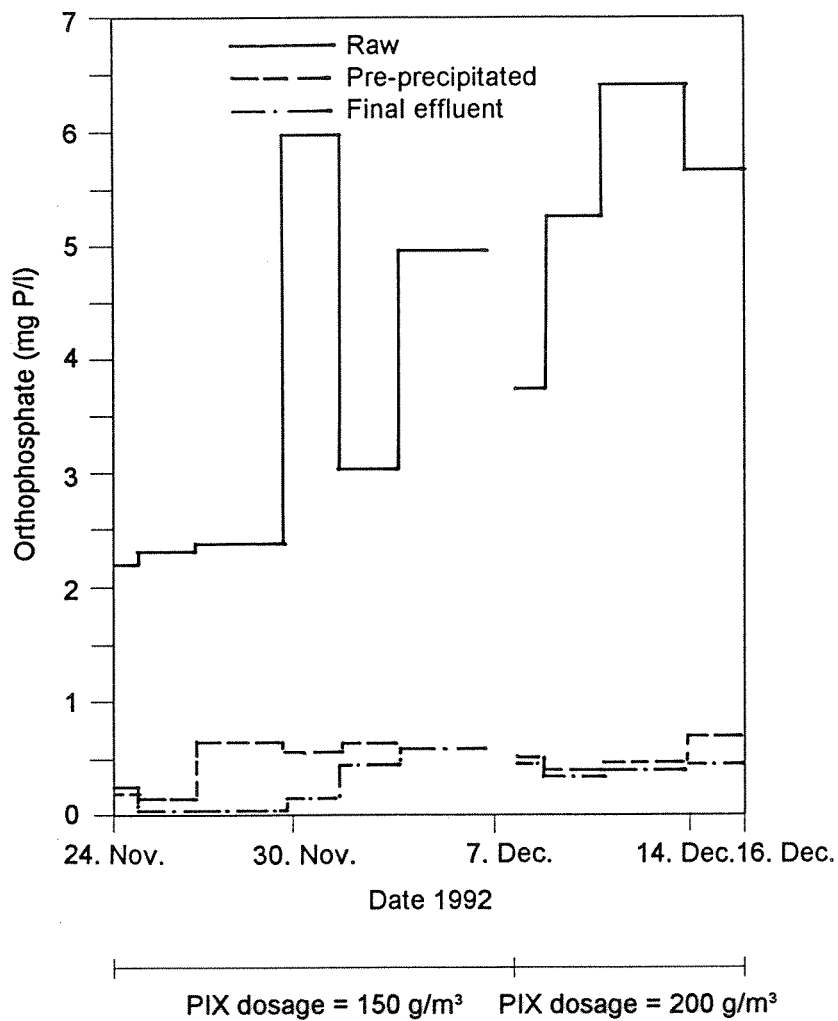


Fig. 6. Variations in orthophosphate concentration of raw wastewater, pre-precipitated wastewater and final effluent

Lomza Sewage Treatment Plant

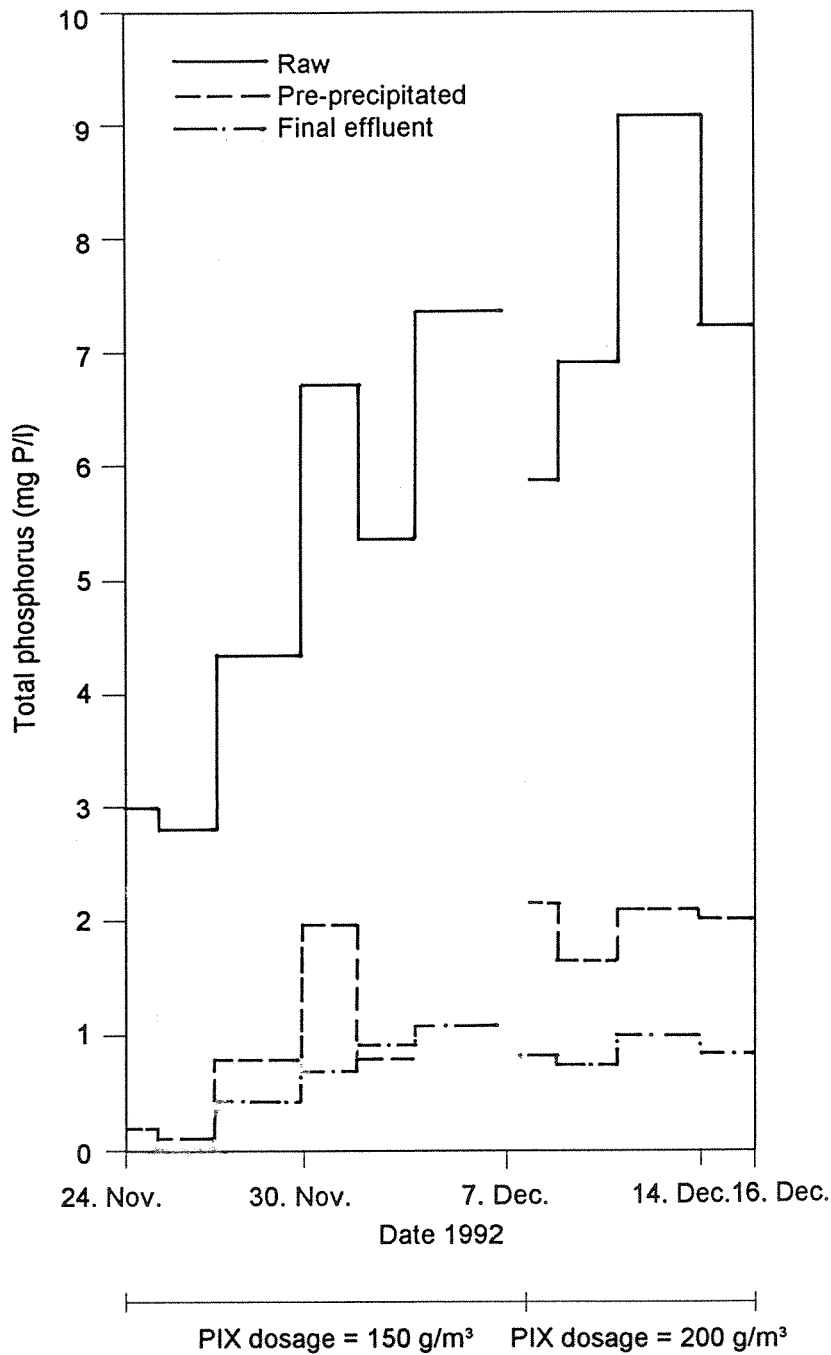


Fig. 7. Variations in total phosphorus concentration of raw wastewater, pre-precipitated wastewater and final effluent

4 Minsk Mazowiecki Wastewater Treatment Plant

4.1 General

Minsk Mazowiecki wastewater treatment plant is a conventional activated sludge plant with an average wastewater flow of about 6500 m³/d. The plant receives periodically high-organic wastewater from a dairy, and this increases the organic load of the plant to such an extent that sludge bulking (filamentous bacteria) occurs and causes loss of activated sludge in the plant effluent. This was also the situation during most of the test period.

The full scale tests with pre-precipitation were performed during one month from September 17 to October 18, 1993. This was about 8 months later than originally planned, due to several operational problems at the plant and waiting periods for the coagulant storage and dosing equipment. The coagulant (ferric sulphate) was mixed with incoming wastewater just after the inlet pumping station, and the dosage was controlled by the on-off switch of the pumps. The coagulant dosage (g/m³) was determined at the plant at time of test startup and not based upon the previous jar tests.

4.2 Results

All the results from analyses and wastewater flow measurements are summarized in Appendix 3. The variations in BOD₅, COD, ortho-P and total-P concentrations in raw wastewater, pre-precipitated wastewater and final effluent are presented in Figures 8-11. The average pollutant loads and removal rates for the two main coagulant dosages are shown in Tables 5 and 6.

Table 5. Minsk Mazowiecki wastewater treatment plant. Test period 17/09/93 - 29/09/93. PIX-dosage = 120 g/m³

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	2651	640	76	389	85
COD	5551	2130	62	1062	81
TSS	1760	509	71	657	63
Ortho-P	45	9	80	5	89
Total-P	65	32	51	24	63

Table 6. Minsk Mazowiecki wastewater treatment plant. Test period 04/10/93 - 18/10/93. PIX-dosage = 75 g/m³

Parameter	Raw wastewater	After pre-precipitation		Final effluent	
	Average load (kg/d)	Average load (kg/d)	Removal rate (%)	Average load (kg/d)	Removal rate (%)
BOD ₅	3879	1052	73	357	91
COD	7254	2052	72	743	90
TSS	2147	849	60	374	82
Ortho-P	50	14	72	6	88
Total-P	71	30	58	16	77

Figures 8 and 9 show that there have been several days in the test period with high influent concentrations of BOD₅ and COD, and this is probably caused by wastewater discharges from the dairy. At test start-up the treatment plant experienced substantial problems with sludge bulking and loss of activated sludge in the effluent, causing high discharges of suspended solids, organic matter and phosphorus. This situation was not desirable for demonstrating the effect of pre-precipitation on the whole treatment plant (including the activated sludge step), but the pre-precipitation itself exhibited very good removal rates for organic matter (73-76% BOD₅-removal). The removal of total phosphorus, however, was not very good, but that could be expected with the low coagulant dosages (120 and 75 g/m³), which were not sufficient to precipitate all the orthophosphate in the raw wastewater.

About two weeks after the test start-up (September 30, 1993), sludge from the anaerobic digester was pumped to the plant inlet in order to increase the sludge content of the aeration tanks. Waste activated sludge was also pumped back to the inlet of the primary clarifier. All this resulted in a very high pollutant load on the primary clarifier, and the effect of pre-precipitation was reduced, even with a higher coagulant dosage (140-150 g/m³). From October 4, 1993 the activated sludge plant gradually recovered, but the effluent concentration of BOD and COD was still exceeding effluent standards (BOD₅ = 25 mg O₂/l). For some reason (probably economic) the ferric sulphate dosage was reduced to 75 g/m³ in the last part of the test period, and the phosphorus removal rate was correspondingly low, even with a better capture of particulate phosphorus in the final clarifier.

Minsk Mazowiecki Sewage Treatment Plant

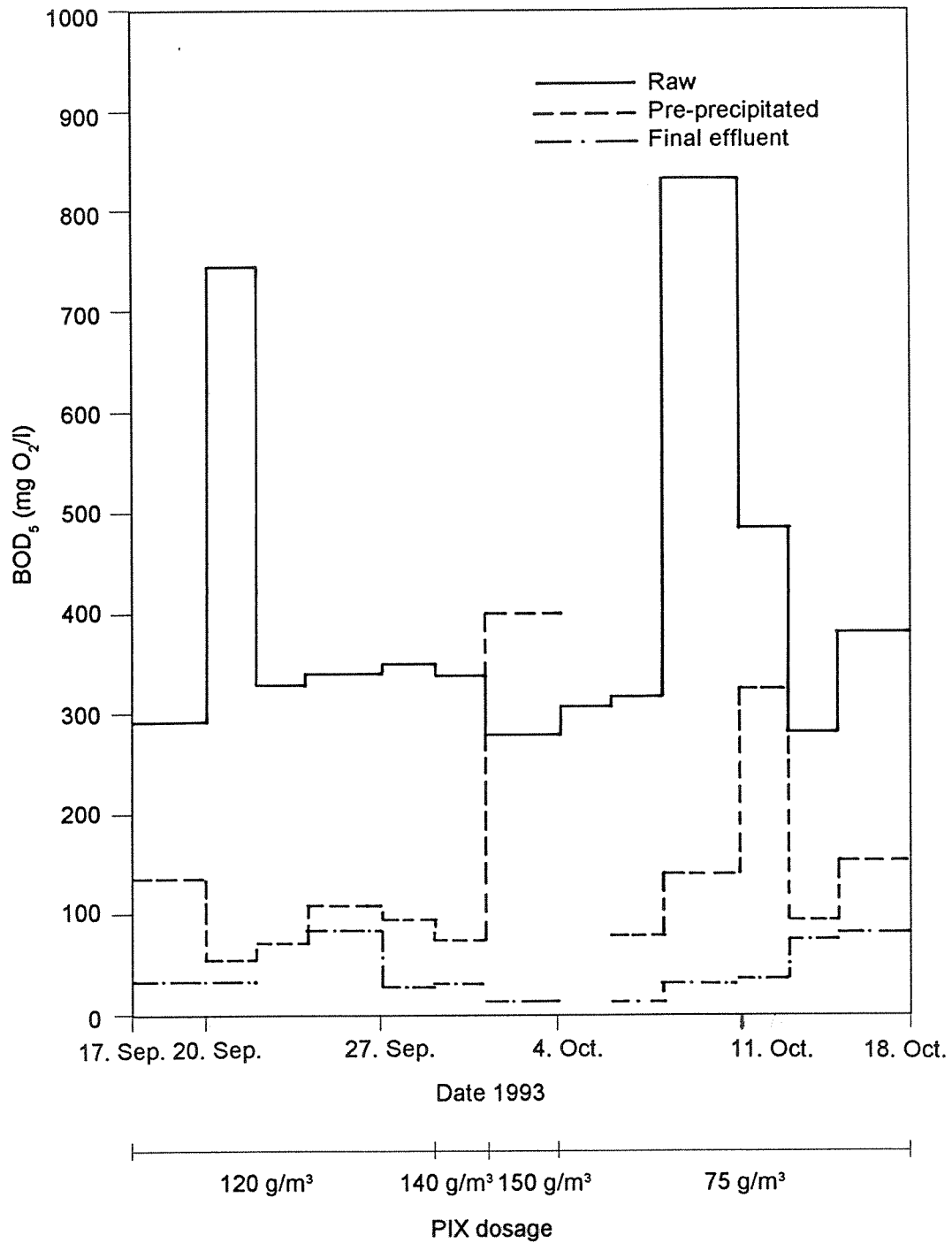


Fig. 8. Variations in BOD_5 concentrations of raw wastewater, pre-precipitated wastewater and final effluent

Minsk Mazowiecki Sewage Treatment Plant

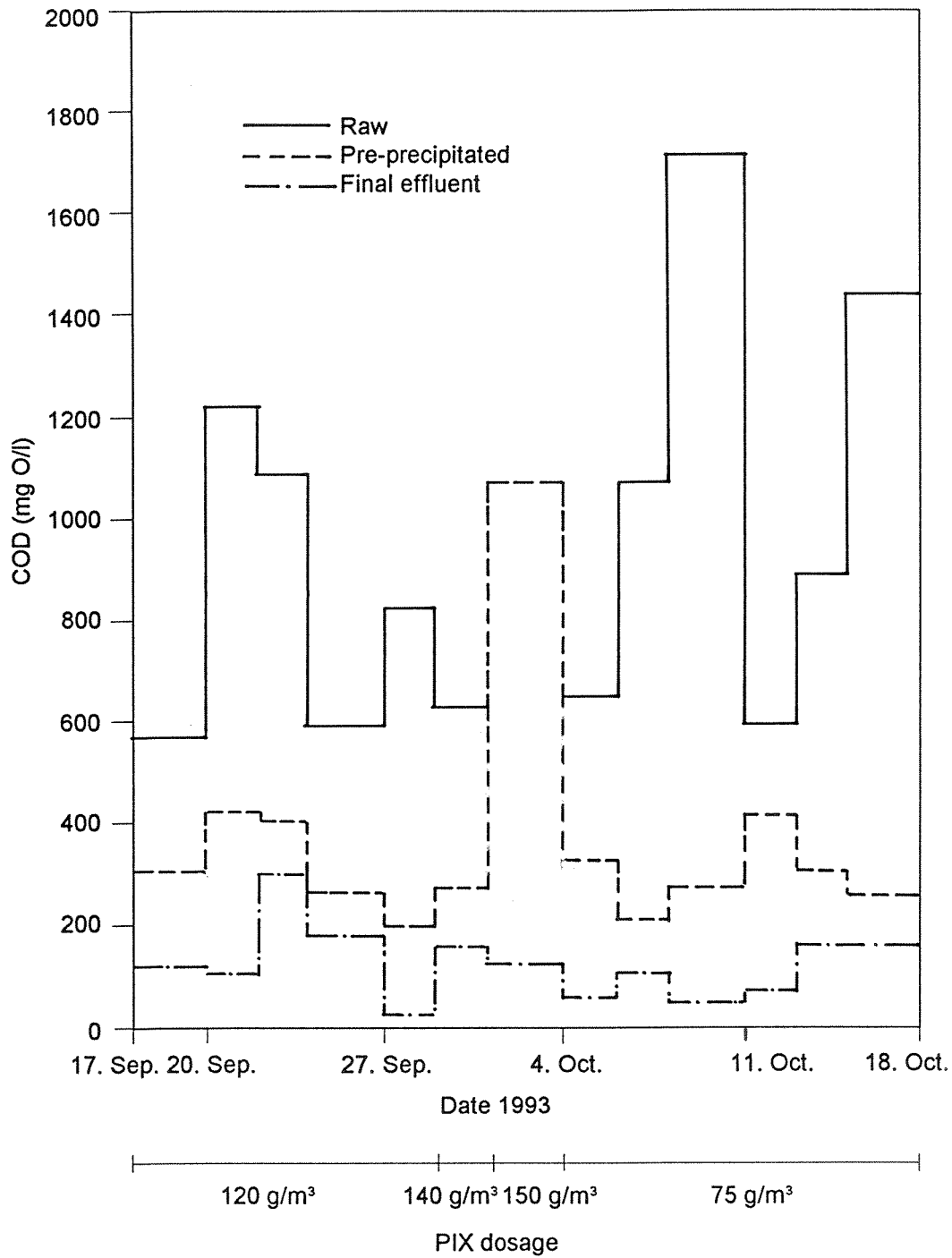


Fig. 9. Variations in COD concentration of raw wastewater, pre-precipitated wastewater and final effluent

Minsk Mazowiecki Sewage Treatment Plant

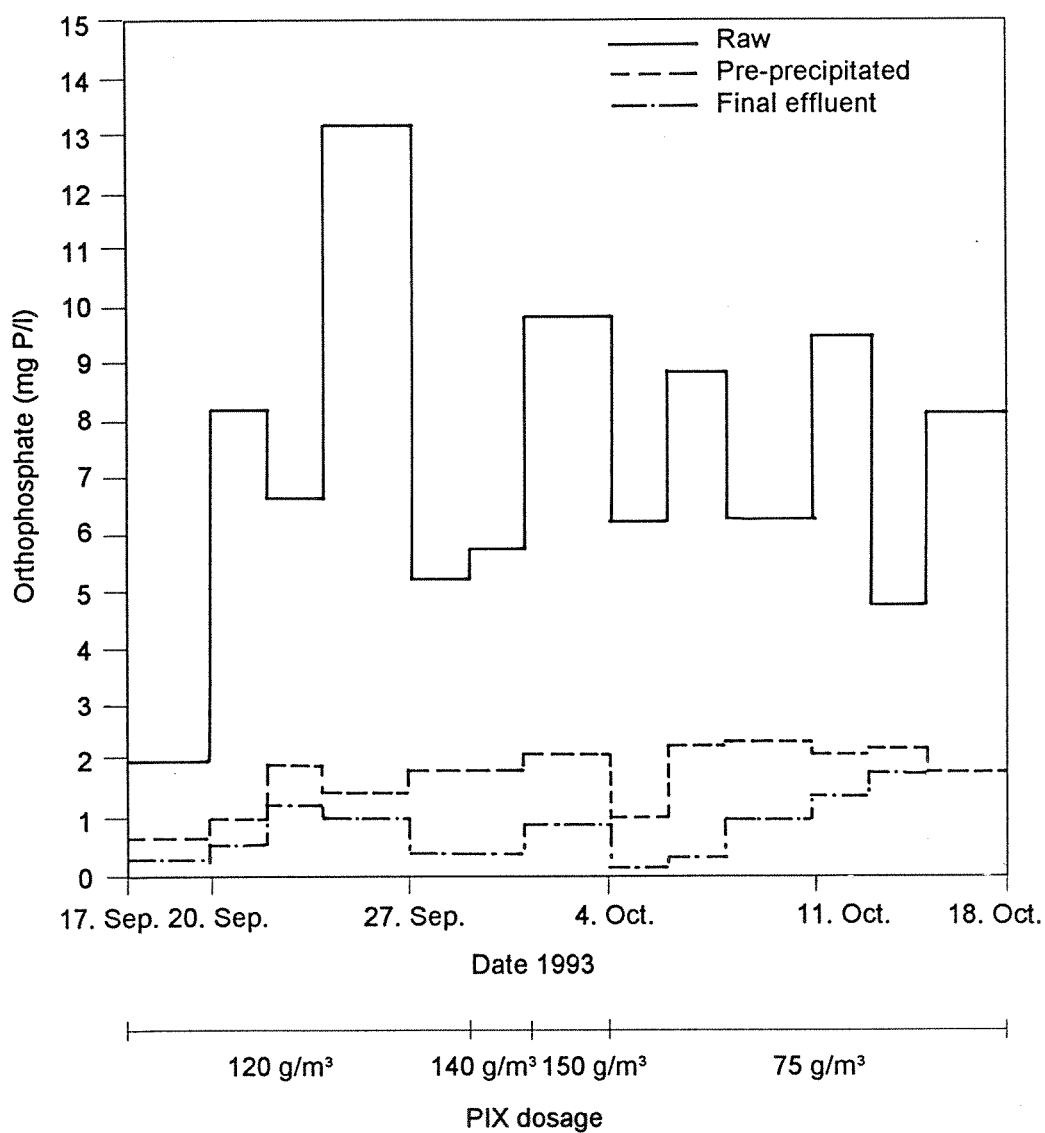


Fig. 10. Variations in orthophosphate concentration of raw wastewater, pre-precipitated wastewater and final effluent

Minsk Mazowiecki Sewage Treatment Plant

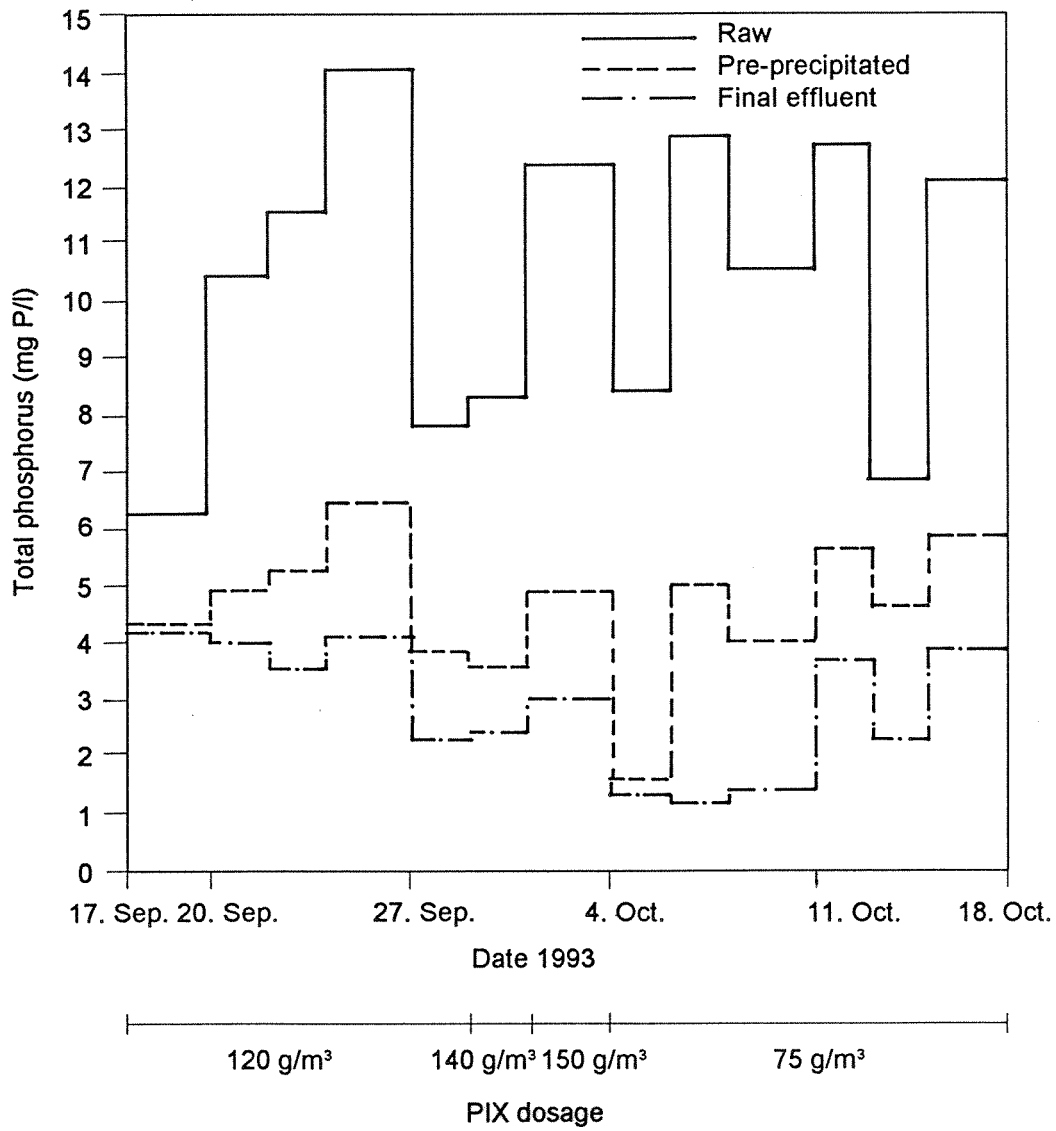


Fig. 11. Variations in total phosphorus concentration of raw wastewater, pre-precipitated wastewater and final effluent

Appendix 1. Plonsk wastewater treatment plant. Results from full scale testing of pre-precipitation with ferric sulphate

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRISULPHATE (PIX)
PLONSK SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Friday 16.10.92 at 16.00 to Monday 19.10.92 at 08.00		Periods for composite sampling		From Monday 19.10.92 at 08.00 to Wednesday 21.10.92 at 08.00		Periods for composite sampling		From Wednesday 21.10.92 at 08.00 to Friday 23.10.92 at 08.00	
Parameter		Raw		Effluent		Raw		Effluent		Raw	
PIX-dosage (g/m ³)		311		210		470		280		400	
Wastewater flow (m ³ /d) (for each day in sampl. period)		760		684		1763		882		1854	
Sampling Point		120		155		258		125		542	
BOD ₅ (mgO ₂ /l)		-		-		-		-		-	
COD (mg O/l)		3.3		1.0		3.3		0.33		3.3	
TSS (mg/l)		-		-		-		-		-	
Total-P (mg P/l)		-		-		-		-		-	
Ortho-P (mg P/l)		-		-		-		-		-	
Periods without PIX-dosing		From 18.10.92 at 03.00 to 19.10.92 at 13.00		From 18.10.92 at 03.00 to 19.10.92 at 13.00		From 19.10.92 at 08.00 to 19.10.92 at 13.00		From 19.10.92 at 08.00 to 19.10.92 at 13.00		From 20.10.92 at 17.00 to 21.10.92 at 13.30	
Periods for composite sampling		From Friday 23.10.92 at 08.00 to Monday 26.10.92 at 08.00		Periods for composite sampling		From Wednesday 28.10.92 at 08.00 to Friday 30.10.92 at 08.00		Periods for composite sampling		From Wednesday 28.10.92 at 08.00 to Friday 30.10.92 at 08.00	
Parameter		Raw		Effluent		Raw		Effluent		Raw	
PIX-dosage (g/m ³)		190		130		210		125		380	
Wastewater flow (m ³ /d) (for each day in sampl. period)		973		289		669		365		1550	
Sampling Point		211		123		309		100		195	
BOD ₅ (mgO ₂ /l)		-		-		-		-		-	
COD (mg O/l)		4.9		0.07		3.3		0.03		3.3	
TSS (mg/l)		-		-		-		-		-	
Total-P (mg P/l)		-		-		-		-		-	
Ortho-P (mg P/l)		-		-		-		-		-	
Periods without PIX-dosing		From 18.10.92 at 03.00 to 19.10.92 at 13.00		From 18.10.92 at 03.00 to 19.10.92 at 13.00		From 19.10.92 at 08.00 to 19.10.92 at 13.00		From 19.10.92 at 08.00 to 19.10.92 at 13.00		From 20.10.92 at 17.00 to 21.10.92 at 13.30	

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRISULPHATE (PIX)
PLONSK SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Friday 30.10.92 at 08.00 to Monday 2.11.92 at 08.00		Periods for composite sampling		From Monday 2.11.92 at 08.00 to Wednesday 4.11.92 at 08.00		Periods for composite sampling		From Wednesday 4.11.92 at 08.00 to Friday 6.11.92 at 08.00					
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-Prec.	Effluent	
BOD ₅ (mgO ₂ /l)		190	115	4	BOD ₅ (mgO ₂ /l)		396	195	7	BOD ₅ (mgO ₂ /l)		290	188	11	
COD (mg O/l)		456	289	39	COD (mg O/l)		912	699	42	COD (mg O/l)		595	308	61	
TSS (mg/l)		203	108	21	TSS (mg/l)		251	147	22	TSS (mg/l)		201	123	24	
Total-P (mg P/l)		5.9	0.62	0.29	Total-P (mg P/l)		4.9	0.56	0.26	Total-P (mg P/l)		6.9	1.0	0.49	
Ortho-P (mg P/l)		3.3	0.02	0.02	Ortho-P (mg P/l)		3.1	0.07	0.07	Ortho-P (mg P/l)		5	0.16	0.16	
Periods without PIX-dosing				Periods without PIX-dosing						Periods without PIX-dosing					
Periods for composite sampling		From Friday 6.10.92 at 08.00 to Monday 9.10.92 at 08.00		Periods for composite sampling		From Monday 9.10.92 at 08.00 to Tuesday 10.10.92 at 08.00		Periods for composite sampling		From Tuesday 10.11.92 at 08.00 to Thursday 12.11.92 at 08.00					
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-Prec.	Effluent	
BOD ₅ (mgO ₂ /l)		190	87	4	BOD ₅ (mgO ₂ /l)		385	170	16	BOD ₅ (mgO ₂ /l)		350	268	18	
COD (mg O/l)		518	365	53	COD (mg O/l)		749	394	62	COD (mg O/l)		1056	614	47	
TSS (mg/l)		180	164	18	TSS (mg/l)		582	229	35	TSS (mg/l)		482	286	65	
Total-P (mg P/l)		-	-	-	Total-P (mg P/l)		-	-	-	Total-P (mg P/l)		-	-	-	
Ortho-P (mg P/l)		2.6	0.16	0.16	Ortho-P (mg P/l)		2.5	0.16	0.16	Ortho-P (mg P/l)		3.2	0.26	0.26	
Periods without PIX-dosing				Periods without PIX-dosing						Periods without PIX-dosing					

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRISULPHATE (PIX)
PLONSK SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Thursday 12.11.92 at 08.00 to Friday 13.11.92 at 08.00		From Friday 13.11.92 at 08.00 to Monday 16.11.92 at 08.00		From Monday 16.11.92 at 08.00 to Tuesday 17.11.92 at 08.00			
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-Prec.	Effluent
		390	230	18			368	198	3
		1075	317	47			864	451	31
		438	298	28			666	304	54
		-	-	-			-	-	-
		9.8	0.42	0.42			4.1	0.16	0.16
Periods without PIX-dosing					Periods without PIX-dosing				
Periods for composite sampling		From		From		From			
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-Prec.	Effluent
Periods without PIX-dosing					Periods without PIX-dosing				

Appendix 2. Lomza wastewater treatment plant. Results from full scale testing of pre-precipitation with ferric sulphate

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRIC SULPHATE (PIX)
LOMZA SEWAGE TREATMENT PLANT**

Periods for composite sampling Parameter	From Tuesday 24.11.92 at 08.00 to Wednesday 25.11.92 at 08.00		From Wednesday 25.11.92 at 08.00 to Friday 27.11.92 at 08.00		From Friday 27.11.92 at 08.00 to Monday 30.11.92 at 08.00		
	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent
PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	150 14950	150 14900	150 14900	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	150 14300 13650 14440	150 14300 13650 14440	150 14300 13650 14440
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent
BOD ₅ (mgO ₂ /l)	151	72	16	BOD ₅ (mgO ₂ /l)	87	79	16
COD (mg O/l)	760	260	90	COD (mg O/l)	410	160	40
TSS (mg/l)	240	28	10	TSS (mg/l)	165	48	0
Total-P (mg P/l)	3	0.23	-	Total-P (mg P/l)	4.4	0.79	0.53
Ortho-P (mg P/l)	2.2	0.20	0.23	Ortho-P (mg P/l)	2.3	0.58	0.02
Periods for composite sampling Parameter	From Monday 30.11.92 at 08.00 to Wednesday 2.12.92 at 08.00		From Wednesday 02.12.92 at 08.00 to Friday 04.12.92 at 08.00		From Friday 04.12.92 at 08.00 to Monday 07.12.92 at 08.00		
PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	150 15600 14950	150 15600 15550	150 15600 15550	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	150 9750 14950 19500	150 9750 14950 19500	150 9750 14950 19500
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent
BOD ₅ (mgO ₂ /l)	102	76	13	BOD ₅ (mgO ₂ /l)	122	-	18
COD (mg O/l)	320	260	20	COD (mg O/l)	340	-	40
TSS (mg/l)	17	20	0	TSS (mg/l)	106	-	12
Total-P (mg P/l)	6.7	2.0	0.73	Total-P (mg P/l)	7.3	-	1.1
Ortho-P (mg P/l)	5.9	0.53	0.12	Ortho-P (mg P/l)	4.9	-	0.55

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRIC SULPHATE (PIX)
LOMZA SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Tuesday 08.12.92 at 12.00 to Wednesday 09.12.92 at 08.00		Periods for composite sampling		From Wednesday 09.12.92 at 08.00 to Friday 11.12.92 at 08.00		Periods for composite sampling		From Friday 11.12.92 at 08.00 to Monday 14.12.92 at 08.00				
Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)				
Sampling Point		Raw	Pre-prec.	Effluent	Sampling Point		Raw	Pre-prec.	Effluent	Sampling Point		Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)		64	53	10	BOD ₅ (mgO ₂ /l)		157	76	18	BOD ₅ (mgO ₂ /l)		95	68	17
COD (mg O/l)		415	280	66	COD (mg O/l)		500	280	86	COD (mg O/l)		290	210	62
TSS (mg/l)		116	40	12	TSS (mg/l)		152	80	50	TSS (mg/l)		68	56	16
Total-P (mg P/l)		5.8	2.2	0.85	Total-P (mg P/l)		6.9	1.7	0.71	Total-P (mg P/l)		9.0	2.2	1.1
Ortho-P (mg P/l)		3.7	0.42	0.47	Ortho-P (mg P/l)		5.2	0.35	0.28	Ortho-P (mg P/l)		6.3	0.42	0.35
Periods for composite sampling		From Monday 14.12.92 at 08.00 to Wednesday 16.12.92 at 08.00		Periods for composite sampling		From		Periods for composite sampling		From				
Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)				
Sampling Point		Raw	Pre-prec.	Effluent	Sampling Point		Raw	Pre-prec.	Effluent	Sampling Point		Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)		171	61	20	BOD ₅ (mgO ₂ /l)					BOD ₅ (mgO ₂ /l)				
COD (mg O/l)		425	220	80	COD (mg O/l)					COD (mg O/l)				
TSS (mg/l)		225	32	4	TSS (mg/l)					TSS (mg/l)				
Total-P (mg P/l)		7.2	2.1	0.88	Total-P (mg P/l)					Total-P (mg P/l)				
Ortho-P (mg P/l)		5.5	0.65	0.39	Ortho-P (mg P/l)					Ortho-P (mg P/l)				

**Appendix 3. Minsk Mazowiecki wastewater treatment plant.
Results from full scale testing of pre-precipitation
with ferric sulphate**

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRIC SULPHATE (PIX).
MINSK MAZOWIECKI SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Friday 17.09.93 at 08.00 to Monday 20.09.93 at 08.00		Periods for composite sampling		From Monday 20.09.93 at 08.00 to Wednesday 22.09.93 at 08.00		Periods for composite sampling		From Wednesday 22.09.93 at 08.00 to Friday 24.09.93 at 08.00	
Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)	295	140	44	BOD ₅ (mgO ₂ /l)	740	64	44	BOD ₅ (mgO ₂ /l)	330	76	86
COD (mg O/l)	572	314	143	COD (mg O/l)	1207	434	133	COD (mg O/l)	1080	405	305
TSS (mg/l)	73	41	41	TSS (mg/l)	541	127	377	TSS (mg/l)	331	103	73
Total-P (mg P/l)	6.2	4.4	4.3	Total-P (mg P/l)	10.5	4.9	4.0	Total-P (mg P/l)	11.5	5.2	3.5
Ortho-P (mg P/l)	2.1	0.78	0.46	Ortho-P (mg P/l)	8.2	1.1	0.62	Ortho-P (mg P/l)	6.5	2.0	1.4
Periods for composite sampling		From Friday 24.09.93 at 08.00 to Monday 27.09.93 at 08.00		Periods for composite sampling		From Monday 27.09.93 at 08.00 to Wednesday 29.09.93 at 08.00		Periods for composite sampling		From Wednesday 29.09.93 at 08.00 to Friday 01.10.93 at 08.00	
Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)		Parameter		PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)	340	115	92	BOD ₅ (mgO ₂ /l)	350	100	34	BOD ₅ (mgO ₂ /l)	340	80	36
COD (mg O/l)	596	279	193	COD (mg O/l)	833	211	41	COD (mg O/l)	630	280	171
TSS (mg/l)	202	78	126	TSS (mg/l)	215	44	17	TSS (mg/l)	729	450	238
Total-P (mg P/l)	14.1	6.4	4.1	Total-P (mg P/l)	7.8	3.4	2.4	Total-P (mg P/l)	8.3	3.5	2.5
Ortho-P (mg P/l)	13.1	1.5	1.2	Ortho-P (mg P/l)	5.2	1.9	0.52	Ortho-P (mg P/l)	5.8	2.0	0.5

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRIC SULPHATE (PIX).
MINSK MAZOWIECKI SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Friday 01.10.93 at 08.00 to Monday 04.10.93 at 08.00		Periods for composite sampling		From Monday 04.10.93 at 08.00 to Wednesday 06.10.93 at 08.00		Periods for composite sampling		From Wednesday 06.10.93 at 08.00 to Friday 08.10.93 at 08.00	
Parameter		Parameter		Parameter		Parameter		Parameter		Parameter	
PIX-dosage (g/m ³)		150		PIX-dosage (g/m ³)		75		PIX-dosage (g/m ³)		75	
Wastewater flow (m ³ /d) (for each day in sampl. period)		6378 6552 6334		Wastewater flow (m ³ /d) (for each day in sampl. period)		6796 7338		Wastewater flow (m ³ /d) (for each day in sampl. period)		6410 6820	
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)	280	400	23	BOD ₅ (mgO ₂ /l)	310	-	-	BOD ₅ (mgO ₂ /l)	320	80	18
COD (mg O/l)	-	1067	144	COD (mg O/l)	651	331	72	COD (mg O/l)	1070	224	104
TSS (mg/l)	295	302	109	TSS (mg/l)	422	231	22	TSS (mg/l)	464	43	37
Total-P (mg P/l)	12.3	4.8	3.0	Total-P (mg P/l)	8.3	1.6	1.4	Total-P (mg P/l)	12.8	5.1	1.2
Ortho-P (mg P/l)	9.8	2.2	1.0	Ortho-P (mg P/l)	6.2	1.1	0.29	Ortho-P (mg P/l)	8.8	2.4	0.39
Periods for composite sampling		From Friday 08.10.93 at 08.00 to Monday 11.10.93 at 08.00		Periods for composite sampling		From Monday 11.10.93 at 08.00 to Wednesday 13.10.93 at 08.00		Periods for composite sampling		From Wednesday 13.10.93 at 08.00 to Friday 15.10.93 at 08.00	
Parameter		Parameter		Parameter		Parameter		Parameter		Parameter	
PIX-dosage (g/m ³)		75		PIX-dosage (g/m ³)		75		PIX-dosage (g/m ³)		75	
Wastewater flow (m ³ /d) (for each day in sampl. period)		6630 7504 6614		Wastewater flow (m ³ /d) (for each day in sampl. period)		5570 6642		Wastewater flow (m ³ /d) (for each day in sampl. period)		5840 7362	
Sampling Point	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-Prec.	Effluent	Sampling Point	Raw	Pre-Prec.	Effluent
BOD ₅ (mgO ₂ /l)	824	140	38	BOD ₅ (mgO ₂ /l)	480	325	40	BOD ₅ (mgO ₂ /l)	280	95	80
COD (mg O/l)	1700	280	60	COD (mg O/l)	597	420	85	COD (mg O/l)	880	304	166
TSS (mg/l)	155	61	23	TSS (mg/l)	319	103	71	TSS (mg/l)	257	117	109
Total-P (mg P/l)	10.5	4.0	1.5	Total-P (mg P/l)	12.6	5.6	3.7	Total-P (mg P/l)	6.7	4.6	2.3
Ortho-P (mg P/l)	6.4	2.5	1.1	Ortho-P (mg P/l)	9.5	2.3	1.5	Ortho-P (mg P/l)	4.7	2.3	1.9

**RESULTS FROM FULL SCALE TESTING OF PRE-PRECIPITATION WITH FERRIC SULPHATE (PIX).
MINSK MAZOWIECKI SEWAGE TREATMENT PLANT**

Periods for composite sampling		From Friday 15.10.93 at 08.00 to Monday 18.10.93 at 08.00		Periods for composite sampling		Periods for composite sampling		
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent
BOD ₅ (mgO ₂ /l)	75	380	155	85	BOD ₅ (mgO ₂ /l)			
COD (mg O/l)	8762	1432	267	166	COD (mg O/l)			
TSS (mg/l)	6974	285	192	72	TSS (mg/l)			
Total-P (mg P/l)	6484	12.0	5.7	3.8	Total-P (mg P/l)			
Ortho-P (mg P/l)		8.2	1.9	-	Ortho-P (mg P/l)			
Periods for composite sampling		From		Periods for composite sampling		Periods for composite sampling		
Parameter	PIX-dosage (g/m ³) Wastewater flow (m ³ /d) (for each day in sampl. period)	Raw	Pre-prec.	Effluent	Sampling Point	Raw	Pre-prec.	Effluent
BOD ₅ (mgO ₂ /l)	75	380	155	85	BOD ₅ (mgO ₂ /l)			
COD (mg O/l)	8762	1432	267	166	COD (mg O/l)			
TSS (mg/l)	6974	285	192	72	TSS (mg/l)			
Total-P (mg P/l)	6484	12.0	5.7	3.8	Total-P (mg P/l)			
Ortho-P (mg P/l)		8.2	1.9	-	Ortho-P (mg P/l)			

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