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Final Report

Project TF/HUN/94/F90-Hospital Waste Management
Waste Water Analysis in Szent Imre Hospital, Budapest, Hungary

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Budapest

Executive Summary

The immediate objective of the project TF/HUN/94/F90 is to assist the "Szent Imre Teaching Hospital" in the establishment and operation of a hospital waste-water management system in accordance with the Directives of the European Union.

Our job was to monitor the quality of hospital waste waters at six measurement points for a period of four months. 126 samples were tested for classical water quality parameters; of these, the concentrations of five heavy metals and some pre-selected organic micropolluters were also determined in 36 samples. In the selection of micropollutants, preference was given to those compounds and molecular structures which might distinguish the hospital waste water from the household waste water. The concentrations of low-molecular weight halogenated hydrocarbons and simple aromatic compounds were determined in the group of volatile solvents; phenols, aldehydes and quaternary ammonium compounds were also tested. In accordance with the preliminary terms of reference, only the volatile substances were determined in a further group of 18 samples. The microbiological contamination of 36 samples was determined.

The main conclusion of the analysis of results is that the average quality of discharged waste waters of the "Szent Imre Teaching Hospital" does not differ significantly from that of community waste waters as regards the classical water quality parameters, the heavy metals and organic micropollutants. The classical water parameters are lower than the limit given for the municipal sewage waters in Hungary. The concentration of the tested organic micropollutants was significantly lower than the tolerated amount in drinking waters as per the Directives of the European Union. In a few cases, the amount of chloroform exceeded the maximum limit specified for drinking water in the European Union but remained within the tolerated amount specified by the WHO standard.

Recommendations:

1. The quality of waste waters should preferably be carried out by analysing representative average samples collected by an automated sample-taking apparatus.
2. Similar studies should be conducted in a hospital where the management of waste has not been organized so well as in the "Szent Imre Teaching Hospital".

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Introduction

The immediate objective of the project TF/HUN/94/F90 is to assist the "Szent Imre Teaching Hospital" in the establishment and operation of a hospital waste-water management system in accordance with the Directives of the European Union.

The Hungarian Government intends to develop a system for the treatment of hospital waste waters, which is not only in compliance with the Hungarian regulatory requirements but also with the Directives of the European Union. The experience gained through this pilot project will provide data to develop a program for the management of hospital waste waters in Hungary and other Central-East European countries.

The "Szent Imre Teaching Hospital", the national counterpart in the project, is one of the main hospitals in Budapest with 1,100 beds as of to-day.

A large variety of hazardous materials is generated in hospitals although the overall quantity of waste is relatively low. It is often difficult to identify hazardous wastes due to the lack of a record-keeping system on waste generation in hospitals. Data, if available, are very often unreliable.

The "Szent Imre" Teaching Hospital generates approximately the following amounts of waste annually:

Ampoules, syringes, needles, infusion bottles, etc.		850 kg/year
Formaldehyde (10% aqueous solution)		500 liters/year
Organic solvents	xylene	500 liters/year
	acetone	500 liters/year
	ethanol	300 liters/year

Plastic materials	12,000 kg/year
Photographic chemicals	3,640 liters/year
Biologically hazardous waste materials	30,000-50,000 kg/year

In this project, waste waters of the "Szent Imre Teaching Hospital" were analysed from 07 July till 06 November 1997. Samples of waste waters were collected at six pre-selected discharge points within the territory of the "Szent Imre Teaching Hospital".

The monitored water quality parameters, metals and organic micropollutants, were chosen taking into consideration both the EPA Directives, "Guides to Pollution Prevention: Selected Hospital Waste Streams" and the results of our preliminary experimental surveys.

Each sample was analyzed for pH, biological oxygen demand (BOD), suspended solids, ammonia, phenol index and fat and oil content (organic solvent extract). The concentrations of heavy metals (Ag, Cd, Cr, Hg, Zn), and organic micro-pollutants [volatile organic compounds (VOC), phenols, aldehydes and quaternary ammonium salts], were measured on six occasions. Microbiological test (total bacterial cell count, coliforms, E.coli) have also been carried out on six occasions.

This report describes briefly the applied analytical methods, the analytical data of the waste water samples as well as the evaluation of the results. The analytical data are summarized in tables while the changes of data as a function of time and location, respectively, are illustrated in graphs. For easy reference, a column was inserted in the tables indicating, where available, the limit values of micropollutants both in the Directives of European Union (EU95/C131/03) and the 1993 recommendations of the WHO entitled "Guidelines for Drinking Water Quality" in order to demonstrate that the micropollutant concentrations of the tested waste water samples do not exceed the tolerated concentrations in drinking waters.

The raw data of GC-MS measurements as well as the chromatograms of GC-MS and HPLC runs are annexed to the report.

Waste Water Analysis

1. Sampling

Samples are collected at 6 discharge points:

Point A = pump of sewage (kitchen, pathology, boiler house, offices)
Point B = Hemodialysis Center (dialysis unit)
Point C = Southern corner of building "A" (Isotope lab, clinical chemistry, otolaryngology, gynaecology/obstetrics)
Point D = Northern corner of building "A" (surgery, gyn/obs, intensive care unit, inpatients)
Point E = Building "B" (Inpatients, psychiatry, neurology)
Point TW = tap water (input)

Two automatic samplers were used at points C and D between 07 July and 12 July. The samples were collected here between 7:30 a.m. and 3:00 p.m. All other samples are collected manually at 12:00 a.m. on each sampling days.

Sampling days:

7 July*	4 September **C**	21 October
8 July* **C**	9 September	22 October
9 July*	11 September	30 October **C**
10 July* **C**	23 September	
11 July *	25 September	4 November
12 July*		6 November
15 July	3 October **C**	
17 July	7 October	
22 July	9 October	
24 July	16 October **C**	

Because of sampling problems and destruction of some sample during transportation in some case the sampling were taken later.

*automatic sampling at points C and D

C = complete analysis

2. Methods

2.1. Classical water quality parameters and metals

Parameter	Hungarian National Standard	Summary of method
pH	MSZ 260-4:1971	Potentiometric measurement with WTW pMX3000 and glass-calomel electrodes
BOD (5)	non-standard method	Manometric method with WTW OxiTop
Suspended solids	MSZ 260-3:1973	Gravimetric method after membrane filtration (0.45 μm) and drying at 105 °C
Ammonia	MSZ 260-9:1988	Spectrometric method with Nessler reagent after distillation at pH 7.4, measured with Varian Cary 3 spectrophotometer at 660 nm
Phenol index	MSZ 1484-1:1992	4-aminoantipyrine spectrometric method after steam-distillation with Varian Cary 3 spectrophotometer at 510 nm
Organic solvent extract	MSZ 260-22:1974	Gravimetric method after extraction with tetrachloro-methane
Total silver	MSZ 260-45:1983	Flame atomic absorption method with Varian SpectrAA 20 Plus AAS
Total cadmium	MSZ 260-34:1981	Flame atomic absorption method with Varian SpectrAA 20 Plus AAS
Total chromium	MSZ 260-32:1989	Flame atomic absorption method with Varian SpectrAA 20 Plus AAS
Total mercury	MSZ 260-43:1980	Cold vapor atomic absorption method with Unicam Solaar 939 AA
Total zinc	MSZ 260-34:1981	Flame atomic absorption method with Varian SpectrAA 20 Plus AAS

2.2. Organic micropollutants

The organic micropollutants were determined after extraction, sample concentration and clean-up by GC-MS and HPLC method.
Quantitation was obtained by internal standard method at the GC-MS measurements, and by external calibration method in the case of HPLC measurements.

2.2.1. Sample preparation

2.2.1.1. Volatile organic compounds (VOC)

100 ml waste water sample containing surrogate standards was extracted with 1 ml pentane. Calibration standards at five concentrations containing the same quantity of surrogate standards were prepared, added to 100 ml organic free distilled water and extracted with pentane. The extracts were used direct for GC-MS measurement. During the hole process the samples and the calibration standards were cooled. The purity of surrogate standards was tested.

2.2.1.2. Phenols

Sodium hydroxide solution was added to 250 ml waste water sample containing surrogate standard to a pH value 12. The sample was extracted with 3x10 ml dichloromethane. The extracts were discarded. Hydrochloric acid (5N) was then added to the sample to a pH value 2 and the sample was extracted with 3x10 ml dichloromethane again. The combined dichloromethane extracts was evaporated to app. 500 µl under nitrogen. The extract was used for derivatization.
Derivatization. The phenols were determined in form of phenol-acetates. 250µl pyridine and 250µl acetic anhydride were added to the 500µl extract. After standing 15 minutes at room temperature the solution was extracted with distilled water, dried with sodium sulphate, and injected. The calibration standards were prepared in the same way.

2.2.1.3. Aldehydes

250 ml water sample + 25 ml DNPH (25 µg/ml in 2M HCl) was reacted for 10 minutes at room temperature., then was extracted 3 times with 15-15 ml dichloromethane. The combined dichloromethane extracts was washed 2 times with 30-30 ml 2M HCl, then with 30 ml distilled water. The dichloromethane was evaporated to dryness, and the residue was dissolved in 100 µl acetonitrile.

2.2.1.4.Quaternary ammonium salts

The samples were determined according to the German Standard DIN 38409 Teil 20.

2.2.2. GC-MS measurements

Instrument: HP6890 Gas Chromatograph - HP5972 Mass Selective Detector

2.2.2.1. Volatiles

MS EI+, GC/SIM
Source temperature: 180 C°
EM Voltage: 3000
Solvent delay: 7.50 min

GC Column: Quadrex, 30 m, 0.25 mm, 3 μm + guard column: 2.5 m
Carrier gas: Helium
Ramped flow: 1.7, 0.7 ml/min
Mode: pulsed split
Injector temperature: 230 C°
Injected volume: 2 μl
Oven temperature: 35 C°(8 min)-10 C°/min-280 C°(5 min)
Interface line: 280 C°

2.2.2.2. Phenols

MS EI+, GC/SIM
Source temperature: 180 C°
EM Voltage: 3000
Solvent delay: 3.40 min

GC Column: J&W DB-5ms, 20 m, 0.18 mm, 0.18 μm + guard column: 5.0 m
Carrier gas: Helium
Ramped flow: 0.4, 1.3 ml/min
Mode: pulsed split
Injector temperature: 250 C°
Injected volume: 2 μl
Oven temperature: 45 C°(2 min)-8 C°/min-195 C°(0 min)-25 C°/min-300 C°(5 min)
Interface line: 300 C°

2.2.3. HPLC Measurements - Aldehydes

Instrument: HP-1090/II HPLC - diode array detector
Column: Hypersil BDS C18, 3μ, 100x4.6 mm
Temperature: 40 C°
Injected volume: 10 μl
Eluent: acetonitrile/water
Gradient:

time	water%	acetonitrile%
0	60	40
5	60	40
25	0	100

Flow rate: 1 ml/min
Detection wavelength: 360 nm

2.2.4. Spectrophotometric measurements - Quaternary ammonium salts

Instrument: Specord UV/VIS
Wavelength: 628 nm

3. Analytical Data

3.1. Classical water quality parameters and metals

3.1.1. pH, BOD, suspended solids, ammonia, phenol index, organic solvent extract

Sampling date (dd.mm.)	Code of sampling site	pH	BOD(5) (mg/l)	Suspended solids (mg/l)	Ammonia (mg/l)	Phenol index (mg/l)	Organic solvent extract (mg/l)
07.07.	**A**	7.42	34	82	5.54	0.094	1.9
	B	4.51	298	8	0.146	0.328	6.0
	D	8.44	180	80	19.1	0.398	7.5
	E	9.45	105	46	0.180	0.045	2.8
08.07.	**A**	7.32	26	46	3.12	0.086	1.0
	B	5.42	460	46	1.48	0.536	7.6
	C	7.56	130	60	5.30	0.131	1.4
	D	7.93	210	132	27.6	0.475	3.9
	E	8.55	30	34	2.42	0.052	0.87
	TW	7.73	<2	4	0.024	0.068	0.12
09.07.	**A**	7.50	25	44	3.51	0.102	0.63
	B	7.17	440	34	0.646	0.041	1.4
	C	7.20	270	288	24.0	0.251	0.62
	D	7.61	165	124	26.9	0.425	2.4
	E	7.15	75	76	4.21	0.085	3.5
10.07.	**A**	7.30	22	56	2.29	<0.014	0.25
	B	4.32	80	2	0.094	0.015	6.5
	C	7.55	160	156	34.1	-	4.1
	D	7.76	100	60	31.9	0.057	3.5
	E	7.81	74	34	2.95	0.045	1.1
	TW	7.39	<2	22	0.015	<0.014	0.12
11.07.	**A**	7.18	29	20	2.63	0.018	2.3
	B	5.11	200	18	0.121	0.211	4.3
	C	7.97	100	112	22.9	0.039	4.0
	D	8.11	196	114	32.3	0.082	5.8
	E	8.00	38	32	3.63	<0.014	0.37
12.07.	**A**	7.22	11	4	1.12	<0.014	0.5
	B	7.19	600	54	0.430	0.136	6.1
	C	7.28	170	96	40.3	0.088	4.6
	D	7.41	170	150	69.0	0.063	5.4
	E	8.39	220	178	89.7	0.134	1.5
15.07.	**A**	7.57	18	18	3.38	0.055	3.1
	B	7.61	31	210	0.390	0.020	4.1
	C	7.51	205	92	2.24	0.100	17
	D	7.99	195	324	76.0	0.192	10
	E	7.71	36	212	3.30	0.092	4.0

Sampling date (dd.mm.)	Code of sampling site	pH	BOD(5) (mg/l)	Suspen-ded solids (mg/l)	Ammonia (mg/l)	Phenol index (mg/l)	Organic solvent extract (mg/l)
17.07.	**C**	7.57	115	74	5.15	0.159	0.38
	D	8.27	330	50	24.6	0.547	2.50
	E	6.90	140	80	32.9	0.365	0.50
22.07.	**A**	6.93	50	38	15.9	0.087	0.50
	B	3.83	400	14	1.58	0.183	1.3
	C	7.29	85	38	3.68	0.183	0.63
	D	6.28	210	128	30.7	0.263	1.8
	E	6.54	75	60	21.3	0.120	0.38
24.07.	**A**	6.81	36	20	10.5	0.152	0.50
	B	4.05	426	10	0.148	0.091	1.5
	C	6.97	85	66	1.10	0.125	0.63
	D	7.27	620	194	8.71	0.183	14
	E	8.07	40	36	23.6	0.116	1.4
04.09	**A**	7.88	38.0	8	9.36	0.073	0.88
	B	5.75	10	8	0.211	0.084	0.75
	C	7.74	120	56	4.48	0.443	2.0
	D	8.33	300	328	5.04	0.071	5.75
	E	7.92	26	4	1.688	0.250	0.88
	TW	7.29	0.36	2	0.007	0.008	0.12
09.09.	**A**	7.83	42	28	12.3	0.109	1.76
	B	5.86	350	16	11.2	0.026	1.65
	C	7.62	85	58	12.0	0.126	3.76
	D	8.17	180	184	52.7	0206	9.33
	E	7.73	50	34	12.3	0.059	1.89
11.09.	**A**	7.78	30	36	20.8	0.045	4.57
	B	8.12	500	38	5.24	0.029	1.14
	C	7.88	165	60	26.8	0.317	5.71
	D	8.02	250	152	6.00	0.303	15.5
	E	8.26	260	120	59.4	0.313	6.41
23.09	**A**	7.51	38	40	16.4	<0.003	10.0
	B	2.80	100	40	0.238	0.096	15.5
	C	7.16	135	56	79.6	0.040	7.5
	D	7.52	105	146	97.5	0.086	22.5
	E	7.43	90	46	21.6	0.041	5.25
25.09	**A**	7.96	125	42	27.4	0.080	4.1
	B	8.06	29	4	0.73	0.028	0.24
	C	7.82	70	22	3.042	0.089	1.94
	D	8.16	170	142	31.1	0.124	6.52
	E	8.26	60	30	4.347	0.049	3.54
02.10	**A**	7.68	58	112	18.90	0.075	9.5
	B	2.97	40 ?	40	0.169	0.067	1.0
	C	7.23	45	48	4.01	0.086	6.0
	D	8.46	240	300	108.9	0.197	2.0
	E	8.15	50	20	6.64	0.112	1.0
	Tw	7.46	0.44	4	0.167	0.051	0.12

Sampling date (dd.mm.)	Code of sampling site	pH	BOD(5) (mg/l)	Suspen-ded solids (mg/l)	Ammonia (mg/l)	Phenol index (mg/l)	Organic solvent extract (mg/l)
07.10	**A**	7.36	44	44	17.8	0.126	0.21
	B	3.57	170	6	0.84	0.016	0.32
	C	7.06	70	20	1.26	0.100	0.21
	D	7.10	210	80	38.2	0.146	13.6
	E	7.52	26	52	13.7	0.151	0.44
09.10	**A**	7.34	56	36	14.8	0.088	3.11
	B	7.02	95	6	0.26	0.070	0.53
	C	8.03	145	70	17.8	0.124	14.7
	D	7.93	140	116	20.0	0.135	0.96
	E	7.99	72	10	11.5	0.113	0.21
16.10	**A**	7.34	50	12	19.3	0.046	1.37
	B	5.87	50	4	0.172	0.005	3.12
	C	7.81	45	14	34.2	0.014	4.87
	D	6.93	155	78	109	<0.003	4.12
	E	7.95	40	14	35.3	0.107	5.25
	Tw	7.36	1.5	4	0.073	0.003	0.12
21.10	**A**	8.16	75	18	16.0	0.098	2.00
	B	7.92	95	28	0.300	0.020	8.87
	C	7.85	65	38	8.5	0.082	6.75
	D	7.74	115	40	28.6	0.106	6.25
	E	7.95	60	14	11.9	0.090	4.37
22.10	**A**	7.67	27	6	15.2	0.033	2.50
	B	6.80	62	10	0.117	<0.003	3.62
	C	7.80	105	42	17.5	0.064	8.62
	E	7.56	28	14	1.21	0.039	5.90
28.10	**A**	8.14	46	46	13.3	0.127	6.33
	B	4.37	400	180	0.394	0.227	13.4
	D	8.02	550	264	88.3	0.252	17.4
30.10	**A**	8.17	44	52	18.3	0.143	7.88
	B	6.54	190	62	0.008	0.157	2.93
	C	7.20	100	22	11.8	0.146	3.97
	D	8.35	400	176	84.5	0.147	16.3
	E	8.05	190	88	60.9	0.164	4.97
	Tw	7.85	0.89	2.0	0.033	<0.003	0.12
04.11	**A**	7.82	55	24	28.6	0.258	6.20
	B	2.76	1500	14	0.500	0.054	5.05
	C	6.97	155	44	19.8	0.185	10.2
	D	8.62	55	46	26.7	0.126	5.18
	E	8.23	70	68	27.4	0.066	4.22
06.11	**A**	7.90	34	58	20.2	0.137	4.88
	B	7.40	170	16	0.083	0.080	7.30
	C	7.73	170	154	12.9	0.286	23.3
	D	8.19	140	132	14.5	0.502	15.6
	E	8.41	45	68	32.4	0.065	10.5

3.1.2. Heavy Metals (Ag , Cd, Cr, Hg, Zn)

Sampling date (dd.mm.)	Code of sampling site	Total silver (µg/l)	Total cadmium (µg/l)	Total chromi-um (µg/l)	Total mercury (µg/l)	Total zinc (µg/l)
08.07.	**A**	<10	<5	<20	<0.7	39
	B	<10	<5	<20	<0.7	1410
	C	<10	<5	<20	30.3	105
	D	<10	<5	<20	29.7	80
	E	<10	<5	50	1.2	67
	TW	<10	<5	<20	<0.7	<30
10.07.	**A**	<10	<5	<20	<0.7	59
	B	<10	<5	<20	<0.7	<30
	C	<10	<5	<20	27.8	119
	D	<10	<5	<20	34.7	79
	E	<10	<5	<20	<0.7	109
	TW	<10	<5	<20	<0.7	48
09.04	**A**	<10	<5	<20	0.91	153
	B	<10	<5	<20	<0.7	596
	C	<10	<5	<20	<0.7	112
	D	<10	<5	<20	<0.7	87
	E	<10	<5	<20	<0.7	144
	TW	<10	<5	<20	0.99	136
09.11	**A**	<10	<5	<20	<0.7	194
	C	<10	<5	<20	2.0	211
	E	<10	<5	<20	1.5	373

Sampling	Code of sampling site	Total silver (µg/l)	Total cadmium (µg/l)	Total chromi-um (µg/l)	Total mercury (µg/l)	Total zinc (µg/l)
03.10	**A**	<10	<5	<20	<0.7	273
	B	<10	<5	<20	<0.7	533
	C	<10	<5	<20	<0.7	197
	D	<10	<5	<20	<0.7	395
	E	<10	<5	<20	<0.7	124
	Tw	<10	<5	<20	<0.7	180
16.10	**A**	<10	<5	<20	<0.7	106
	B	<10	<5	<20	<0.7	308
	C	<10	<5	<20	2.3	61
	D	<10	<5	<20	<0.7	95
	E	<10	<5	<20	<0.7	28
	Tw	<10	<5	<20	<0.7	343
30.10	**A**	<10	<5	<20	<0.7	177
	B	<10	<5	<20	<0.7	935
	C	<10	<5	<20	1.4	173
	D	<10	<5	<20	<0.7	280
	E	<10	<5	<20	2.3	124
	Tw	<10	<5	<20	<0.7	425

3.2.Organic Micropollutants

3.2.1. Volatile organic compounds (VOC)

c=ng/L

Compounds	Samples							
	8/07 **A**	8/07 **B**	8/07 **C**	8/07 **D**	8/07 **E**	8/07 **TW**	9/07 **C**	DL
cis 1,2-dichloroethene	0	114	0	129	122	0	139	50
chloroform	347	979	3887	1060	272	3119	3554	25
1,1,1-trichloroethane	0	0	0	225	0	0	0	25
1,2-dichloroethane	0	11,8	0	0	0	60,3	0	25
benzene	0	35,5	0	0	0	0	0	10
carbon tetrachloride	0	0	0	0	0	0	0	25
1,2-dichloropropane	0	0	0	147	252	0	171	25
trichloroethene	0	13,8	0	0	0	0	0	10
bromodichloromethane	161	956	409	332	567	3294	0	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	727	166	286	149	126	54,9	455	5
dibromochloromethane	0	6664	872	802	1541	3052	844	25
tetrachloroethene	0	17,3	0	0	0	76,9	0	25
chlorobenzene	0	0	0	0	0	0	0	10
ethyl benzene	31,7	33,5	41,6	39,1	43,4	34,9	65	10
m-,p-xylene	120	106	150	188	119	114	137	10
bromoform	151	727	353	428	553	577	400	25
o-xylene	75,9	155	154	267	0	124	217	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

Compounds	Samples							
	10/07 **A**	10/07 **B**	10/07 **C**	10/07 **D**	10/07 **E**	10/07 **TW**	11/07 **C**	DL
cis 1,2-dichloroethene	135	121	0	0	142	114	0	50
chloroform	284	126	19122	2120	260	3083	2563	25
1,1,1-trichloroethane	0	0	921	1041	0	0	861	25
1,2-dichloroethane	0	0	0	0	0	0	58	25
benzene	0	0	0	0	0	0	26	10
carbon tetrachloride	0	0	0	0	0	0	0	25
1,2-dichloropropane	0	116	0	0	0	0	0	25
trichloroethene	0	0	0	0	0	0	0	10
bromodichloromethane	168	0	308	464	545	3164	0	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	581	107	386	6884	144	0	218	5
dibromochloromethane	365	0	724	1018	1361	2974	30	25
tetrachloroethene	0	0	0	0	0	76	87	25
chlorobenzene	0	0	0	0	0	0	0	10
ethyl benzene	27	50	52	358	62	35	51	10
m-,p-xylene	111	180	193	410	171	130	217	10
bromoform	136	193	316	0	652	568	0	25
o-xylene	0	110	421	955	198	96	593	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

0 = not detectable

3.2.1. Volatile organic compounds (VOC) (cont.)

c=ng/L

Compounds	Samples							
	12/07 **C**	15/07 **C**	16/07 **C**	17/07 **C**	22/07 **C**	24/07 **C**	04/09 **A**	DL
cis 1,2-dichloroethene	0	0	0	0	0	0	0	50
chloroform	2510	1885	1858	17656	7278	17022	580	25
1,1,1-trichloroethane	845	0	476	0	0	0	0	25
1,2-dichloroethane	48	0	29	0	16,2	15,6	0	25
benzene	24	22	27	27	41	24	0	10
carbon tetrachloride	0	0	0	55	24	31	0	25
1,2-dichloropropane	0	0	0	0	0	0	0	25
trichloroethene	10	12	9	17	15	14	0	10
bromodichloromethane	0	589	72	4629	4029	6486	0	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	214	771	559	791	448	282	3164	5
dibromochloromethane	30	1040	73	2805	3002	4584	0	25
tetrachloroethene	45	42	51	57	59	62	155	25
chlorobenzene	6	11	17	18	60	0	0	10
ethyl benzene	42	31	44	211	44	38	346	10
m-,p-xylene	214	131	197	151	174	140	685	10
bromoform	0	295	0	622	716	900	0	25
o-xylene	530	135	509	255	0	193	0	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

Compounds	Samples							
	04/09 **B**	04/09 **C**	04/09 **D**	04/09 **E**	04/09 **TW**	09/09 **C**	11/09 **C**	DL
cis 1,2-dichloroethene	0	0	0	0	0	0	0	50
chloroform	362	16780	0	72685	1100	10629	1710	25
1,1,1-trichloroethane	0	0	0	0	0	0	0	25
1,2-dichloroethane	0	0	0	0	0	0	0	25
benzene	0	0	0	0	0	167	0	10
carbon tetrachloride	0	0	0	0	0	648	0	25
1,2-dichloropropane	0	0	0	0	0	0	0	25
trichloroethene	45	0	0	0	0	2814	0	10
bromodichloromethane	0	0	0	0	0	1172	546	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	74	578	110	912	0	1531	223	5
dibromochloromethane	0	0	0	0	0	1959	1099	25
tetrachloroethene	146	231	0	0	413	947	0	25
chlorobenzene	0	0	0	0	0	0	0	10
ethyl benzene	128	164	301	0	0	203	0	10
m-,p-xylene	242	395	976	0	0	481	0	10
bromoform	0	0	0	0	0	0	0	25
o-xylene	0	0	0	0	0	0	0	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

0 = not detectable

c=ng/L

3.2.1. Volatile organic compounds (VOC) (cont.)

Compounds	Samples							
	23/09 C	25/09 C	02/10 A	02/10 B	02/10 C	02/10 D	02/10 E	DL
cis 1,2-dichloroethene	0	0	0	0	0	0	0	50
chloroform	777	1430	58555	3551	8303	7880	1958	25
1,1,1-trichloroethane	0	0	0	0	0	0	0	25
1,2-dichloroethane	0	0	0	0	0	0	0	25
benzene	331	29	0	541	0	681	1414	10
carbon tetrachloride	0	0	0	0	0	0	0	25
1,2-dichloropropane	0	0	0	0	0	0	0	25
trichloroethene	79	0	0	0	0	0	1432	10
bromodichloromethane	0	0	3549	6887	6553	0	4378	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	477	165	8048	0	0	4495	408	5
dibromochloromethane	0	0	8104	12893	13712	8626	10606	25
tetrachloroethene	0	0	0	0	0	0	0	25
chlorobenzene	0	0	0	0	0	0	0	10
ethyl benzene	70	42	1184	684	802	0	540	10
m-,p-xylene	198	185	1875	1332	1600	0	1154	10
bromoform	0	0	5044	0	0	0	0	25
o-xylene	0	0	0	0	0	0	0	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

Compounds	Samples							
	02/10 TW	07/10 C	09/10 C	16/10 A	16/10 B	16/10 C	16/10 D	DL
cis 1,2-dichloroethene	0	0	0	0	0	0	0	50
chloroform	4727	62285	5785	5148	1314	5081	2861	25
1,1,1-trichloroethane	0	0	0	0	0	0	0	25
1,2-dichloroethane	0	0	0	0	0	0	2626	25
benzene	611	938	514	10099	1281	264	1324	10
carbon tetrachloride	0	0	0	0	0	0	2361	25
1,2-dichloropropane	0	0	0	0	0	0	0	25
trichloroethene	0	0	0	0	0	0	1471	10
bromodichloromethane	14126	3720	5600	1903	3957	3341	3040	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	0	1189	1161	9165	0	834	5174	5
dibromochloromethane	27938	11543	13416	4583	9060	8280	8857	25
tetrachloroethene	0	0	0	0	0	0	0	25
chlorobenzene	0	0	0	27845	0	0	0	10
ethyl benzene	0	4139	866	0	0	541	1347	10
m-,p-xylene	0	8967	2245	0	0	1028	2469	10
bromoform	14558	10740	10241	0	5977	0	7651	25
o-xylene	0	5076	2142	0	0	0	3891	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	1860	0	0	0	10
1,4-dichlorobenzene	0	0	0	1665	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

0 = not detectable

3.2.1. Volatile organic compounds (VOC) (cont.)

c=ng/L

Compounds	Samples							
	16/10 E	16/10 TW	21/10 C	22/10 C	30/10 A	30/10 B	30/10 C	DL
cis 1,2-dichloroethene	0	0	0	0	0	0	0	50
chloroform	918	3347	17313	3903	4859	1803	3779	25
1,1,1-trichloroethane	0	0	0	0	0	0	0	25
1,2-dichloroethane	0	0	0	0	0	0	0	25
benzene	0	0	235	279	127	157	165	10
carbon tetrachloride	0	0	0	540	156	122	76	25
1,2-dichloropropane	0	0	0	0	0	0	0	25
trichloroethene	0	0	0	0	0	0	0	10
bromodichloromethane	4067	8313	3032	3762	2458	1006	2179	25
1,3-dichloropropene	0	0	0	0	0	0	0	25
2,3-dichloropropene	0	0	0	0	0	0	0	25
toluene	0	298	2153	3994	10683	0	0	5
dibromochloromethane	11190	15544	9270	10079	0	0	5942	25
tetrachloroethene	0	1035	0	0	0	0	0	25
chlorobenzene	0	0	0	0	0	0	0	10
ethyl benzene	996	0	810	1044	1724	1900	1971	10
m-,p-xylene	1657	0	1785	2433	3655	1961	1905	10
bromoform	8089	8968	8178	8397	0	0	0	25
o-xylene	2368	0	3231	3367	0	0	0	10
tetrachloroethane	0	0	0	0	0	0	0	25
1,3-dichlorobenzene	0	0	0	0	0	0	0	10
1,4-dichlorobenzene	0	0	0	0	0	0	0	10
1,2-dichlorobenzene	0	0	0	0	0	0	0	10

Compounds	Samples							
	30/10 D	30/10 E	30/10 TW	4/11 C	6/11 C			DL
cis 1,2-dichloroethene	0	0	0	0	0			50
chloroform	2470	2211	4453	11019	14387			25
1,1,1-trichloroethane	0	0	0	707	418			25
1,2-dichloroethane	0	0	0	3532	3730			25
benzene	243	200	1	1454	1978			10
carbon tetrachloride	44	74	635	1192	1441			25
1,2-dichloropropane	0	0	0	0	0			25
trichloroethene	0	0	0	578	624			10
bromodichloromethane	2002	2585	9229	4896	5643			25
1,3-dichloropropene	0	0	0	0	0			25
2,3-dichloropropene	0	0	0	0	0			25
toluene	913	0	0	3401	3782			5
dibromochloromethane	0	7649	19524	5499	6554			25
tetrachloroethene	0	0	0	0	238			25
chlorobenzene	0	0	0	0	0			10
ethyl benzene	1824	1694	3002	358	394			10
m-,p-xylene	2146	1746	1710	424	824			10
bromoform	0	0	12909	2342	2652			25
o-xylene	0	0	0	751	923			10
tetrachloroethane	0	0	0	0	0			25
1,3-dichlorobenzene	0	0	0	0	0			10
1,4-dichlorobenzene	0	0	0	0	0			10
1,2-dichlorobenzene	0	0	0	0	0			10

0 = not detectable

3.2.2. Phenols

c= µg/L

Samples	Compounds							
	Phenol	2-Methylphenol	3-Methylphenol	4-Methylphenol	2-Ethylphenol	3-Ethylphenol	4-Ethylphenol	2-Phenylphenol
8/07 A	1,8	0	0	2,8	0	0	0	2,1
8/07 B	0,4	0	0	0,1	0	0	0	0,3
8/07 C	1,3	0	0	3,3	0	0	0	0,8
8/07 D	5,4	0	0	38	0	0	0	2,4
8/07 E	2,6	0	0	3,7	0	0	0	2,8
8/07 TW	0,5	0	0,1	0	0,1	0	0	0
10/07 A	1,7	0	0	2,3	0	0	0	1,0
10/07 B	1,8	0	0	0,7	0	0	0	0
10/07 C	9,0	0	0	9,1	0,2	0	0	0,7
10/07 D	12	0	0	36	0	0	0	4,6
10/07 E	1,4	0	0	2,2	0	0	0	0,4
10/07TW	0,5	0	0	0	0,1	0	0	0
04/09 A	0	0	0	0	0	0	0	0
04/09 B	1,1	0	0	66	0	0	0	0,2
04/09 C	12	0	0	11	0	0	0	2,0
04/09 D	22	0	0	23	0	0	0,1	0,3
04/09 E	2,9	0	0	6,1	0	0	0,1	0,6
04/09 TW	0,5	0	0	0	0	0	0	0
DL	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1

0 = not detectable

3.2.2. Phenols (cont.)

c= µg/L

Samples	Compounds										
	Phenol	2-Methylphenol	3-Methylphenol	4-Methylphenol	2-Ethylphenol	3-Ethylphenol	4-Ethylphenol	2,4-Dichloro-pheno	2-Phenylphenol	4-Phenylphenol	5-Cl-2,4-dichlorophenoxy-phenol
2/10 **A**	133	0,1	0,2	98	0	0	0,3	0,2	7,9	0	1,3
2/10 **B**	2,8	0	0	24	0,4	0	0,1	0,2	0,2	0	0
2/10 **C**	1,1	0	0	0,1	0	0	0	0,5	0	0	0,2
2/10 **D**	396	0,2	0,6	403	0	0	1,1	0,2	2,7	0	0,3
2/10 **E**	0,8	0	0	0,1	0	0	0	0	0	0	0
2/10 **TW**	0,6	0	0	0	0	0	0	0	0	0	0
16/10 **A**	40	0,1	0,1	36	16	0	0,4	0,1	28	0	0,6
16/10 **B**	3,3	0	0	2,5	0	0	0	8,6	0,1	0	42,8
16/10 **C**	19,6	0,1	0,3	59	0	0,1	0,3	0,3	3,1	0	0,5
16/10 **D**	3361	0,4	4,3	2276	2160	0,9	12	2,0	167	2,0	5,2
16/10 **E**	10,1	0,1	0,0	5,2	0	0	0,3	0,1	15	0	0,1
16/10 **TW**	1,2	0	0	0,1	0	0	0	0	0	0	0
30/10 **A**	16	0,1	0,1	13,3	0	0	0,2	0,2	1,2	0	0,3
30/10 **B**	4,4	0	0	2,0	0	0	0	0,4	0	0	7,9
30/10 **C**	7,1	0	0	16	0	0	0,1	0,3	0,7	0	0
30/10 **D**	37	0,1	0,1	75	0	0	0,3	0,2	0,4	0	0
30/10 **E**	24	0,1	0,2	33	0	0	0,2	0,2	0,6	0	0
30/10 **TW**	2,7	0	0	0,1	0	0	0	0,1	0	0	0
DL	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1

0 = not detectable

3.2.3. Aldehydes

c= µg/L

Samples	Compounds												
	formaldehyde	acetaldehyde	acrolein,aceton	propionaldehyde	crotonaldehyde	butyraldehide	benzaldehyde	gyoxal	glutaraldehyde	valeraldehyde	o-tolualdehyde	p,m-tolualdehyde	hexald.dimetbenz
08/07 **A**	6,8	12	1,5	0	0	2,3	5,0	6,2	0	0	0	2,1	2,2
08/07 **B**	8,9	197	2,8	0	0	0	0	14	0	0	7,3	3,9	0
08/07 **C**	25	2,9	0	0	0	0	0	328	0	6,2	0	2,9	0
08/07 **D**	29	10	1,4	3,7	0	0	0	126	25	49	0	2,5	2,1
08/07 **E**	0	0	0	0	0	0	0	0	0	0	0	0	0
08/07 **TW**	3,2	14	2,9	0	0	0	0	0	0	0	0	0	0
10/07 **A**	6,1	23	3,1	0	0	3,9	3,5	32	122	0	0	2,3	0
10/07 **B**	0	299	0	0	0	2,0	0	88	1,6	2,0	0	1,4	0
10/07 **C**	7,9	4,8	0	0	0	0	0	23	4,6	0	0	0	0
10/07 **D**	6,9	19	3,7	0	0	0	0	37	8,6	30	6,8	4,3	0
10/07 **E**	2,7	19	0	0	0	0	0	0	7,8	0	0	2,1	0
10/07 **TW**	11	27	8,1	3,8	4,3	0	8,3	0	8,8	2,7	0	4,0	2,8
04/09 **A**	0	0	1,4	0	0	3,5	0	46	0	0	0	1,9	2,0
04/09 **B**	4,5	21	0	0	0	2,9	0	0	0	0	0	4,3	0
04/09 **C**	14	6,3	0	0	0	2,5	0	38	0	5,6	4,7	2,8	0
04/09 **D**	0	0	0	0	0	3,1	0	30	0	0	5,3	0	0
04/09 **E**	3,5	0	0	0	0	0	0	0	0	0	0	0	0
04/09 TW	4,0	2,5	0	0	0	0	0	0	0	0	0	0	0
DL	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

0 = not detectable

3.2.3. Aldehydes (cont.)

c= µg/L

	formaldehyde	acetaldehyde	acrolein,aceton	propionaldehyde	crotonaldehyde	butyraldehide	benzaldehyde	gyoxal	glutaraldehyde	valeraldehyde	o-tolualdehyde	p,m-tolualdehyde	hexald.dimetbenz
02.10 **A**	4,2	1	1,7	0	0	1,5	0	0	0	0	1,6	0	0
02.10 **B**	2,6	6,7	0	0	0	0	0	0	0	0	0	0	0
02.10 **C**	0	0	0	0	0	0	0	0	0	0	0	0	0
02.10 **D**	1,6	1	1,2	0	0	0	0	0	0	0	0	0	1
02.10 **E**	0	0	0	0	0	0	0	0	0	0	0	0	0
02.10 **TW**	1,8	1	1	0	0	0	0	0	0	0	0	0	0
16.10 **A**	4,6	1,2	2,9	0	0	0	0	0	0	0	0	0	0
16.10 **B**	3,5	1,5	0	0	0	0	0	0	0	0	0	1	0
16.10 **C**	8,3	2,9	6,1	0	0	1,5	0	0	0	0	1,2	1	0
16.10 **D**	3,3	3,3	6,0	0	0	0	0	0	0	0	0	0	0
16.10 **E**	5,1	1,8	0	0	0	1	0	0	0	0	0	0	0
16.10 **TW**	1,9	1,1	1	0	0	0	1	0	0	0	1	0,3	0
30.10 **A**	5,7	3,1	1	0	0	0	0	0	0	0	0	1	0
30.10 **B**	9,1	73	2,1	0	0	0	0	0	0	0	0	2,4	0
30.10 **C**	22	28	1	0	0	0	0	0	0	0	0	1	0
30.10 **D**	5,6	3,0	1	0	0	0	0	0	0	0	0	1	0
30.10 **E**	5,7	3,0	1	0	0	0	0	0	0	0	0	1	0
30.10 TW	2,4	0,0	0	0	0	0	0	0	0	0	0	0	0
DL	1,0	1,0	1,0	1,000	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

0 = not detectable

3.2.4. Quaternary ammonium salts

mg/L

Sample	8/07 A	8/07 B	8/07 C	8/07 D	8/07 E	8/07 Csv	10/07 A	10/07 B	10/07 C	10/07 D	10/07 E	10/07 Csv
Σ Quaternary	0,08	0,43	0,4	0,5	0,15	0,02	0,21	0,42	0,68	0,6	0,45	0,02

Sample	04/09 A	04/09 B	04/09 C	04/09 D	04/09 E	04/09 Csv	2/10 A	2/10 B	2/10 C	2/10 D	2/10 E	2/10 Csv
Σ Quaternary	0,21	0,45	0,53	0,75	0,78	0,04	0,35	0,58	0,6	0,67	0,45	0,04

Sample	16/10 A	16/10 B	16/10 C	16/10 D	16/10 E	16/10 Csv	30/10 A	30/10 B	30/10 C	30/10 D	30/10 E	30/10 Csv
Σ Quaternary	0,38	0,75	0,72	0,82	0,67	0,03	0,41	0,48	0,84	0,79	0,53	0,03

DL= 0,02

3.3. Microbiological Tests

Bacterial investigation of sewage of the "St. Imre" Hospital of Budapest Municipal Council

Sampling date 10th September 1997

	Total bacterial cell count	Coliforms	E.coli
A	$8*10^5$ cfu/ml	$1*10^5$ cfu/ml	$4*10^4$ cfu/ml
B	$9*10^4$ cfu/ml	$1*10^5$ cfu/ml	$4*10^3$ cfu/ml
C	$8*10^4$ cfu/ml	$7*10^3$ cfu/ml	$2*10^3$ cfu/ml
D	$6*10^5$ cfu/ml	$1*10^4$ cfu/ml	$8*10^2$ cfu/ml
E	$8*10^3$ cfu/ml	$9*10^2$ cfu/ml	$2*10^2$ cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

Sampling date 17th September 1997

	Total bacterial cell count	Coliforms	E.coli
A	$8*10^4$ cfu/ml	$2*10^3$ cfu/ml	$4*10^2$ cfu/ml
B	$1*10^4$ cfu/ml	$1*10^2$ cfu/ml	$5*10^1$ cfu/ml
C	$5*10^5$ cfu/ml	$6*10^4$ cfu/ml	$6*10^3$ cfu/ml
D	$3*10^4$ cfu/ml	$1*10^3$ cfu/ml	$2*10^2$ cfu/ml
E	$5*10^5$ cfu/ml	$6*10^3$ cfu/ml	$6*10^2$ cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

Sampling date 25th September 1997

	Total bacterial cell count	Coliforms	E.coli
A	$8*10^5$ cfu/ml	$6*10^4$ cfu/ml	$2*10^4$ cfu/ml
B	$5*10^3$ cfu/ml	$2*10^4$ cfu/ml	$4*10^3$ cfu/ml
C	$1*10^4$ cfu/ml	$6*10^3$ cfu/ml	$8*10^2$ cfu/ml
D	$4*10^2$ cfu/ml	<1*10 cfu/ml	<1*10 cfu/ml
E	$6*10^2$ cfu/ml	<1*10 cfu/ml	<1*10 cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

cfu = colony forming unit

Sampling date 3rd October 1997

	Total bacterial cell count	Coliforms	E.coli
A	$2*10^4$ cfu/ml	$2*10^3$ cfu/ml	$1*10^3$ cfu/ml
B	$6*10^4$ cfu/ml	$8*10^3$ cfu/ml	$8*10^2$ cfu/ml
C	$2*10^4$ cfu/ml	$8*10^3$ cfu/ml	$8*10^3$ cfu/ml
D	$8*10^4$ cfu/ml	$2*10^3$ cfu/ml	$1*10^3$ cfu/ml
E	$2*10^3$ cfu/ml	$2*10^2$ cfu/ml	$1*10^2$ cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

Sampling date 16th October 1997

	Total bacterial cell count	Coliforms	E.coli
A	$4*10^6$ cfu/ml	$6*10^4$ cfu/ml	$6*10^3$ cfu/ml
B	$5*10^3$ cfu/ml	$6*10^2$ cfu/ml	$1*10^2$ cfu/ml
C	$4*10^4$ cfu/ml	$6*10^3$ cfu/ml	$8*10^2$ cfu/ml
D	$6*10^4$ cfu/ml	$8*10^3$ cfu/ml	$5*10^3$ cfu/ml
E	$5*10^4$ cfu/ml	$6*10^3$ cfu/ml	$4*10^1$ cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

Sampling date 31th October 1997

	Total bacterial cell count	Coliforms	E.coli
A	$6*10^5$ cfu/ml	$5*10^4$ cfu/ml	$8*10^3$ cfu/ml
B	$8*10^5$ cfu/ml	$2*10^4$ cfu/ml	$1*10^4$cfu/ml
C	$6*10^6$ cfu/ml	$8*10^4$ cfu/ml	$8*10^3$ cfu/ml
D	$7*10^5$ cfu/ml	$6*10^4$ cfu/ml	$1*10^3$ cfu/ml
E	$1*10^5$ cfu/ml	$2*10^4$ cfu/ml	$9*10^3$ cfu/ml
TW	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml	$<1*10^1$ cfu/ml

cfu = colony forming unit

3.4. Limit values

Limit values for drinking water

Compounds	ug/L	ug/L
	EU 95/C131/03	WHO 1993
cis 1,2-dichloroethene		30
chloroform	40	200
1,1,1-trichloroethane		2000
1,2-dichloroetane	3	50
benzene		10
carbon tetrachloride		2
trichloroethene	70	70
bromodichloromethane	15	60
toluene		700
dibromochloromethane		100
tetrachloroethene	40	40
chlorobenzene		300
ethyl benzene		300
m-,p-xylene		500
bromoform		100
1,4-dichlorobenzene		300
1,2-dichlorobenzene		1000

Hungarian limit values for sewage water

	Limit mg/L
Organic solvent extract	40-60
Phenols	5,0-10
pH	6,5-10
Ammonia	100-150
Zn	2,0-10
Hg	0,005-0,05
Benzol	50-100
Organic solvent	50-100

4. Discussion

Average samples were collected with an automatic sampling apparatus at testing points C and D in the first week between 8 A.M. and 3 P.M. at 10-minute intervals. It can be concluded that the measured values of classical water quality parameters, metals and organic micropollutants are found in a narrow range, therefore, they are characteristic of the waste water discharge of the hospital. The single-time samples show differences of orders of magnitude (Fig.1.). At exceptionally high values, some organic micropollutants could be identified which had not been included in the original study plan.

Samples taken at testing points C and D -containing the waste waters of surgical operation rooms, obstetrics and gynecology and the laboratories- showed the highest pollutant concentrations.

4.1 Classical water quality parameters and metals

4.1.1. pH, BOD, suspended solids, ammonia, phenol index, organic solvent extract

The values of the classical water quality parameters were similar to those of typical community waste waters. The same conclusion applies to the test results of metals. The values do not exceed the limits given for the sewage water. Mercury traces could be detected in a few cases. The mercury contamination could have resulted from broken thermometers. The fate and evaporation of mercury in the sewage system could not be followed, of course. The extremely high zinc contents in a few samples might be attributed to dissolution from old joints of the water pipeline (Table 4.1.1.).

pH

The pH values were generally found between 6.5 and 8.5, as expected with common waste waters, with the exception of samples taken at sampling point B where values between 3 and 4 were also measured (Fig.2).

BOD

Higher values were found in samples taken at testing points B and D (Fig.3.).

Suspended solids

The highest values were measured in samples taken at testing points D (Fig.4).

Ammonia

The highest values were measured in samples taken at testing points D (Fig.5).

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Phenol index

Correlation could not be established between the sums of the values measured by GC-MS for individual phenols and the phenol index (Fig.6).

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Fat and oil content (organic solvent extract)

The highest values were expected at testing point A where the waste waters of the kitchen are discharged. The results did not prove this assumption because the compounds soluble in carbon tetrachloride showed maximum values at the other testing points and, finally these later determined the findings (Fig.7).

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4.1.2. Heavy metals (Ag , Cd, Cr, Hg, Zn)

Quantities above the detection level could be measured only in the case of zinc, the highest concentrations at testing point B. Very small quantities of mercury could be measured on two occasions at testing points C and D (Fig.8, Table 4.1.2.).

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4.2. Organic micropollutants

Fatty acids, fatty acid esters and aliphatic hydrocarbons could primarily been identified by gaschromatographic-mass spectrometric (GC-MS) scanning tests in the average waste water samples (Annex A-1-6, A-8). Hazardous micropollutants appear only in low concentrations in municipal waste waters. Many waste water samples had been extracted and analyzed by GC-MS scanning tests to select the compounds to be studied before the series measurements were started.

4.2.1. Volatile organic compounds (VOC)

The prohibition list of the EU for drinking water and surface waters was the starting point for the determination of VOC, partly because we assumed that the quality of waste waters is fundamentally affected by the quality of drinking water, partly because the discharged waste waters might affect the quality of surface waters. The quality of tap water was monitored both for the concentration of typical components and potentially appearing new pollutants. Special attention was paid to chlorinated hydrocarbons and simple aromatic compounds. The former compounds, byproducts of the chlorination of drinking waters, were detected in higher quantities first in July. At this time, because of the flooding on the Danube, the Water Works increased the chlorination to prevent the potential contamination of the bank-filtered water resources. The relatively low volatile tri- and tetrachloroethylene, the haloform compounds and the mixed haloforms of the chlorination products were identified also in the waste waters. There was no close correlation always between the drinking water and waste water values because the quantities of VOC in waste waters depends to a large extent on the utilization of tap water. The haloforms showed high values both in the tap water and the waste waters also in October when the surface water levels were low. With the exception of a few samples, the quantities of the above pollutants were lower than those specified for drinking waters in the EU Directives.

Chloroform values in excess of the maximum limit established for surface waters were observed in some cases independently from the quality of tap water. It turned

out that the chloroform at testing point C originated from the laboratory where it was used in small quantities for bilirubin tests. The hospital management took immediate action for the collection of chloroform as hazardous substance in the future.

The presence of aromatic derivatives -benzene, toluene, ethylbenzene, xylene- in waste waters can primarily be attributed to pollution from road transport. Testing points C and D are located at the fence of the hospital close to the high-volume transport of the Tétényi road. Testing point B is found at a distance of about 20 meters form the Tétényi road and testing point A is located at the vehicle entrance gate of the hospital. The aromatic hydrocarbons might appear in the tested samples due to the dissolution of vehicle exhaust gases into the waste waters. This assumption is supported by the chromatograms of qualitative GC-MS scanning tests in which peaks of high carbon-atom aliphatic hydrocarbons -characteristic of engine oils- appeared (Annex A-8.) The quantities of aromatic compounds were less the tolerated limits for drinking water in the EU Directives.

The following compounds were determined quantitatively: cis-1,2-dichloroethane, chloroform, 1,1,1-trichlororethane, 1,2-dichloroethane, benzene, carbon tetrachloride, 1,2-dichloropropane, trichloroethane, bromodichloromethan, 1,3-dichloropropane, 2,3-dichloropropane, toluene, dibromochloromethane, tetrachloroethane, chlorobenzene, ethylbenzene, m-,p-xylene, bromoform, o-xylene, tetrachloroethane, 1,3-dichlorobenzene, 1,4-dichlorobenzen, 1,2-dichlorobenzene (Fig.9-10., Table 4.2.1., Annex A-11-118).

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4.2.2. Phenols

Disinfectants contain phenols so it was expected that the concentration of phenols would be higher in hospital waste waters than in municipal waste waters. Phenol, methyl- and ethyl-phenols and 2-phenyl-phenol isomers -detected in scanning tests- were measured in the initial sampling period. Later on, randomly occurring small quantities of 2,4-dichlorophenol, 4-phenyl-phenol and trichlorophenoxy-phenol were identified (Annex A-10, A-7) and these three compounds were also determined in the second sampling period. 2,4-dichlorophenol may be a byproduct

of water chlorination but it may also originate from disinfectants. Highest concentrations of phenols were found at testing point D where the waste waters of all surgical operation rooms are discharged. Phenols were detected rarely and in small concentrations at the other four testing points (Fig.11., Table 4.2.2., Annex A-119-190).

In conclusion, the observed concentrations of phenols were low and the quantity of dichlorophenol, detected from time to time, were lower than the "A" values of the Dutch standards for surface waters.

4.2.3. Aldehydes

Aldehydes, like phenols, are components of disinfectants. Disinfectants contain simple C1- and C2-aldehydes as well as glyoxal and glutaraldehyde in larger quantities. The exact composition of commercially available products is not known. Glutaraldehyde is used itself as a disinfectant.

The following aldehydes were measured: formaldehyde, acetaldehyde, acroleine, propionaldehyde, crotonaldehyde, butyraldehyde, benzaldehyde, glyoxal, glutaraldehyde, valeraldehyde, o-tolualdehyde, p,m-tolualdehyde, hexaldehyde and dimethyl-benzaldehyde.

Among the monitored aldehydes, formaldehyde, acetaldehyde, glyoxal, valeraldehyde and glutaraldehyde were found in significant quantities while the other aldehydes could be detected only in traces. It should be noted that formaldehyde is produced also as a chlorination byproduct.

The retention values of the dinitrophenylhydrazine derivative of isovaleraldehyde and glutaraldehyde show very small differences in the applied liquid chromatographic system. For this reason, the component identified clearly as glutaraldehyde in the second sampling period was first assumed to be isovaleraldehyde and labeled as such in the original chromatograms attached.

It is noted that the samples were less concentrated due to experimental difficulties in the second sampling period and this may be perhaps the cause of the fact that

glyoxal found in smaller quantities in the first sampling period could not be detected in samples taken during the autumn period.

As regards the measurement of C1-C5 aldehydes, the hospital emission cannot be separated from the road traffic contamination due to the reasons described under the evaluation of volatile aromatic compounds.

Acetaldehyde was observed in higher quantities primarily in samples taken at testing point B. With the exception of testing point E, glyoxal was measured in smaller or larger quantities at all testing points. Low concentrations of glutaraldehyde could be detected in practically all samples. Extreme value was found on one occasion in a waste water sample taken at point A (Fig.12., Table 4.2.3., Annex A-191-226).

4.2.4. Quaternary ammonium salts

The total quaternary ammonium concentration was measured with spectrophotometric method. The quantity of quaternary ammonium salts is insignificant (Fig.13., Table 4.2.4.)

4.3. Microbiological tests

The results of microbiological tests show of the values of common municipal sewage water (Fig.14-16., Table 4.3.).

Summary

The waste waters of the "Szent Imre Teaching Hospital" in Budapest were studied from samples collected at six testing points between 7 July and 6 November 1997.

It was concluded that the average samples taken by an automatic sampling apparatus at the beginning of the study period showed little variation for the classical water quality parameters, metals and micropollutants, thus they are considered more characteristic for the waste water emissions of the hospital than the results of samples taken at a specific point of time. The latter show sometimes great differences but still within the tolerated limits which permitted the identification of some micropollutants originally not included in the study plan.

Samples taken at testing points C and D were the most polluted. The waste waters of the surgical operation rooms, obstetrics and gyneacology, and the laboratories were discharged at these points.

The observations for the tested components can be summarized as follows:

The **classical water quality parameters** showed values similar to those of community waste waters. The same statement applies to **metals** and **organic micropollutants**.

Low concentrations of **chlorinated hydrocarbons** found in waste waters originate from the drinking water as byproducts of chlorination. The relatively low-volatile tri- and tetrachloroethylene and the "mixed" haloforms resulting from chlorination can be detected also in waste waters.

In some cases, the **chloroform** values were higher than the average and exceeded the tolerated limit for surface waters. It was established that chloroform found at testing point C originates from the laboratory where it is used for bilirubin tests. The hospital management took immediate action to collect chloroform as a hazardous waste in future.

The appearance of **aromatic compounds** -benzene, toluene, ethylbenzene and xylenes- in waste waters can be attributed primarily to road traffic. These compounds appear in the samples probably due to the dissolution of exhaust gases in waste waters.

Disinfectants contain **phenols** so it could be expected that the concentration of phenols would be higher in hospital waste waters than in community waste waters. Highest concentration of phenols were found in samples taken at testing point D where the waste waters of all surgical rooms are discharged. Phenols were detected only occasionally and in small concentrations at the other four testing points.

Similar to phenols, **aldehydes** are components of disinfectants. Among the monitored aldehydes, formaldehyde, acetaldehyde, glyoxal, valeraldehyde and glutaraldehyde was found in significant quantities. The other aldehydes could be detected only in traces. Formaldehyde is produced during the chlorination of drinking water. Aldehydes were observed mainly in the first part of the study period and at the end of October, respectively. As regards the measurement of C1-C5 aldehydes, the hospital emission cannot be differentiated from the road traffic contamination due to the reasons described under the evaluation of volatile aromatic compounds.

The highest quaternary ammonium compound values were observed at testing points C and D, and occasionally at testing point B.

The main conclusion of the analysis of results is that the average quality of discharged waste waters of the "Szent Imre Teaching Hospital" does not differ significantly from that of community waste waters as regards the classical water quality parameters, the heavy metals and organic micropollutants. The concentration of the tested organic micropollutants was significantly lower than the tolerated amount in drinking waters as per the Directives of the European Union. In a few cases, the amount of chloroform exceeded the maximum limit specified for drinking water in the European Union but remained within the tolerated amount specified by the WHO standard.

Recommendations:

1. The quality of waste waters should preferably be carried out by analysing representative average samples collected by an automated sample-taking apparatus.
2. Similar studies should be conducted in a hospital where the management of waste has not been organized so well as in the "Szent Imre Teaching Hospital".

Figures

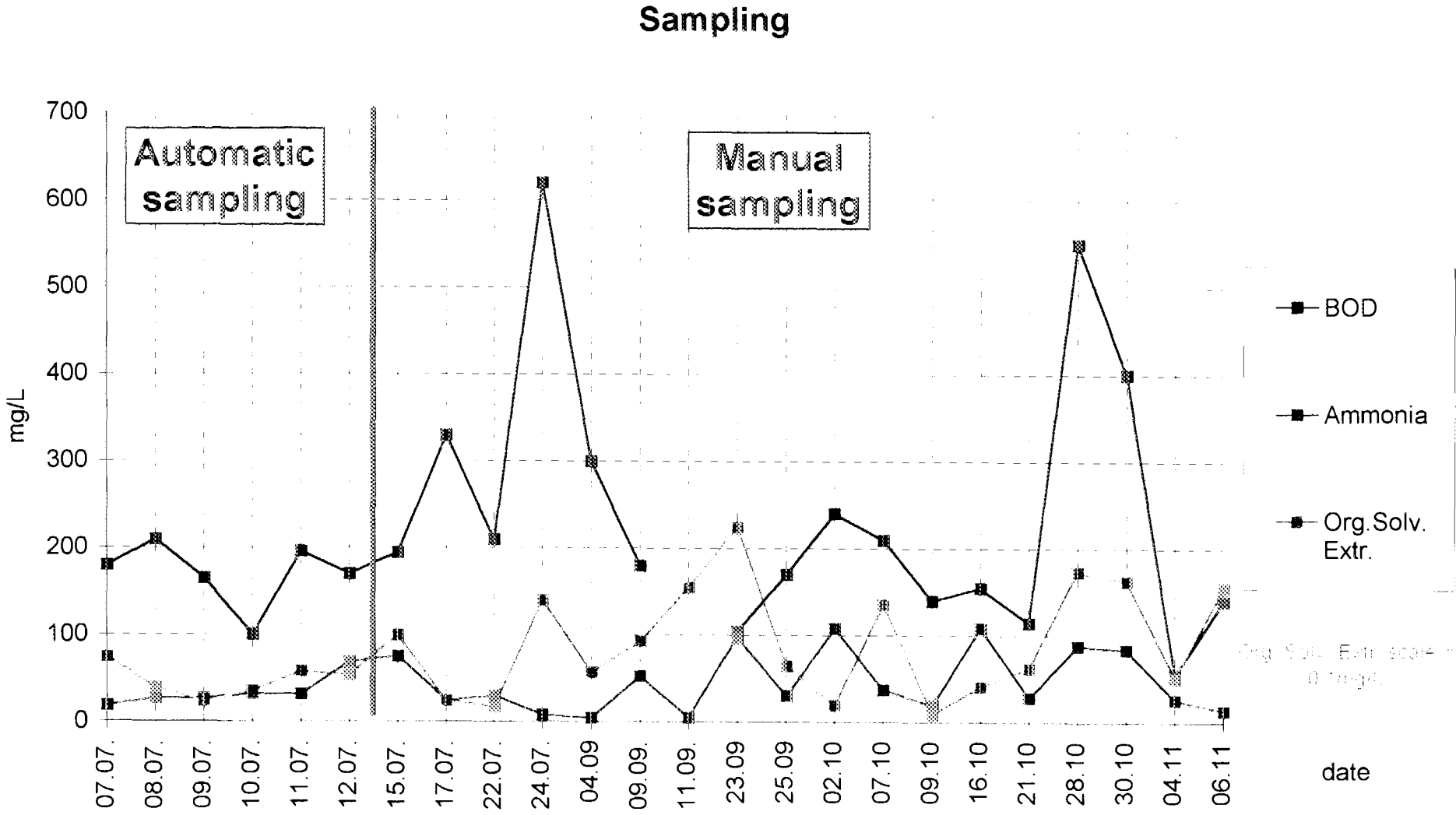
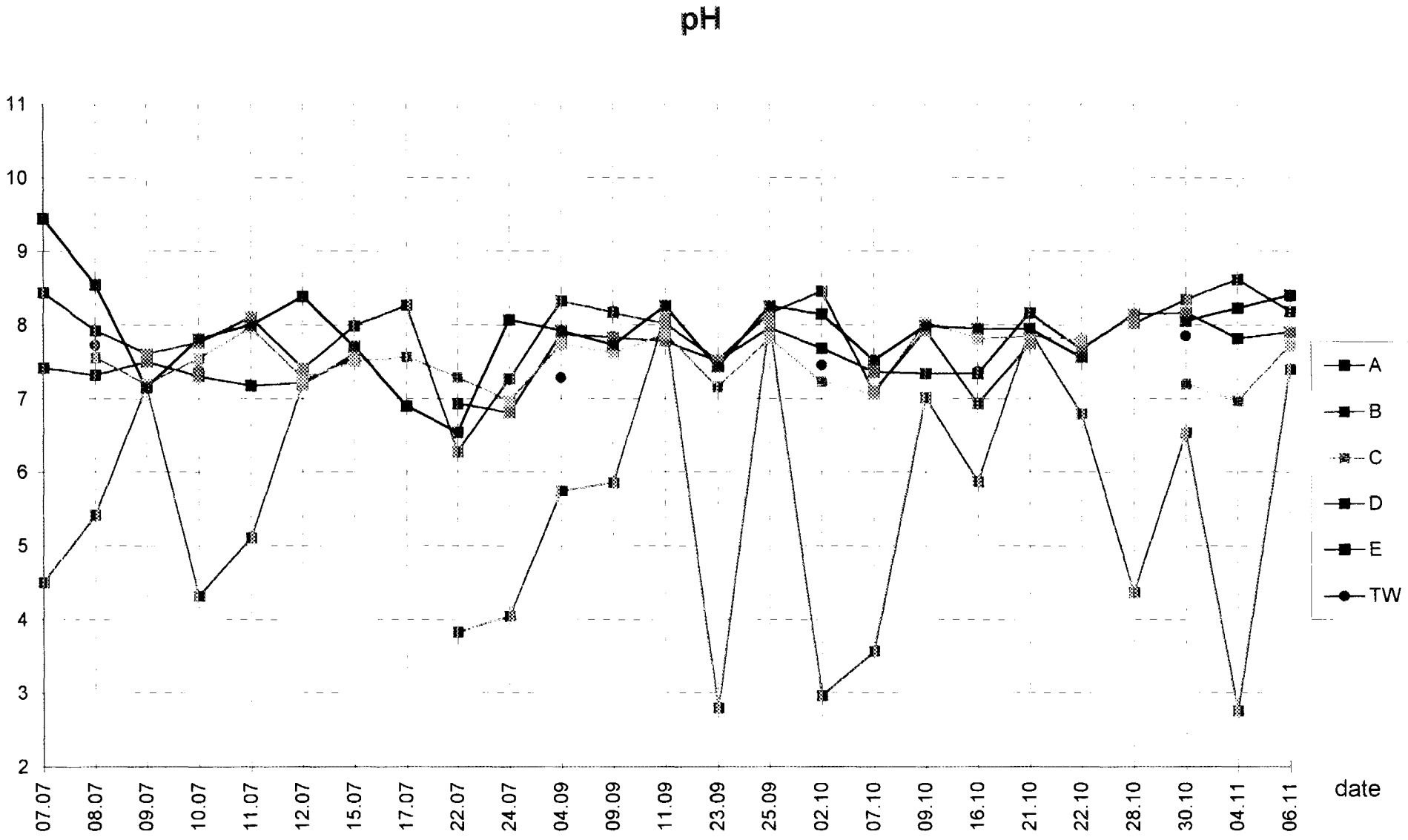

Sampling
Automatic sampling
Manual sampling
mg/L
700
600
500
400
300
200
100
0
07.07.
08.07.
09.07.
10.07.
11.07.
12.07.
15.07.
17.07.
22.07.
24.07.
04.09
09.09.
11.09.
23.09
25.09
02.10
07.10
09.10
16.10
21.10
28.10
30.10
04.11
06.11
date
BOD
Ammonia
Org.Solv. Extr.

Figure 1.


pH
11
10
9
8
7
6
5
4
3
2
07.07
08.07
09.07
10.07
11.07
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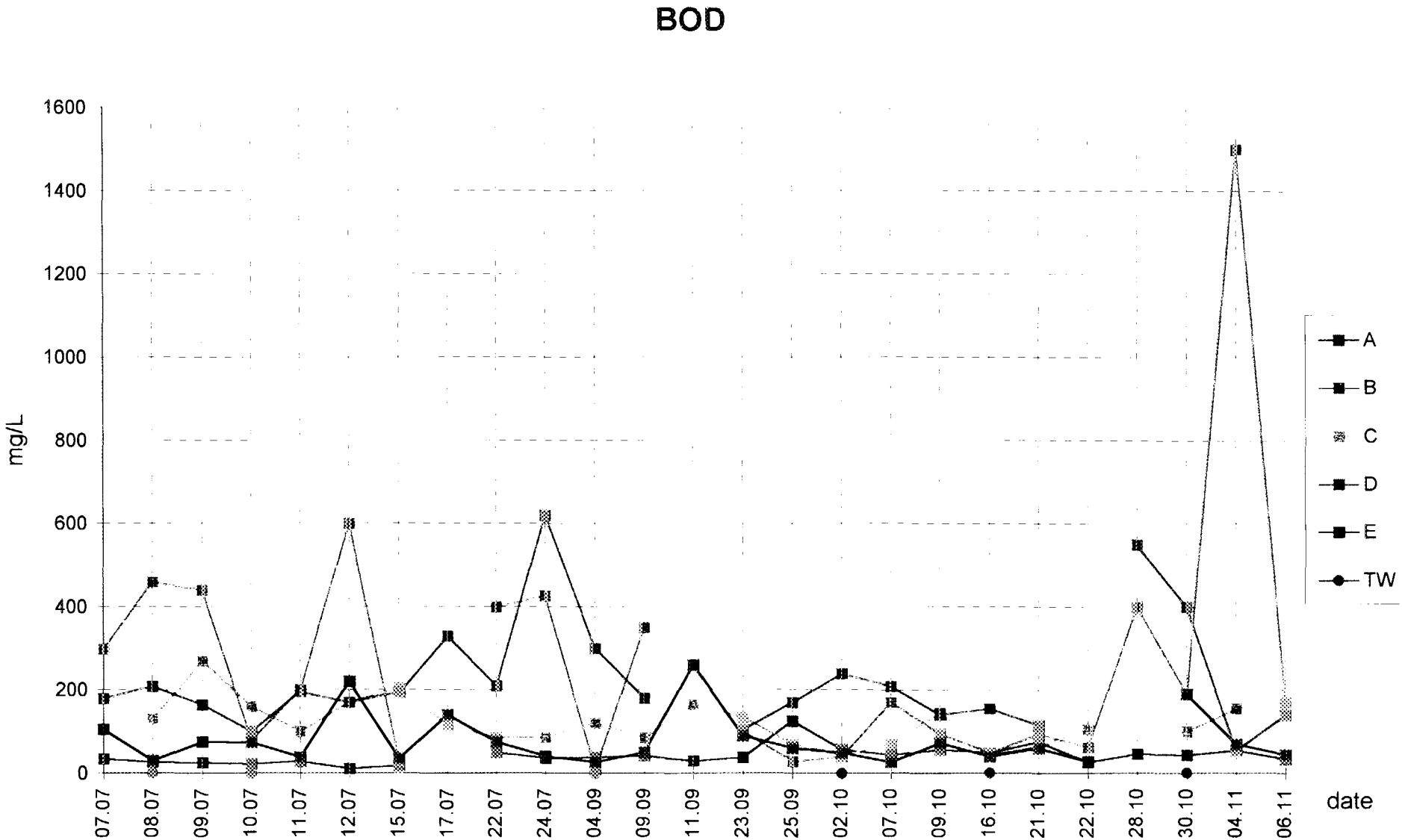
15.07
17.07
22.07
24.07
04.09
09.09
11.09
23.09
25.09
02.10
07.10
09.10
16.10
21.10
22.10
28.10
30.10
04.11
06.11
date
A
B
C
D
E
TW

Figure 2.


BOD
1600
1400
1200
1000
800
600
400
200
0
mg/L
07.07
08.07
09.07
10.07
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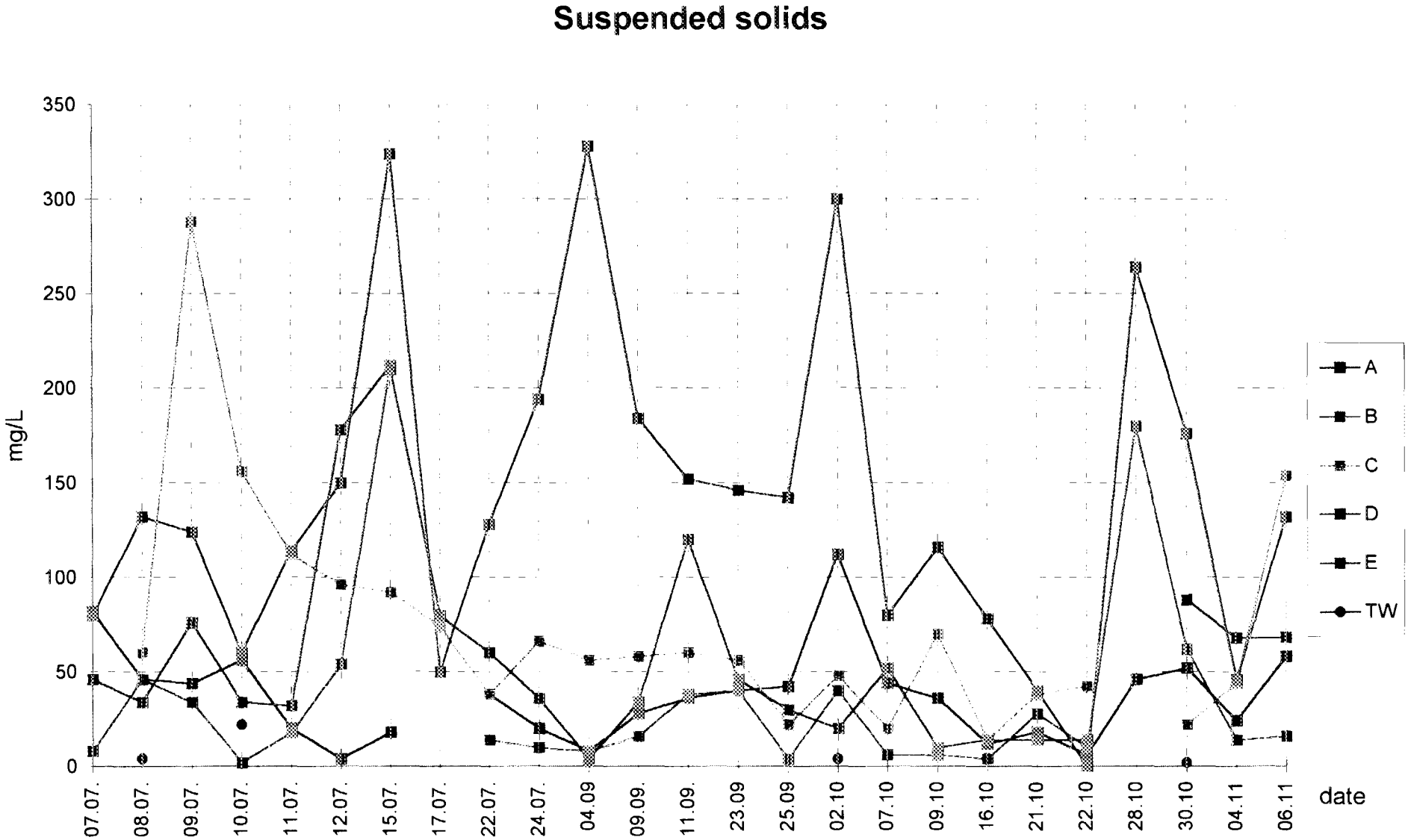
15.07
17.07
22.07
24.07
04.09
09.09
11.09
23.09
25.09
02.10
07.10
09.10
16.10
21.10
22.10
28.10
30.10
04.11
06.11
date
A
B
C
D
E
TW

Figure 3.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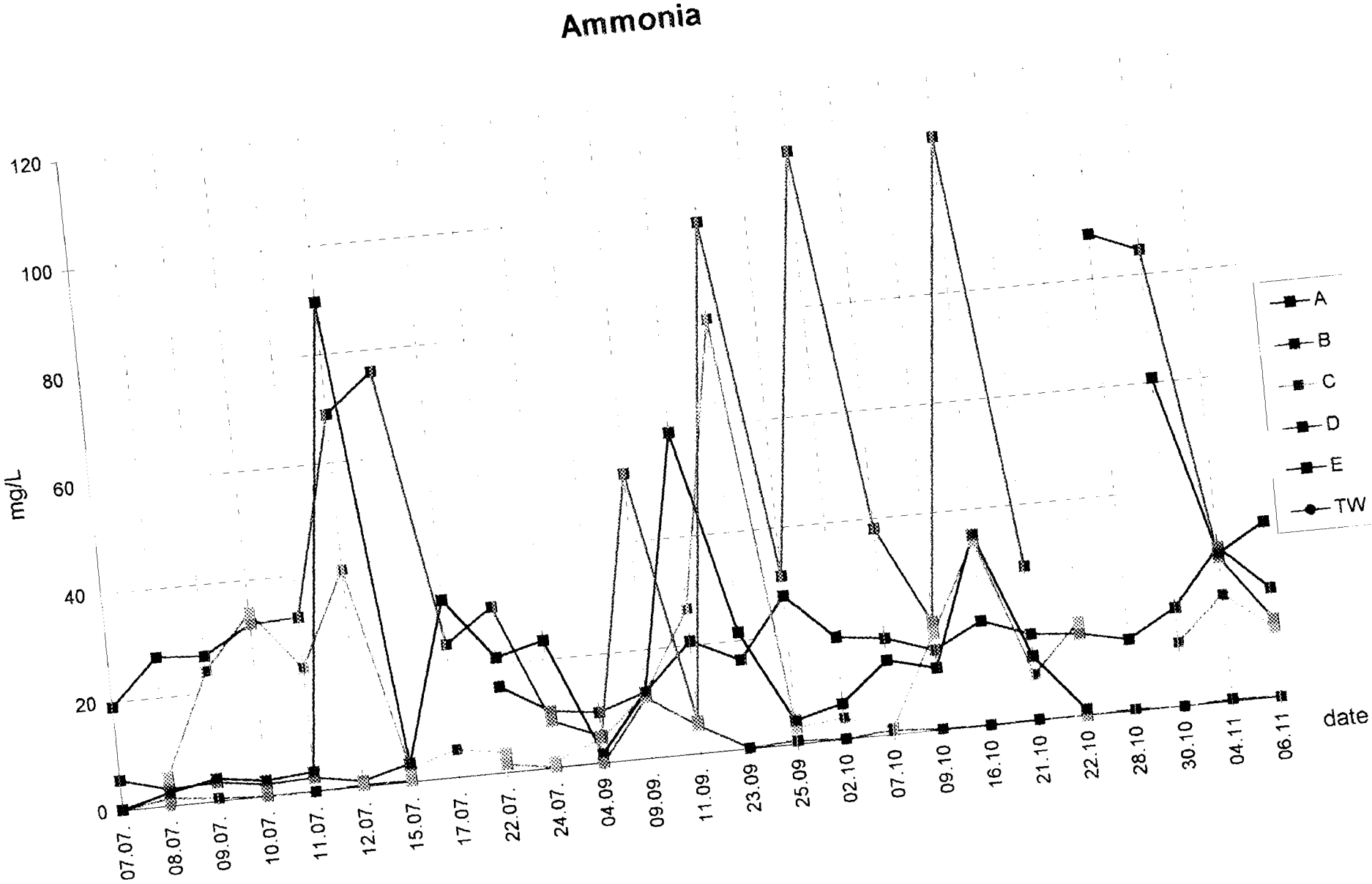
300
250
200
150
100
50
0
mg/L
07.07.
08.07.
09.07.
10.07.
11.07.
12.07.
15.07.
17.07.
22.07.
24.07.
04.09
09.09.
11.09.
23.09
25.09
02.10
07.10
09.10
16.10
21.10
22.10
28.10
30.10
04.11
06.11
date
A
B
C
D
E
TW

Figure 4.


Ammonia
120
100
80
60
40
20
0
mg/L
A
B
C
D
E
TW
date
07.07.
08.07.
09.07.
10.07.
11.07.
12.07.
15.07.
17.07.
22.07.
24.07.
04.09
09.09.
11.09.
23.09
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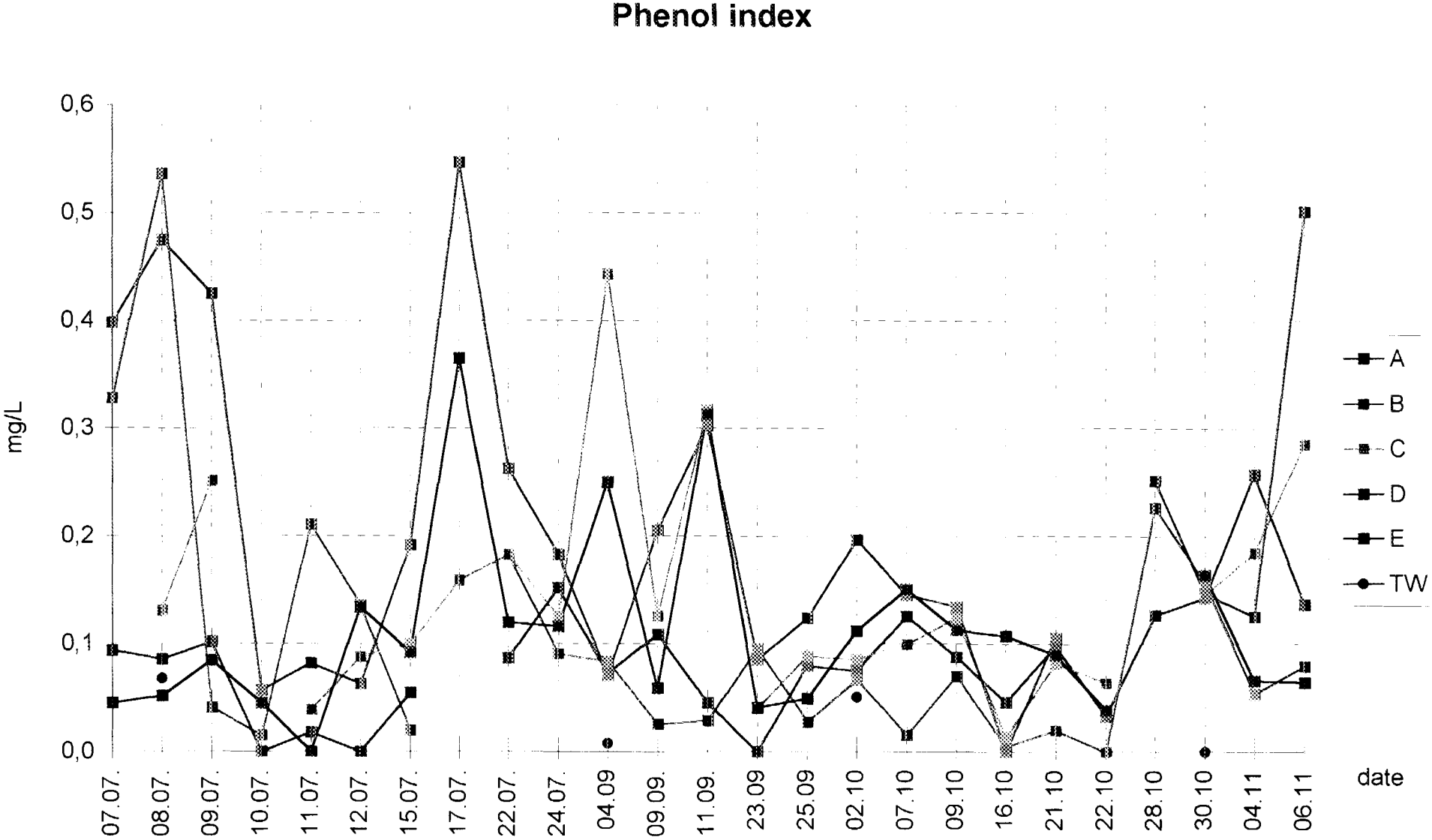
22.10
28.10
30.10
04.11
06.11

Figure 5.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mg/L
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0,5
0,4
0,3
0,2
0,1
0,0
07.07.
08.07.
09.07.
10.07.
11.07.
12.07.
15.07.
17.07.
22.07.
24.07.
04.09
09.09.
11.09.
23.09
25.09
02.10
07.10
09.10
16.10
21.10
22.10
28.10
30.10
04.11
06.11
date
A
B
C
D
E
TW

Figure 6.

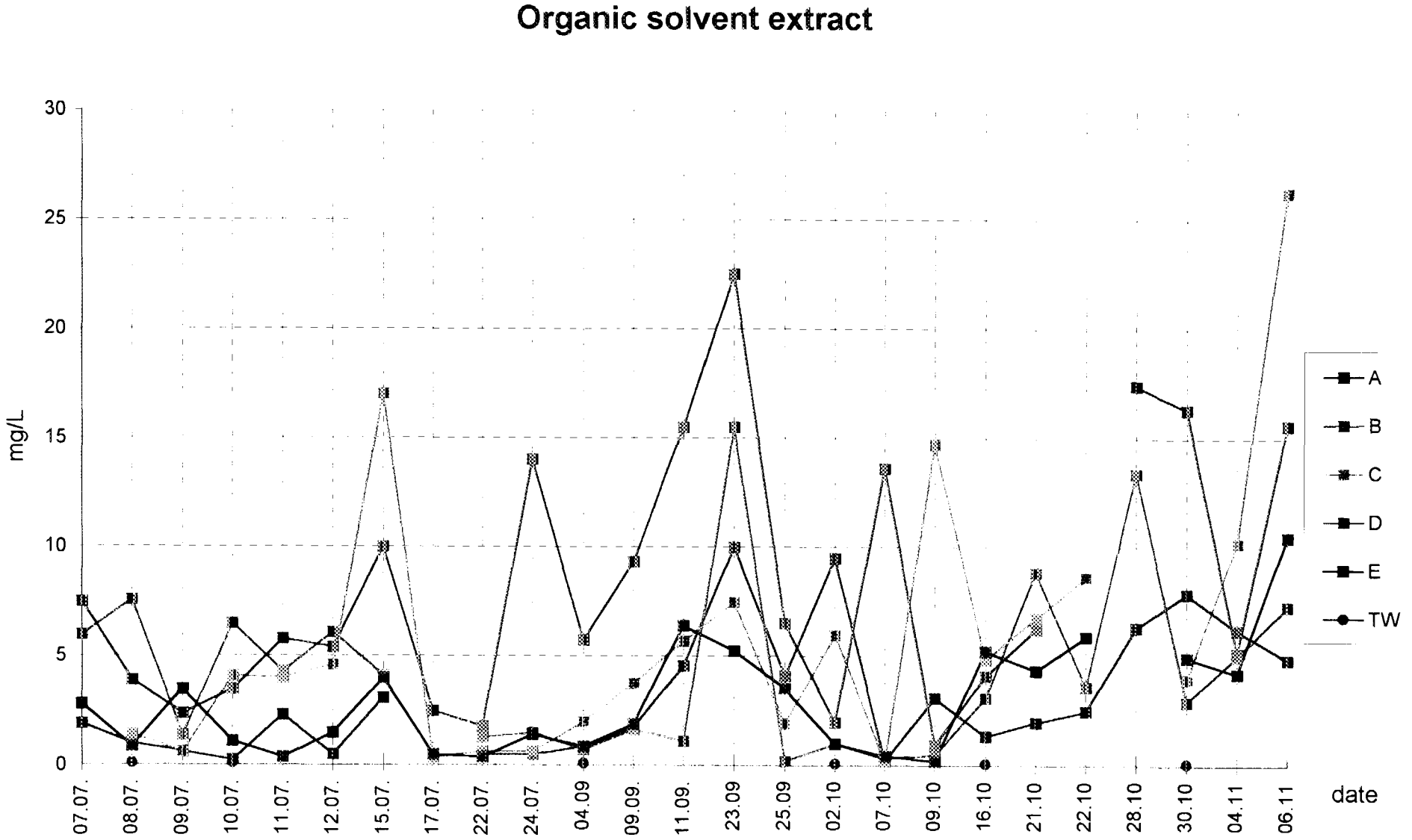
Organic solvent extract
mg/L
30
25
20
15
10
5
0
07.07.
08.07.
09.07.
10.07.
11.07.
12.07.
15.07.
17.07.
22.07.
24.07.
04.09
09.09.
11.09.
23.09
25.09
02.10
07.10
09.10
16.10
21.10
22.10
28.10
30.10
04.11
06.11
date
A
B
C
D
E
TW

Figure 7.

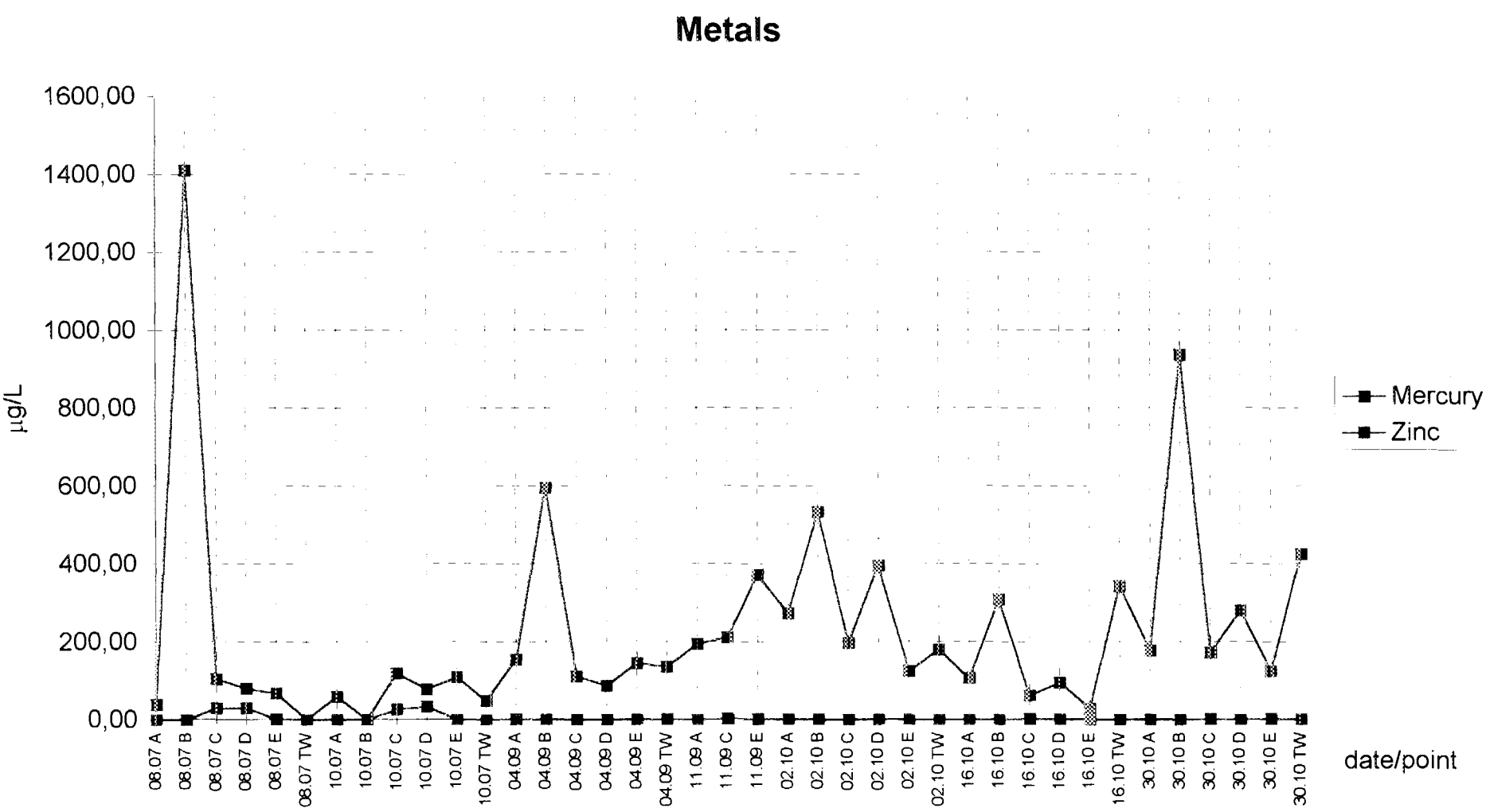
Metals
1600,00
1400,00
1200,00
1000,00
800,00
600,00
400,00
200,00
0,00
µg/L
Mercury
Zinc
08.07 A
08.07 B
08.07 C
08.07 D
08.07 E
08.07 TW
10.07 A
10.07 B
10.07 C
10.07 D
10.07 E
10.07 TW
04.09 A
04.09 B
04.09 C
04.09 D
04.09 E
04.09 TW
11.09 A
11.09 C
11.09 E
02.10 A
02.10 B
02.10 C
02.10 D
02.10 E
02.10 TW
16.10 A
16.10 B
16.10 C
16.10 D
16.10 E
16.10 TW
30.10 A
30.10 B
30.10 C
30.10 D
30.10 E
30.10 TW
date/point

Figure 8.

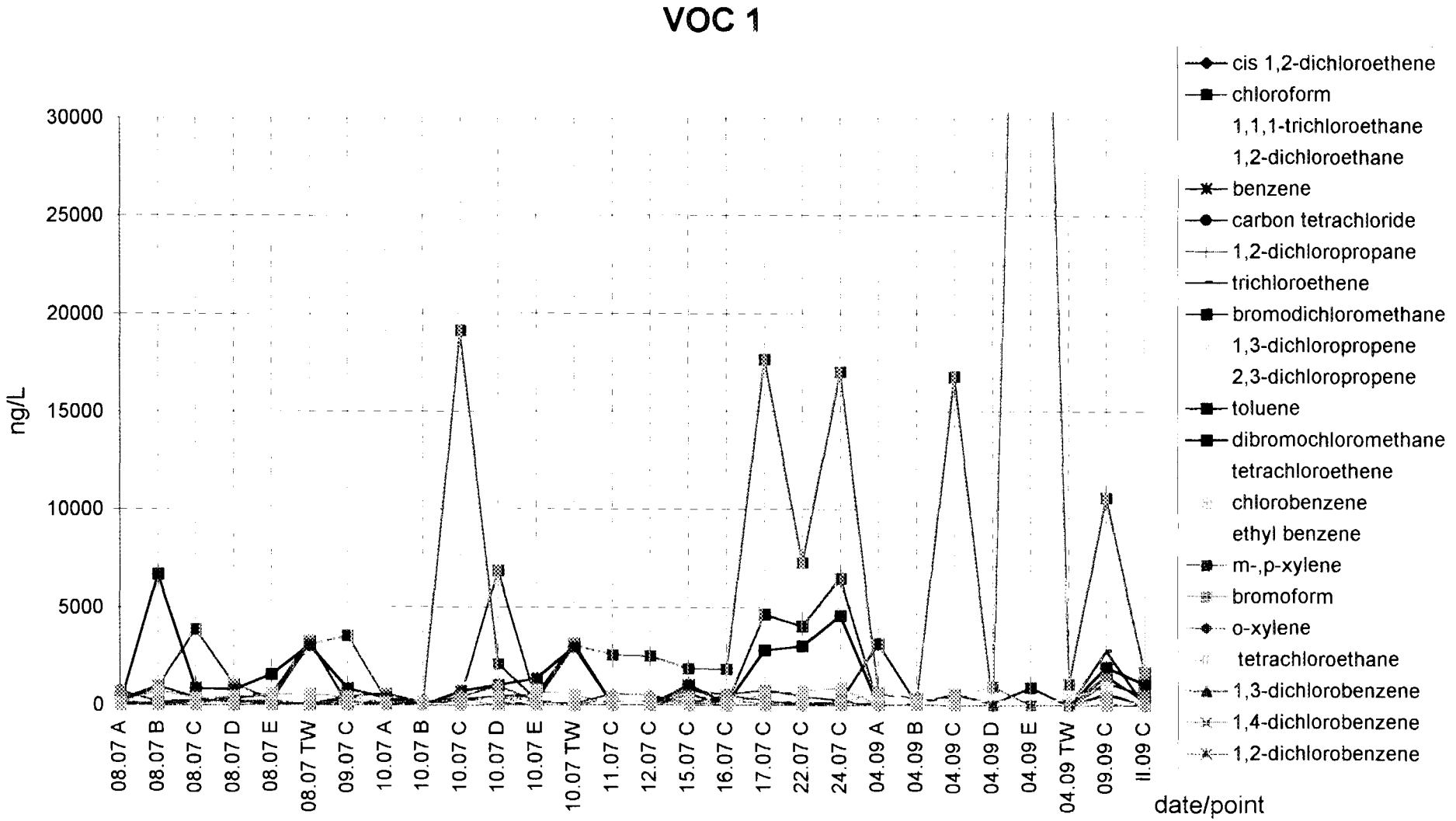
VOC 1
30000
25000
20000
15000
10000
5000
0
ng/L
08.07 A
08.07 B
08.07 C
08.07 D
08.07 E
08.07 TW
09.07 C
10.07 A
10.07 B
10.07 C
10.07 D
10.07 E
10.07 TW
11.07 C
12.07 C
15.07 C
16.07 C
17.07 C
22.07 C
24.07 C
04.09 A
04.09 B
04.09 C
04.09 D
04.09 E
04.09 TW
09.09 C
II.09 C
date/point
cis 1,2-dichloroethene
chloroform
1,1,1-trichloroethane
1,2-dichloroethane
benzene
carbon tetrachloride
1,2-dichloropropane
trichloroethene
bromodichloromethane
1,3-dichloropropene
2,3-dichloropropene
toluene
dibromochloromethane
tetrachloroethene
chlorobenzene
ethyl benzene
m-,p-xylene
bromoform
o-xylene
tetrachloroethane
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2-dichlorobenzene

Figure 9.

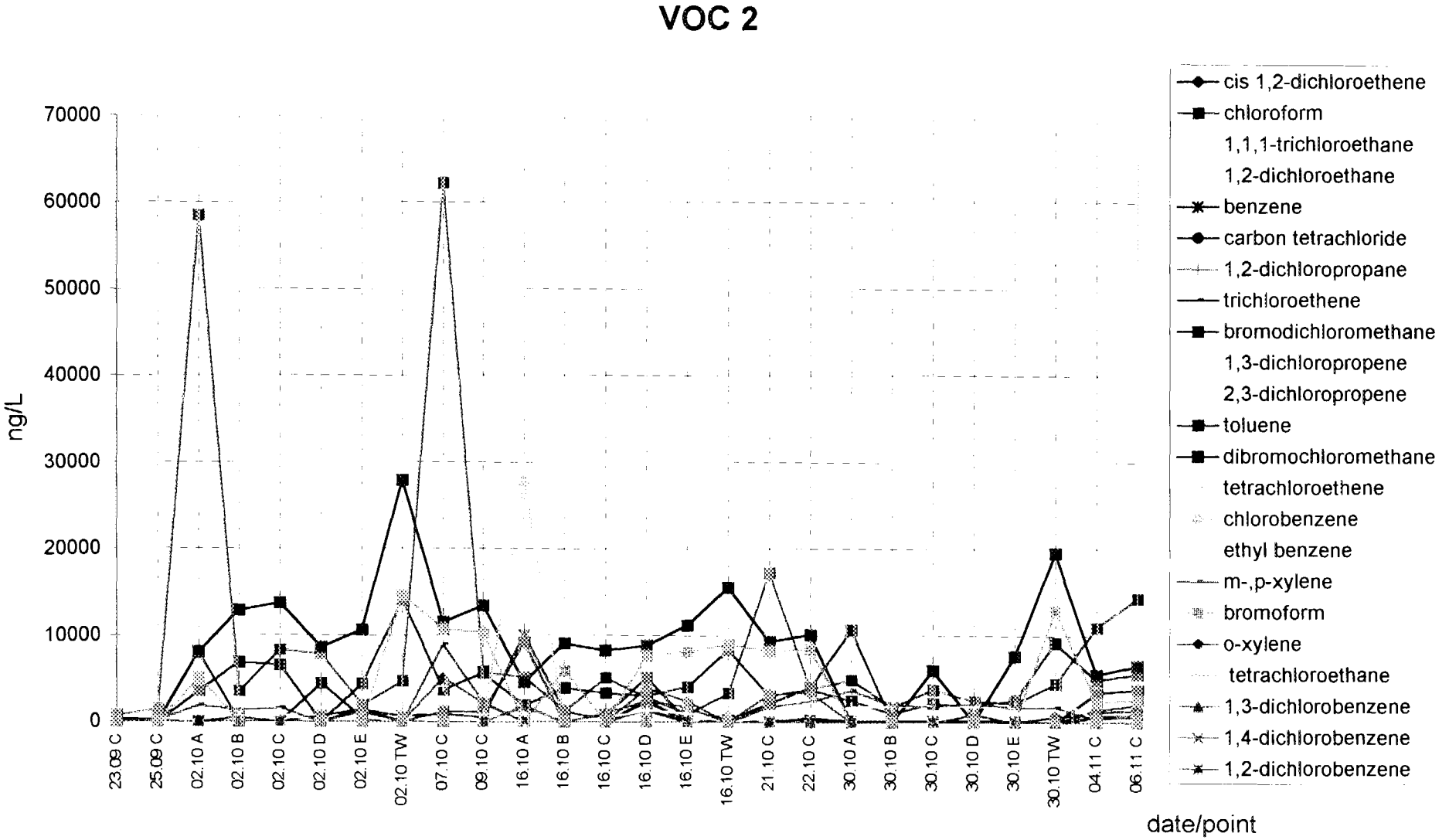
VOC 2
ng/L
70000
60000
50000
40000
30000
20000
10000
0
23.09 C
25.09 C
02.10 A
02.10 B
02.10 C
02.10 D
02.10 E
02.10 TW
07.10 C
09.10 C
16.10 A
16.10 B
16.10 C
16.10 D
16.10 E
16.10 TW
21.10 C
22.10 C
30.10 A
30.10 B
30.10 C
30.10 D
30.10 E
30.10 TW
04.11 C
06.11 C
date/point
cis 1,2-dichloroethene
chloroform
1,1,1-trichloroethane
1,2-dichloroethane
benzene
carbon tetrachloride
1,2-dichloropropane
trichloroethene
bromodichloromethane
1,3-dichloropropene
2,3-dichloropropene
toluene
dibromochloromethane
tetrachloroethene
chlorobenzene
ethyl benzene
m-,p-xylene
bromoform
o-xylene
tetrachloroethane
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2-dichlorobenzene

Figure 10.

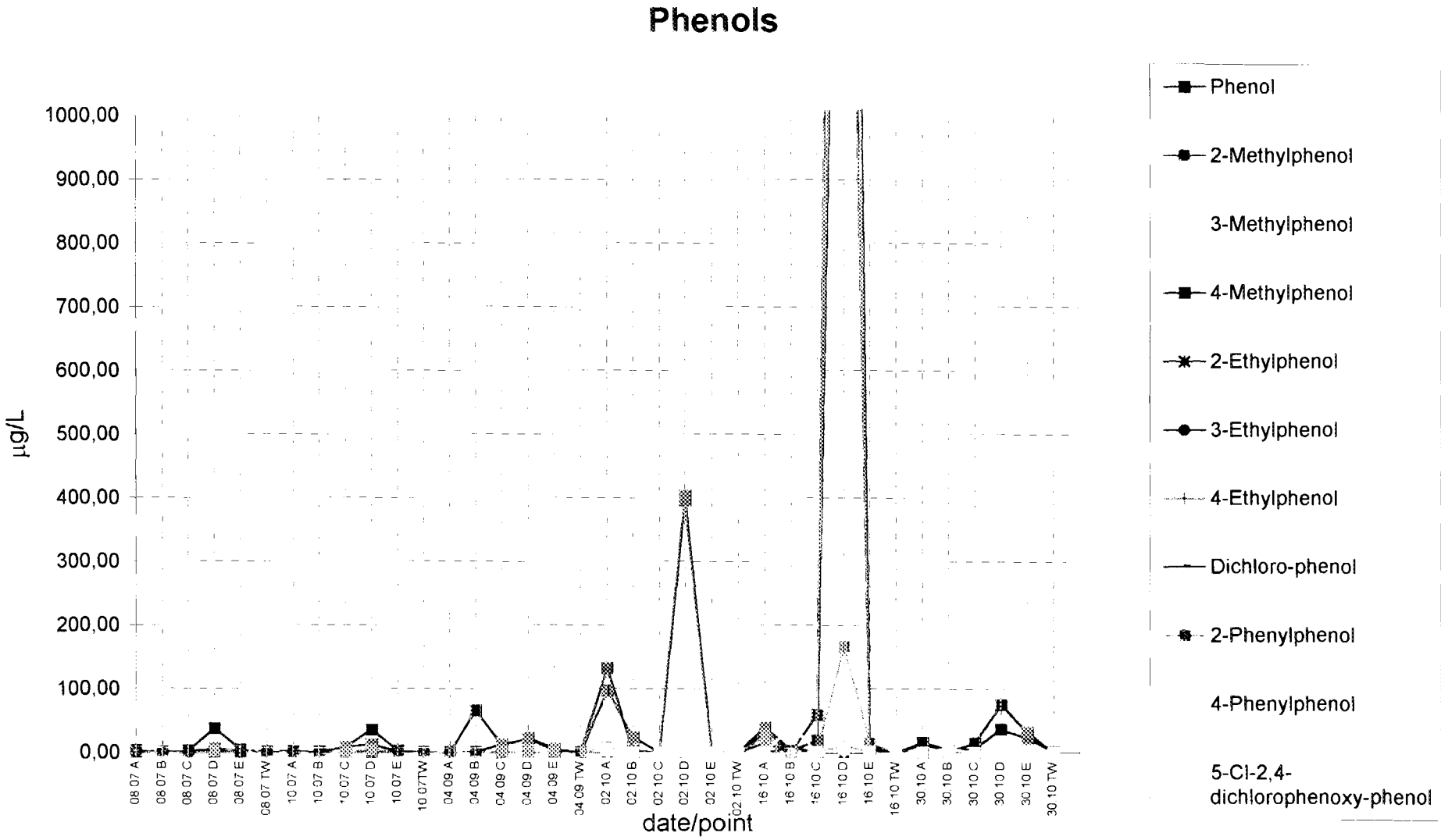
Phenols
1000,00
900,00
800,00
700,00
600,00
500,00
400,00
300,00
200,00
100,00
0,00
µg/L
date/point
Phenol
2-Methylphenol
3-Methylphenol
4-Methylphenol
2-Ethylphenol
3-Ethylphenol
4-Ethylphenol
Dichloro-phenol
2-Phenylphenol
4-Phenylphenol
5-Cl-2,4-dichlorophenoxy-phenol

Figure 11.

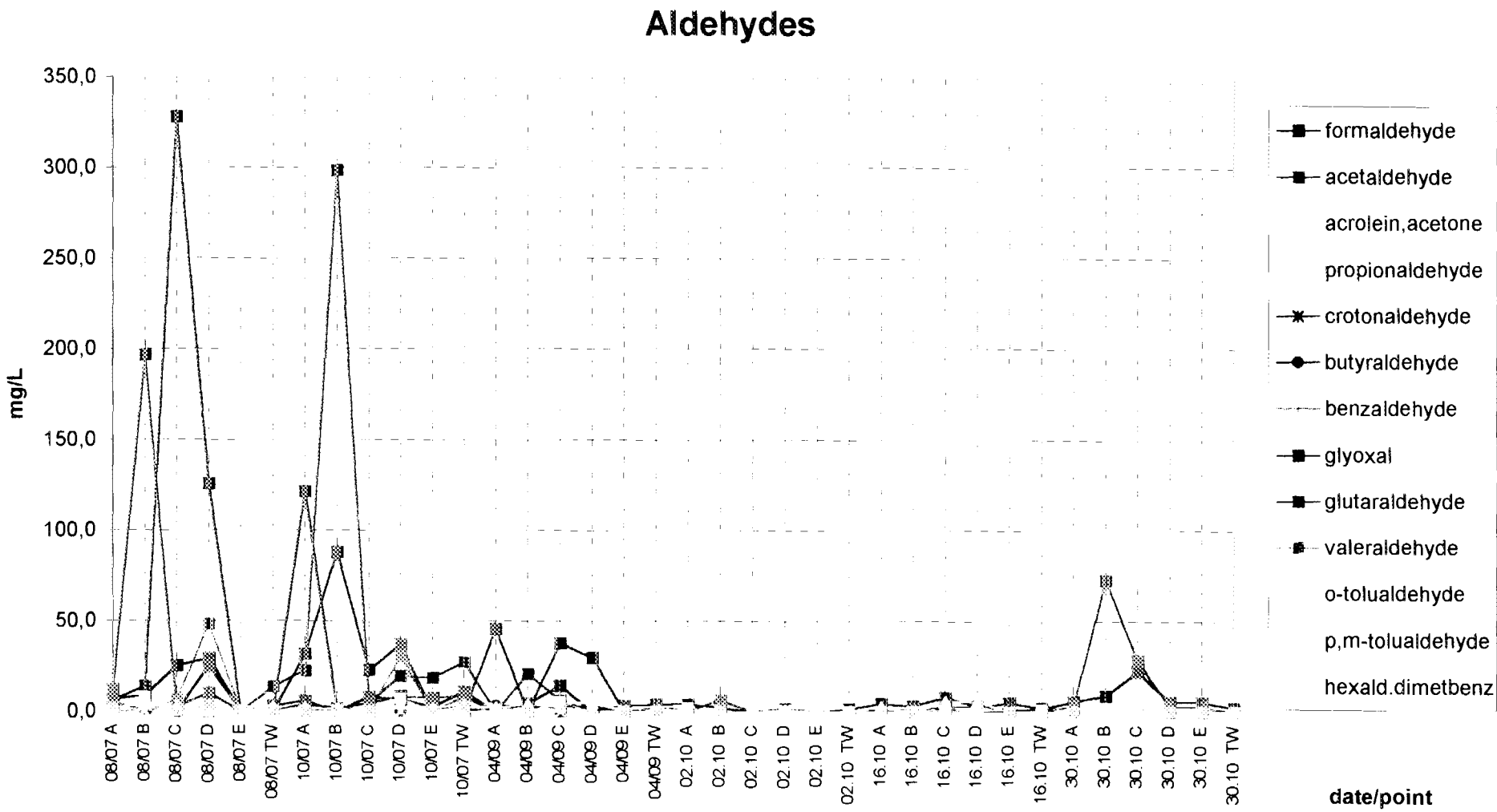
Aldehydes
350,0
300,0
250,0
200,0
150,0
100,0
50,0
0,0
mg/L
08/07 A
08/07 B
08/07 C
08/07 D
08/07 E
08/07 TW
10/07 A
10/07 B
10/07 C
10/07 D
10/07 E
10/07 TW
04/09 A
04/09 B
04/09 C
04/09 D
04/09 E
04/09 TW
02.10 A
02.10 B
02.10 C
02.10 D
02.10 E
02.10 TW
16.10 A
16.10 B
16.10 C
16.10 D
16.10 E
16.10 TW
30.10 A
30.10 B
30.10 C
30.10 D
30.10 E
30.10 TW
formaldehyde
acetaldehyde
acrolein,acetone
propionaldehyde
crotonaldehyde
butyraldehyde
benzaldehyde
glyoxal
glutaraldehyde
valeraldehyde
o-tolualdehyde
p,m-tolualdehyde
hexald.dimetbenz
date/point

Figure 12.

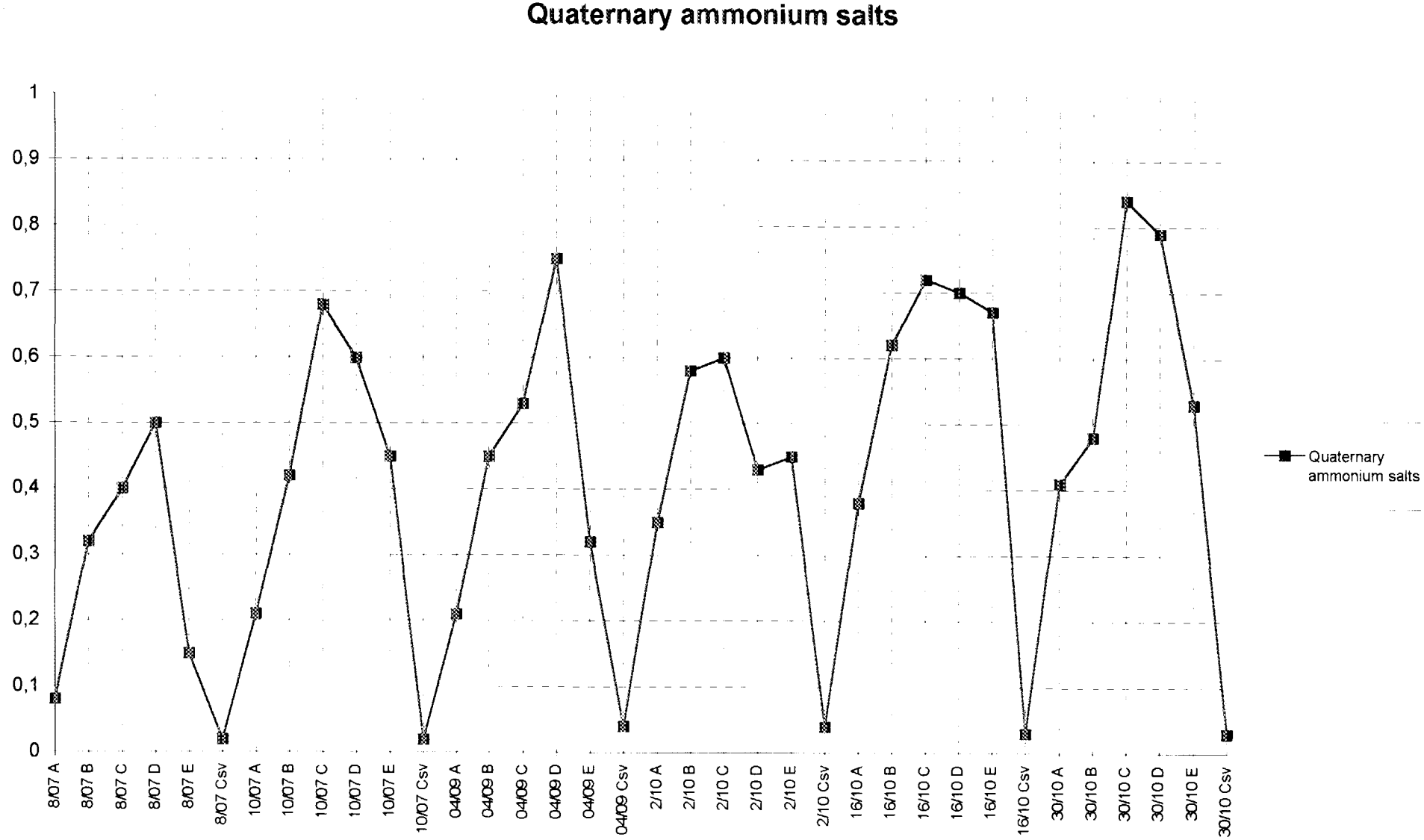
Quaternary ammonium salts
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
8/07 A
8/07 B
8/07 C
8/07 D
8/07 E
8/07 Csv
10/07 A
10/07 B
10/07 C
10/07 D
10/07 E
10/07 Csv
04/09 A
04/09 B
04/09 C
04/09 D
04/09 E
04/09 Csv
2/10 A
2/10 B
2/10 C
2/10 D
2/10 E
2/10 Csv
16/10 A
16/10 B
16/10 C
16/10 D
16/10 E
16/10 Csv
30/10 A
30/10 B
30/10 C
30/10 D
30/10 E
30/10 Csv
Quaternary ammonium salts

Figure 13.

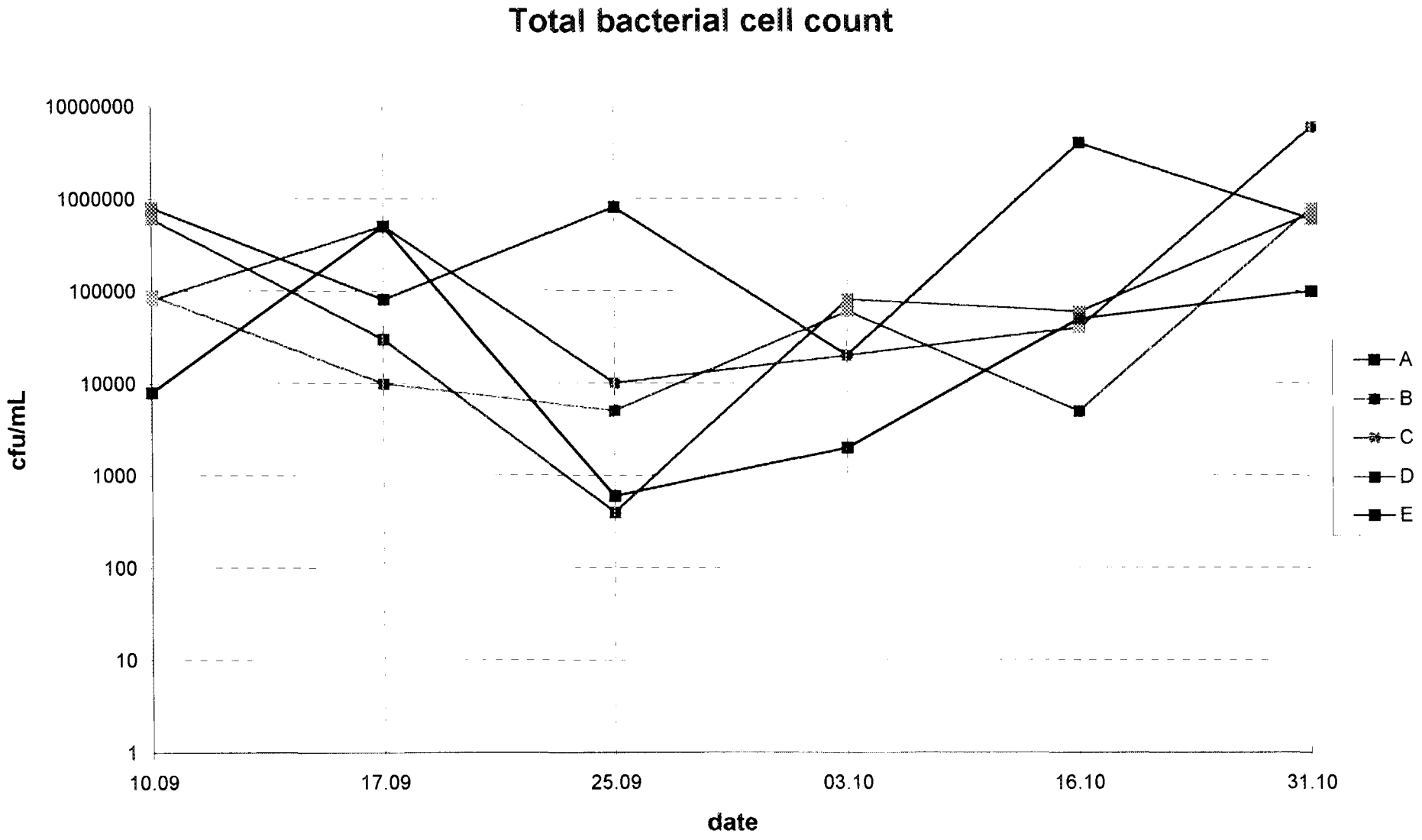
Total bacterial cell count
10000000
1000000
100000
10000
1000
100
10
1
cfu/mL
10.09
17.09
25.09
03.10
16.10
31.10
date
A
B
C
D
E

Figure 14.

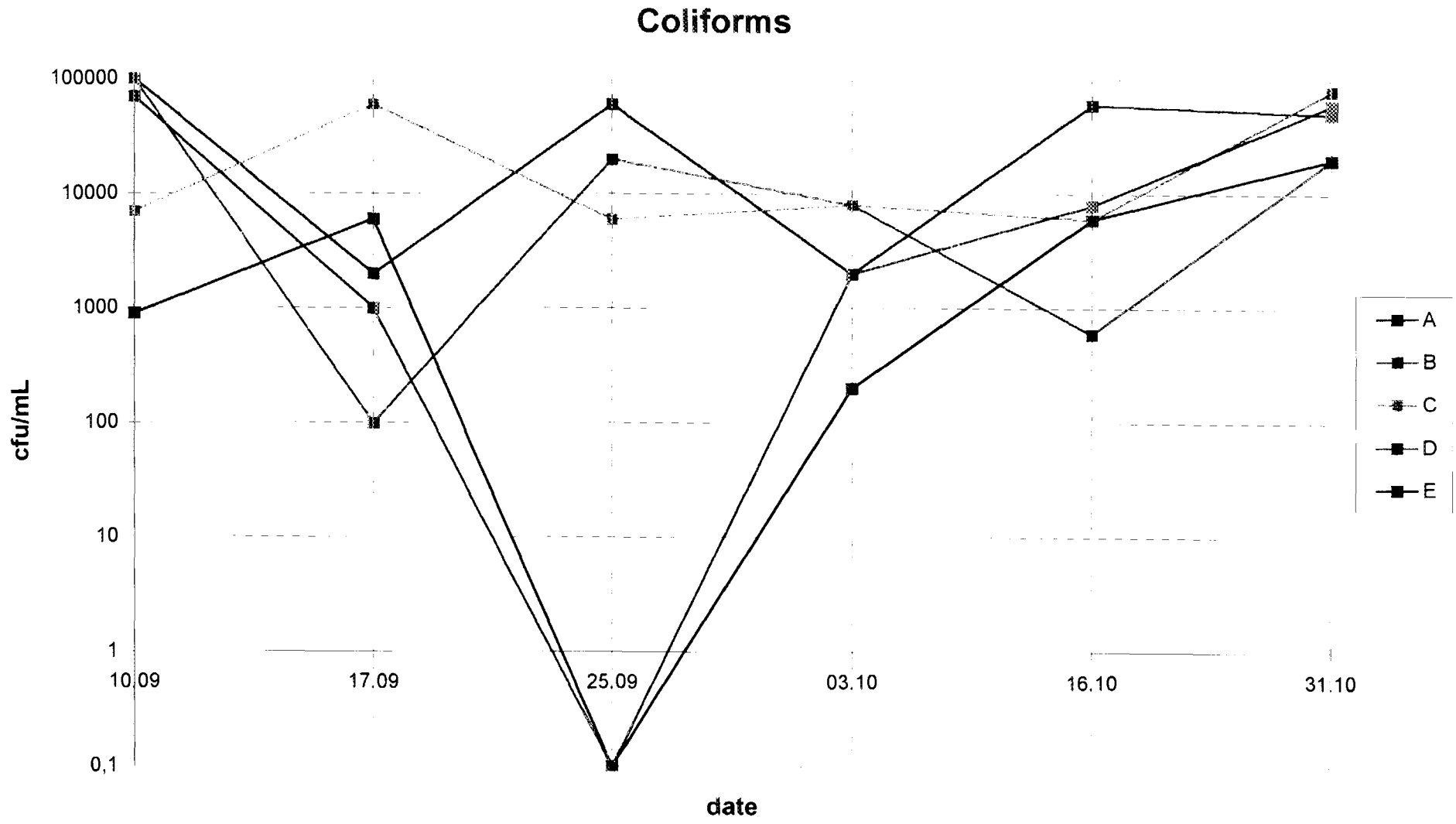
Coliforms
100000
10000
1000
100
10
1
0,1
cfu/mL
10.09
17.09
25.09
03.10
16.10
31.10
date
A
B
C
D
E

Figure 15.

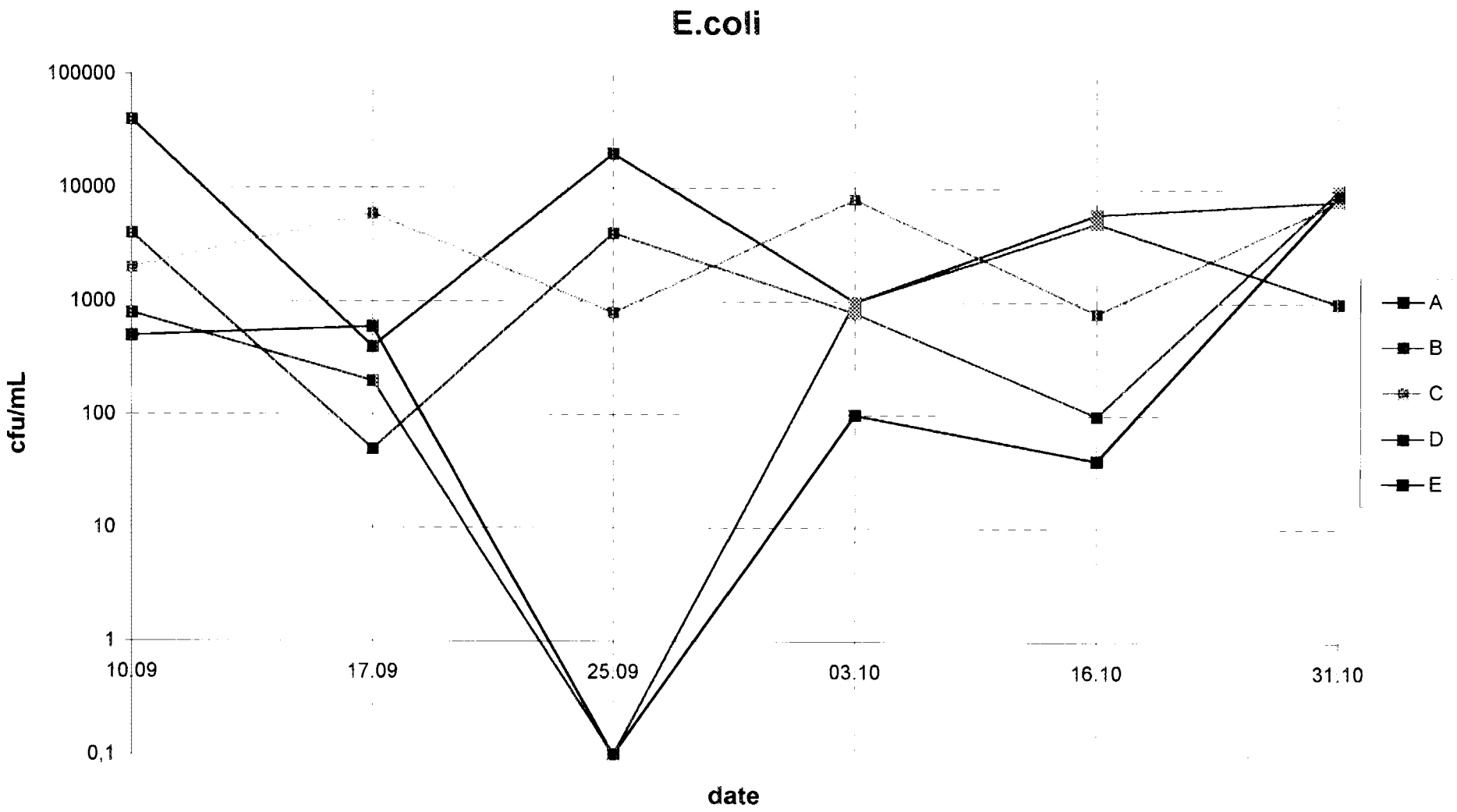
E.coli
100000
10000
1000
100
10
1
0,1
cfu/mL
10.09
17.09
25.09
03.10
16.10
31.10
date
A
B
C
D
E

Figure 16.