Prüfinstitut für Abwassertechnik GmbH

Prüfeinrichtung des Prüf- und Entwicklungsinstituts für Abwassertechnik an der RWTH Aachen

Prüfinstitut für Abwassertechnik GmbH

DIN EN ISO 9001:2000

Report on the treatment efficiency test according to EN 12566-3 of the small wastewater treatment plant

BusseMF-HKA 4 P plus

by

Busse Innovative Systeme GmbH

Test report – No PIA2009-100B60P

PIA GmbH
Prüfinstitut für Abwassertechnik
Hergenrather Weg
52074 Aachen

Aachen, June 2009

Dipl.-Ing. Elmar Lancé

geprüft - tested - testé - NB 1739 PIA EN 12566

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1 Introduction

The company

Busse Innovative Systeme GmbH
Zaucheweg 6
04316 Leipzig
Germany

assigned the

Prüfinstitut für Abwassertechnik (PIA GmbH)
Hergenrather Weg 30
52074 Aachen
Germany

to perform a practical evaluation of the treatment efficiency of the BusseMF-HKA 4 P plus – small wastewater treatment plant for 4 PT with a daily hydraulic flow of 0.6 m^3/d based on the standard EN 12566-3 Annex B.

The evaluation began on 14th of January 2008, subsequent to a biomass start up period. The test ended on 5th of October 2008.

The PIA GmbH has a certified quality management system according to DIN EN ISO 9001:2000 for the field "testing of wastewater equipment" and is approved by the European Commission as a testing authority "Notified Body" (NB 1739) according to the Construction Products Directive (CPD) for small wastewater treatment systems for up to 50 PT according to EN 12566-1 and EN 12566-3.

2 Description of the small wastewater treatment plant BusseMF-HKA 4 P plus

The small wastewater treatment plant BusseMF-HKA 4 P plus is part of a range of systems consisting of three GRP-tanks and two PE-tanks for the P-Elimination. The small wastewater treatment plant is designed for surface installation and for installation in closed frost-free rooms. Hence it does not meet precisely the scope of the standard EN 12566-3 which is specified for small wastewater treatment plants buried in the ground. However for the evaluation of the treatment efficiency the respective parts of the EN 12566-3 can be consulted. According to the EN 12566-3 Annex B requirements, the tested BusseMF-HKA 4 P plus unit is the smallest model of the range. During the test the BusseMF wastewater treatment system was installed and operated in an occasionally heated insulating container.

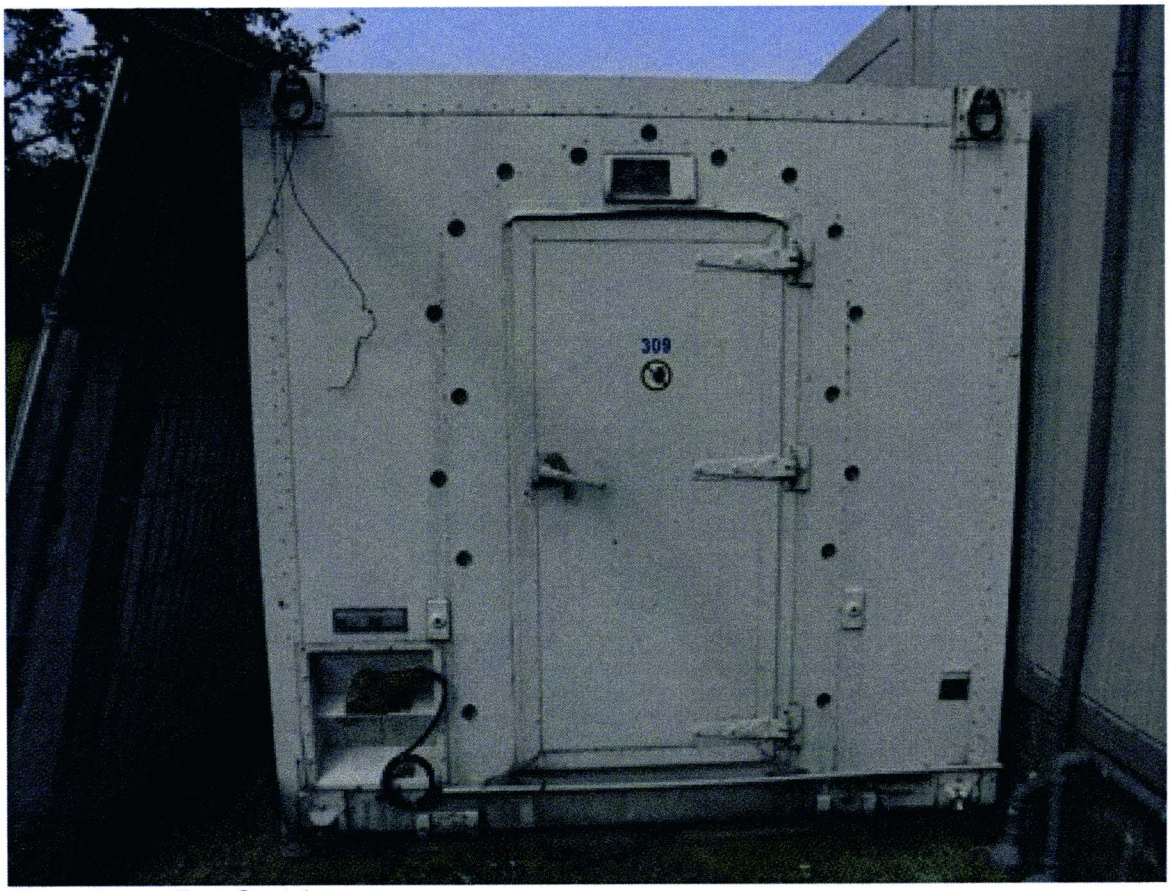

Figure 1: Test-Container

2.1 Description of the tank

The small wastewater treatment plant BusseMF-HKA 4 P plus consists of 3 GRP-tanks with the following functions: primary treatment (1st tank), aerated biological process (2nd tank) and filtration by a membrane-bioreactor (MBR) (3rd tank). Each GRP-tank has the following dimensions: Length: 110 cm, Width: 75 cm, Height: 167 cm. Additionally two PE-tanks with a capacity of 150l per tank (Figure 3) for the P-Elimination are installed downstream. The dimensions of the PE-tanks are: Length: 74 cm, Width: 60 cm, Heigth: 100 cm.

The dimensions of the tanks were checked by the PIA and were found in accordance with the manufacturer's.

Figure 2: Picture of the treatment plant (3 GRP-tanks) in the test-container

Figure 3: View on the P-Elimination section (PE-tanks)

2.2 Description of the treatment process

The small wastewater treatment plant BusseMF-HKA 4 P plus by Busse GmbH operates with a combined process of an aerated biological process with submerged membranes and sedimentation of particulate materials in an upstream tank. The primary settlement tank serves as intermediate storage of wastewater and sludge. The MBR-plant works in an aerated biological process with membranes. For biological reduction the necessary atmospheric oxygen is blown into the tanks by compressors. The downstream phosphorus elimination is accomplished by adsorption on granules in the two additional modules. The complete system operates on gravity flow.

A more detailed description of the BusseMF-HKA 4 P plus plant is attached in the herein annex (manufacturer's information).

Figure 4: View into the pre-settlement of the plant

Figure 5: View into the biological chamber of the plant

Figure 6: View into membrane-bioreactor in operation

Figure 7: View into the first P-Module in operation

2.3 Watertightness test

The tests for watertightness of all tanks were carried out on 18th of December 2007 according to EN 12566-3 Annex A.2 "Water test". There was no detectable water loss and therefore the plant BusseMF-HKA 4 P plus passed the watertightness test.

3 Sampling and analysis

The BusseMF-HKA 4 P plus small wastewater treatment system efficiency test was performed according to EN 12566-3 Annex B. The raw influent and the treated effluent were sampled by 24 h flow proportional composite samples. The bioreactor was grab sampled.

The following parameters were analysed:

Influents	: Temp., pH, COD, BOD_5, NH_4-N, N_{tot}, P_{tot}, conductivity, suspended solids (SS), settleable solids, faecal coliforms (FC), turbidity
Bioreactor	: Temp., SSV_{30}, MLSS, O_2
Effluents	: pH, COD, COD_{fil}*, BOD_5, NH_4-N, NO_3-N, NO_2-N, N_{tot}, P_{tot}, conductivity, suspended solids (SS), settleable solids, faecal coliforms (FC), turbidity

The parameters COD, BOD_5, NH_4-N, NO_3-N, NO_2-N, N_{tot}, P_{tot}, SS, faecal coliforms and MLSS were analysed by the IWA "Institut für Wasser- und Abwasseranalytik GmbH", Jülicher Str. 336 in 52076 Aachen. The IWA uses the standard analytical methods that are required by the EN 12566-3 Annex B. The IWA is accredited according to DIN EN ISO/IEC 17025: 2000-04 and is part of the PIA accreditation as a notified body.

* COD filtrated

4 Course and particularities of the examination

For the surface installation the BusseMF-HKA 4 P plus was positioned in a heatable insulating container and inlet and outlet were connected to the test infrastructure. The temperatures in the insulating container varied between 14°C and 25°C. The small wastewater treatment plant can also be operated without the module for phosphorus elimination. The treatment efficiency achieved by the system without the phosphorus elimination can be found in the test report PIA2009-100B60.

According to the EN 12566-3 requirements, the test schedule includes different periods of loading.

- Nominal loading: 100% of the daily hydraulic load
- Underloading: 50% of the nominal load
- Overloading: 150% of the nominal loading
- Low occupation stress / vacation: no influent

The additional power breakdown in the nominal loading scenarios in sequence 3 and 7 stands for a 24-h power cut-off 2 weeks after the respective sequence started. Low occupation stress / vacations means, that during the whole scenario no influent is dosed into the plant. The whole testing course is shown in Table 1.

Table 1: Test schedule of the BusseMF-HKA 4 p plus system

Sequence	Characteristics	Duration / Date
	Start of test	14.01.2008
1	Nominal	6 weeks
2	Underloading	2 weeks
3	Nominal / Power Breakdown	6 weeks
4	Low occupation stress / vacations	2 weeks
5	Nominal	6 weeks
6	Overloading	2 weeks
7	Nominal / Power Breakdown	6 weeks
8	Underloading	2 weeks
9	Nominal	6 weeks
	End of test	05.10.2008

The daily flow pattern under which the BusseMF-HKA 4 P plus small wastewater treatment system was tested complied with the EN12566 Part 3 daily flow pattern requirements as shown in Table 2. In the nominal sequences (100 %) the wastewater treatment plant was charged with 0.6 m³/d hydraulic load and 0.24 kg/d organic load.

Table 2: Daily flow pattern of the BusseMF-HKA 4 P plus

Duration [h]	Share of daily load
3	30 %
3	15 %
6	0 %
2	40 %
3	15 %
7	0 %

During the entire test period an average power consumption of 3.6 kWh/d was determined.

5 Treatment efficiency

Section 5.1 presents the analytical results of each of the 26 raw influent and treated effluent samples.

The means, minima and maxima results as well as the appropriate standard deviations of the tested system, under nominal loading conditions, are shown in section 5.2 – Table 9 and 10. The tested system efficiency ratios for underloading (50 %) and overloading (150 %) conditions are shown in Table 11. The statistical evaluations of faecal coliform presence in the treated effluents are shown in Table 12.

Section 5.3 presents the treatment efficiency ratios, raw influents and treated effluents characteristics and concentrations graphs for a better appraisal of the tested system.

5.1 Individual results

The individual results of all parameters are presented below in Table 3 to 8.

Table 3: Results from 24.01.2008 to 28.02.2008

Test schedule	Test sequence		1	1	1	1	2
	Loading		100 %	100 %	100 %	100 %	50 %
	Date		24.01.2008	31.01.2008	07.02.2008	14.02.2008	28.02.2008
Air Temperature min/max		[°C]	3/5	-1/4	-4/8	-3/10	3/11
Influent:							
Temperature		[°C]	9,8	13,5	10,6	8,2	10,5
COD_{tot}		[mg/l]	568	904	696	375	616
BOD_5		[mg/l]	178	312	177	183	253
NH_4-N		[mg/l]	30.6	27.5	42.2	28.8	36.6
N_{tot}		[mg/l]	43	47	60	43	54
P_{tot}		[mg/l]	6.3	7.8	7.6	5.8	8.2
pH		[-]	7.4	7.4	7.1	7.1	7.4
Conductivity		[µS/cm]	796	701	786	810	809
SS		[mg/l]	304	575	362	176	562
Settleable $solids_{120}$		[ml/l]	20	25	40	11	24
Turbidity		[FNU]	124	198	157	115	170
Faecal coliforms		[1/100ml]	9300000	4140000	10810000	6500000	10190000
Effluent:							
COD_{hom}		[mg/l]	16	15	24	10	24
COD_{fil}		[mg/l]	14	12	22	6	21
BOD_5		[mg/l]	1	2	1	1	1
NH_4-N		[mg/l]	8.4	0.4	0.2	0.8	0.1
NO_3-N		[mg/l]	1,7	21.0	23.1	22.5	26.5
NO_2-N		[mg/l]	< 0.1	0.2	< 0.1	< 0.1	0.2
N_{inorg}		[mg/l]	10.1	21.6	23.4	23.4	26.8
N_{tot}		[mg/l]	22.3	24.2	23.5	23.5	29.0
P_{tot}		[mg/l]	0.4	0.2	0.1	< 0.1	0.1
pH		[-]	7.3	8.8	7.8	7.8	7.9
Conductivity		[µS/cm]	622	626	663	633	704
SS		[mg/l]	8	6	< 1	1	2
Settleable $solids_{120}$		[ml/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Turbitidy		[FNU]	0.6	0.8	0.8	0.6	0.6
Faecal coliforms		[1/100ml]	36	68	53	< 1	< 1
Biology:							
Temperature		[°C]	13.9	13.0	13.4	12.8	12.1
SSV_{30}		[ml/l]	180	410	600	720	620
MLSS		[g/l]	3.4	4.9	7.2	5.1	5.0
O_2		[mg/l]	8.4	9.4	9.3	9.8	10.3

Table 4: Results from 06.03.2008 to 15.04.2008

Test schedule	Test sequence		2	3	3*	3	3
	Loading		50 %	100 %	100 %	100 %	100 %
	Date		06.03.2008	14.03.2008	03.04.2008	10.04.2008	15.04.2008
Air Temperature min/max		[°C]	-3/8	5/12	5/12	1/12	2/14
Influent:							
Temperature		[°C]	7.3	11.6	11.0	9.4	11.2
COD_{tot}		[mg/l]	488	595	663	947	992
BOD_5		[mg/l]	220	202	259	330	404
NH_4-N		[mg/l]	28.4	34.6	34.8	30.4	26.2
N_{tot}		[mg/l]	38	48	49	62	41
P_{tot}		[mg/l]	5.6	8.4	7.5	9.9	12.0
pH		[-]	7.4	7.5	7.1	7.0	6.7
Conductivity		[µS/cm]	703	890	865	1082	950
SS		[mg/l]	296	228	450	512	420
Settleable $solids_{120}$		[ml/l]	24	21	25	55	34
Turbidity		[FNU]	133	119	262	251	307
Faecal coliforms		[1/100ml]	6020000	5710000	9090000	6770000	9830000
Effluent:							
COD_{hom}		[mg/l]	33	22	18	25	33
COD_{fil}		[mg/l]	30	15	13	16	31
BOD_5		[mg/l]	< 1	1	1	1	< 1
NH_4-N		[mg/l]	< 0.1	< 0.1	0.2	0.1	0.2
NO_3-N		[mg/l]	26.2	29.5	20.3	19.5	23.5
NO_2-N		[mg/l]	0.3	0.2	< 0.1	< 0.1	< 0.1
N_{inorg}		[mg/l]	26.5	29.7	20.6	19.7	23.8
N_{tot}		[mg/l]	28.0	33.5	228	22.5	26.7
P_{tot}		[mg/l]	0.6	0.5	0.1	0.1	0.1
pH		[-]	7.6	7.9	7.9	8.1	8.6
Conductivity		[µS/cm]	660	695	698	661	715
SS		[mg/l]	2	2	2	1	1
Settleable $solids_{120}$		[ml/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Turbidity		[FNU]	0.4	0.5	1.0	0.6	0.6
Faecal coliforms		[1/100ml]	< 1	< 1	76	27	< 1
Biology:							
Temperature		[°C]	13.1	16.1	13.0	12.2	15.0
SSV_{30}		[ml/l]	620	780	580	560	620
MLSS		[g/l]	7.3	9.1	4.5	4.2	5.4
O_2		[mg/l]	10.2	7.1	11.7	11.4	7.8

* Power breakdown from 24.03.08 to 25.03.2008.

Table 5: Results from 17.04.2008 to 19.06.2008

Test schedule	Test sequence		3	5*	5	5	6
	Loading		100 %	100 %	100 %	100 %	150 %
	Date		17.04.2008	15.05.2008	29.05.2008	05.06.2008	19.06.2008
Air Temperature min/max		[°C]	-3/11	13/25	15/25	15/21	7/18
Influent:							
Temperature		[°C]	9.3	17.8	16.0	17.9	16.0
COD_{tot}		[mg/l]	768	936	979	667	816
BOD_5		[mg/l]	379	390	442	329	356
NH_4-N		[mg/l]	31.6	39.3	39.1	39.9	27.0
N_{tot}		[mg/l]	45	55	60	76	40.5
P_{tot}		[mg/l]	6.7	7.3	9.0	9.5	7.4
pH		[-]	7.1	7.0	7.1	6.6	6.7
Conductivity		[µS/cm]	907	961	922	635	909
SS		[mg/l]	548	500	404	498	446
Settleable $solids_{120}$		[ml/l]	24	24	31	30	22
Turbidity		[FNU]	208	176	236	237	252
Faecal coliforms		[1/100ml]	7330000	5730000	8860000	3680000	8330000
Effluent:							
COD_{hom}		[mg/l]	25	25	16	21	36
COD_{fil}		[mg/l]	22	22	13	17	30
BOD_5		[mg/l]	2	1	2	1	< 1
NH_4-N		[mg/l]	0.4	0.2	0.4	0.2	0.2
NO_3-N		[mg/l]	20.5	17.0	15.8	12.2	18.1
NO_2-N		[mg/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
N_{inorg}		[mg/l]	21.0	17.2	16.2	12.4	18.3
N_{tot}		[mg/l]	23.5	19.7	18.1	13.4	20.2
P_{tot}		[mg/l]	0.1	0.1	0.1	0.1	0.1
pH		[-]	8.1	7.9	8.2	7.5	8.1
Conductivity		[µS/cm]	711	690	651	660	666
SS		[mg/l]	1	1	1	2	1
Settleable $solids_{120}$		[ml/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Turbidity		[FNU]	0.7	0.7	0.9	0.8	0.8
Faecal coliforms		[1/100ml]	< 1	0	< 1	0	10
Biology:							
Temperature		[°C]	13.1	19.7	17.9	20.5	17.7
SSV_{30}		[ml/l]	600	600	780	460	840
MLSS		[g/l]	5.2	4.1	5.1	6.5	9.1
O_2		[mg/l]	11.0	8.7	11.2	7.6	6.8

* First sample after sequence vacations

Table 6: Results from 26.06.2008 to 31.07.2008

Test schedule	Test sequence	6	7	7	7*	7
	Loading	150 %	100 %	100 %	100 %	100 %
	Date	26.06.2008	03.07.2008	10.07.2008	24.07.2008	31.07.2008
Air Temperature min/max	[°C]	10/27	18/32	14/25	10/23	15/29
Influent:						
Temperature	[°C]	17.8	18.5	17.1	17.0	20.1
COD_{tot}	[mg/l]	852	524	496	616	764
BOD_5	[mg/l]	391	259	232	282	274
NH_4-N	[mg/l]	25.2	25.3	42.7	32.7	35,6
N_{tot}	[mg/l]	48	39	52	54	63
P_{tot}	[mg/l]	8.4	5.8	5.8	8.2	8.5
pH	[-]	7.1	7.0	7.0	7.1	7.1
Conductivity	[µS/cm]	872	892	816	828	927
SS	[mg/l]	508	304	252	410	416
Settleable $solids_{120}$	[ml/l]	19	19	22	10	19
Turbidity	[FNU]	211	196	212	198	196
Faecal coliforms	[1/100ml]	5040000	15530000	6130000	6020000	9590000
Effluent:						
COD_{hom}	[mg/l]	20	29	28	29	32
COD_{fil}	[mg/l]	18	18	18	17	24
BOD_5	[mg/l]	< 1	< 1	< 1	< 1	< 1
NH_4-N	[mg/l]	0.4	0.4	0.1	< 0.1	< 0.1
NO_3-N	[mg/l]	11.0	11.3	13.9	16.0	12.6
NO_2-N	[mg/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
N_{inorg}	[mg/l]	11.5	11.8	14.1	16.0	12.7
N_{tot}	[mg/l]	12.0	11.8	13.9	16.5	13.2
P_{tot}	[mg/l]	< 0.1	0.1	0.1	< 0.1	< 0.1
pH	[-]	8.2	7.8	8.2	7.9	8.1
Conductivity	[µS/cm]	605	704	637	610	628
SS	[mg/l]	1	1	1	3	2
Settleable $solids_{120}$	[ml/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Turbidity	[FNU]	0.6	0.9	0.5	0.9	0.7
Faecal coliforms	[1/100ml]	< 1	1	< 1	< 1	< 1
Biology:						
Temperature	[°C]	19.9	21.1	18.9	17.2	22.5
SSV_{30}	[ml/l]	660	910	840	870	870
MLSS	[g/l]	5.2	9.2	10.5	10.2	10.3
O_2	[mg/l]	7.8	5.9	6.2	10.6	4.7

* Power breakdown from 14.07.08 to 15.07.2008.

Table 7: Results from 07.08.2008 to 11.09.2008

Test schedule	Test sequence		7	8	8	9	9
	Loading		100 %	50 %	50 %	100 %	100 %
	Date		07.08.2008	14.08.2008	21.08.2008	04.09.2008	11.09.2008
Air Temperature min/max		[°C]	14/27	11/23	9/24	10/23	12/21
Influent:							
Temperature		[°C]	20.1	17.3	18.2	16.0	17.9
COD_{tot}		[mg/l]	692	528	680	688	536
BOD_5		[mg/l]	293	295	355	362	355
NH_4-N		[mg/l]	34,6	40,9	38,8	39,5	49,8
N_{tot}		[mg/l]	51	58	64	60	58
P_{tot}		[mg/l]	7.1	5.6	8.8	9.7	9.2
pH		[-]	7.0	7.0	7.0	6.8	6.9
Conductivity		[µS/cm]	868	877	929	924	962
SS		[mg/l]	218	268	400	330	232
Settleable $solids_{120}$		[ml/l]	23	19	17	20	7
Turbidity		[FNU]	186	187	204	166	137
Faecal coliforms		[1/100ml]	5830000	7980000	3090000	2980000	4950000
Effluent:							
COD_{hom}		[mg/l]	17	15	19	21	18
COD_{fil}		[mg/l]	17	14	15	18	17
BOD_5		[mg/l]	< 1	< 1	< 1	1	< 1
NH_4-N		[mg/l]	0.5	0.9	0.7	< 0.1	0.1
NO_3-N		[mg/l]	10.9	7.4	15.9	13.9	12.6
NO_2-N		[mg/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
N_{inorg}		[mg/l]	11.4	8.4	16.6	14.0	12.7
N_{tot}		[mg/l]	11.6	8.5	17.6	14.9	15.4
P_{tot}		[mg/l]	< 0.1	< 0.1	< 0.1	0.7	0.1
pH		[-]	8.3	8.1	8.4	8.3	7.4
Conductivity		[µS/cm]	620	582	673	658	656
SS		[mg/l]	< 1	3	2	< 1	< 1
Settleable $solids_{120}$		[ml/l]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Turbidity		[FNU]	0.7	0.9	0.7	0.9	0.6
Faecal coliforms		[1/100ml]	< 1	1	< 1	< 1	< 1
Biology:							
Temperature		[°C]	21.5	21.0	20.3	20.0	20.1
SSV_{30}		[ml/l]	900	900	630	900	220
MLSS		[g/l]	8.6	8.4	11.0	13.1	11.6
O_2		[mg/l]	6.6	4.2	5.3	7.5	6.7

Table 8: Results from 18.09.2008

Test schedule	Test sequence		9
	Loading		100 %
	Date		18.09.2008
Air Temperature min/max		[°C]	6/17
Influent:			
Temperature		[°C]	14.1
COD_{tot}		[mg/l]	700
BOD_5		[mg/l]	410
NH_4-N		[mg/l]	60.6
N_{tot}		[mg/l]	64
P_{tot}		[mg/l]	8.6
pH		[-]	7.1
Conductivity		[µS/cm]	929
SS		[mg/l]	452
Settleable $solids_{120}$		[ml/l]	27
Turbidity		[FNU]	214
Faecal coliforms		[1/100ml]	4960000
Effluent:			
COD_{hom}		[mg/l]	12
COD_{fil}		[mg/l]	12
BOD_5		[mg/l]	2
NH_4-N		[mg/l]	0.2
NO_3-N		[mg/l]	17.8
NO_2-N		[mg/l]	< 0.1
N_{inorg}		[mg/l]	18.0
N_{tot}		[mg/l]	21.6
P_{tot}		[mg/l]	0.1
pH		[-]	8.2
Conductivity		[µS/cm]	662
SS		[mg/l]	1
Settleable $solids_{120}$		[ml/l]	< 0.1
Turbidity		[FNU]	0.6
Faecal coliforms		[1/100ml]	1
Biology:			
Temperature		[°C]	16.2
SSV_{30}		[ml/l]	780
MLSS		[g/l]	10.7
O_2		[mg/l]	8.1

5.2 Evaluation of the test sequences

The EN 12566 Part 3 requires the evaluation of the nominal loading sequences, i.e. 20 samples taken in the sequences 1, 3, 5, 7 and 9.

Means, minima and maxima as well as the standard deviations shown hereunder in Tables 9 and 10.

Table 9: Treatment efficiencies under nominal loading conditions (100%)

Efficiency [%]	Mean*	Minimum	Maximum	Standard deviation
COD	96.8	94.4	98.4	1.1
BOD_5	99.6	99.4	99.9	0.2
N_{tot}	61.6	30.4	82.4	149
NH_4-N	97.9	72.5	99.9	6.0
P_{tot}	98.1	92.8	99.4	1.7
SS	99.5	97.4	99.9	0.6
FC	99.9	99.9	99.9	-

Table 10: Treated effluents characteristics under nominal loading conditions (100%)

Effluent		Mean	Minimum	Maximum	Standard deviation
COD	[mg/l]	22	10	33	6.53
BOD_5	[mg/l]	1	< 1	2	0.55
N_{tot}	[mg/l]	20	12	34	5.75
NH_4-N	[mg/l]	0.7	< 0.1	8.4	1.83
NO_3-N	[mg/l]	16.8	1.7	29.5	6.06
N_{inorg}	[mg/l]	17.5	10.1	29.7	5.26
P_{tot}	[mg/l]	0,2	< 0.1	0.7	0.18
SS	[mg/l]	2	< 1	8	1.92
Settleable solids	[ml/l]	< 0.1	< 0.1	< 0.1	-
FC	[1/100ml]	13	< 1	76	-

* Efficiency ratio for the treatment efficiency declaration according to EN 12566-3 chapter 6.3

As per reference to the guideline 91/271/EWG regarding the municipal wastewater treatment (Annex 1, Table 2, Annotation 3), nitrogen requirements only refer to treatment system effluent with temperature equal to or greater than 12 °C in biological reactor.

By operating in a heated environment the BusseMF HKA 4 P-plus wastewater treatment system did not show temperatures of below 12 °C in the bioreactor during the test.

Table 11 shows the efficiency for selected parameters in the test schedules with 50 % and 150 % hydraulic daily load.

Table 11: Efficiencies for 50% and 150% hydraulic daily load

	Test sequence					
	50 %	**50 %**	**150 %**	**150 %**	**50 %**	**50 %**
Date / **Efficiency[%]**	28.2.2008	6.3.2008	19.6.2008	26.6.2008	14.8.2008	21.8.2008
COD	96.1	93.2	95.6	97.7	97.2	97.2
BOD_5	99.6	99.8	99.9	99.9	99.8	99.9
N_{tot}	45.9	26.3	50.1	75.0	85.3	72.3
NH_4-N	99.7	99.8	99.3	98.4	97.8	98.2
P_{tot}	98.8	89.3	98.7	99.4	99.1	99.4
SS	99.6	99.3	99.8	99.8	98.9	99.5
FC	99.9	99.9	99.9	99.9	99.9	99.9

Table 12 presents the statistical evaluation of the faecal coliforms presence in the treated effluents. For the statistical calculation only the nominal test sequences (100 %) including the two nominal sequences with powerbreakdown were considered.

Table 12: statistical evaluation: faecal coliforms (nominal sequences with power breakdown)

Number	[-]	20
Aritmethic mean	[/100ml]	13
Geometric mean	[/100ml]	2
Minimum	[/100ml]	< 1
Maximum	[/100ml]	75.9
Quantile 80%	[/100ml]	29

5.3 Graphical presentation

The tested system influent and effluent characteristics as well as resulting treatment efficiencies of all test sequences, including nominal load, over- and underloading sequences are hereunder presented on chronologic graphs.

For the clarification of the results the concentrations of the influent and effluent are pointed out on the one hand as well as the resulting efficiencies on the other hand.

Raw influent and treated effluent COD concentrations are shown in Figure 8.

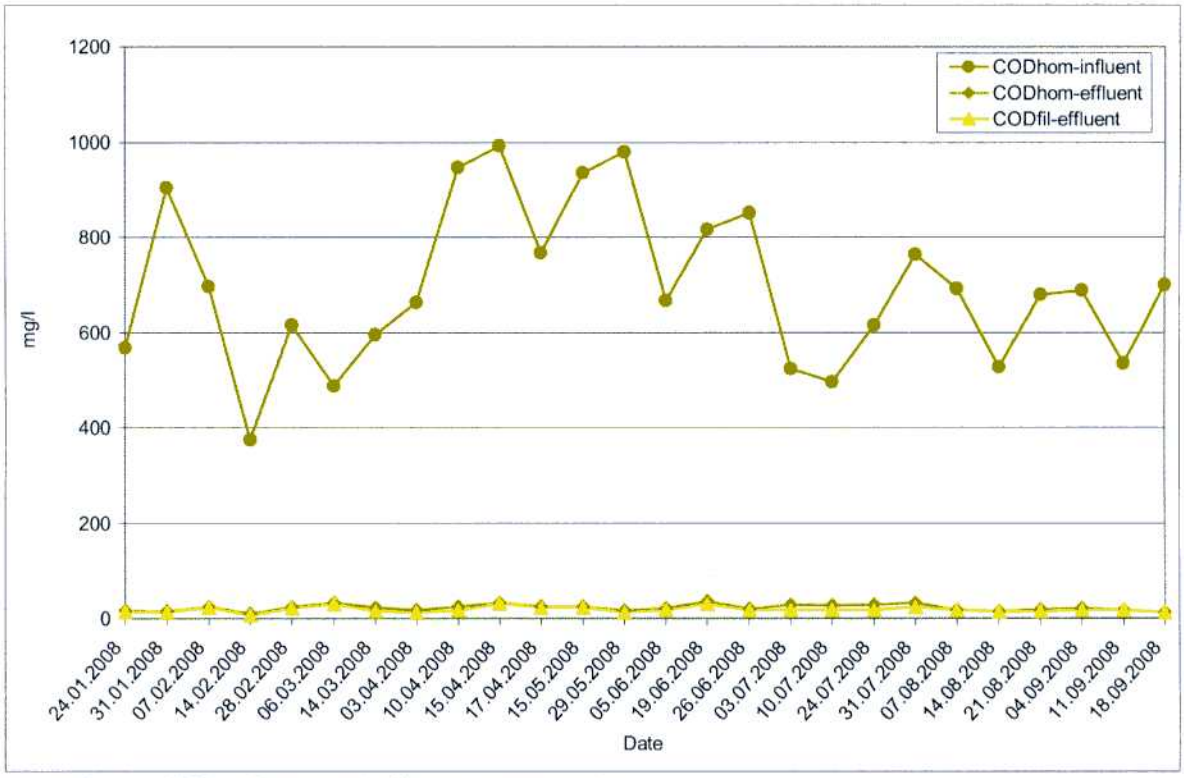

Figure 8: COD influent and effluent concentrations

Raw influent and treated effluent BOD_5 concentrations are shown in Figure 9; the effluent results were below 10 mg/l over the entire test.

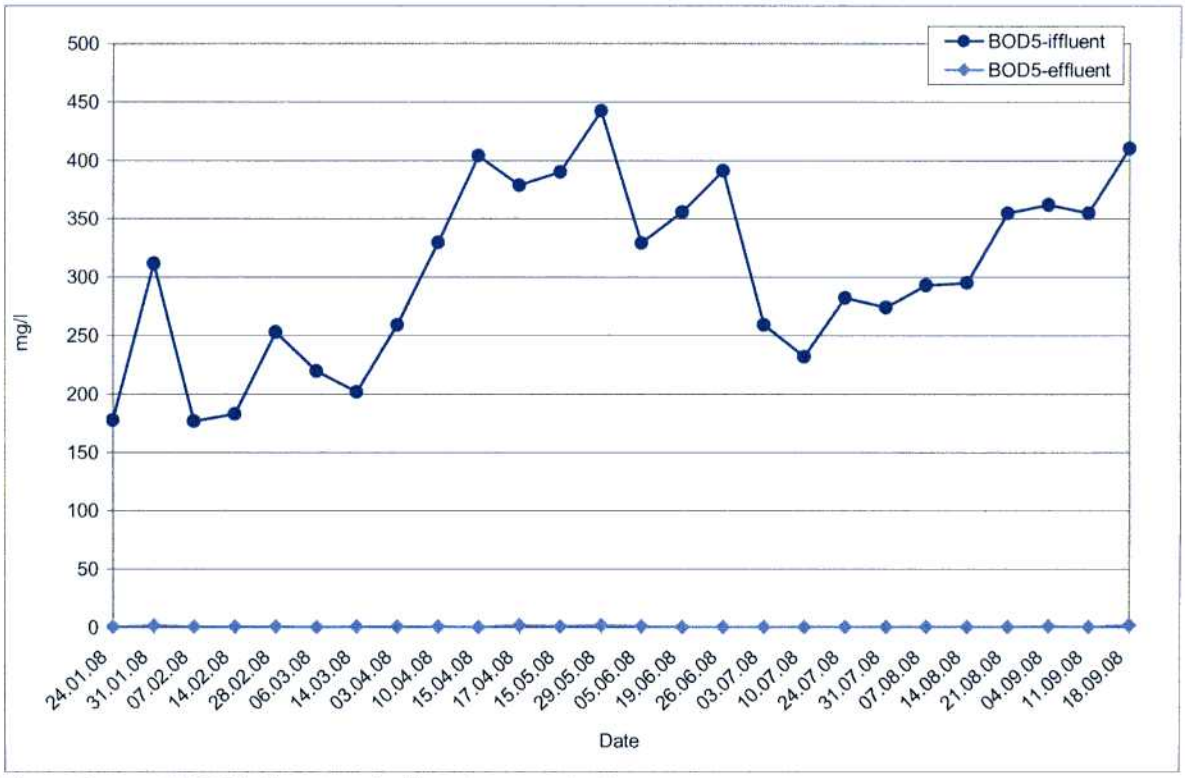

Figure 9: BOD5 influent and effluent concentrations

BOD_5 and COD treatment efficiency percentages are displayed in Figure 10.

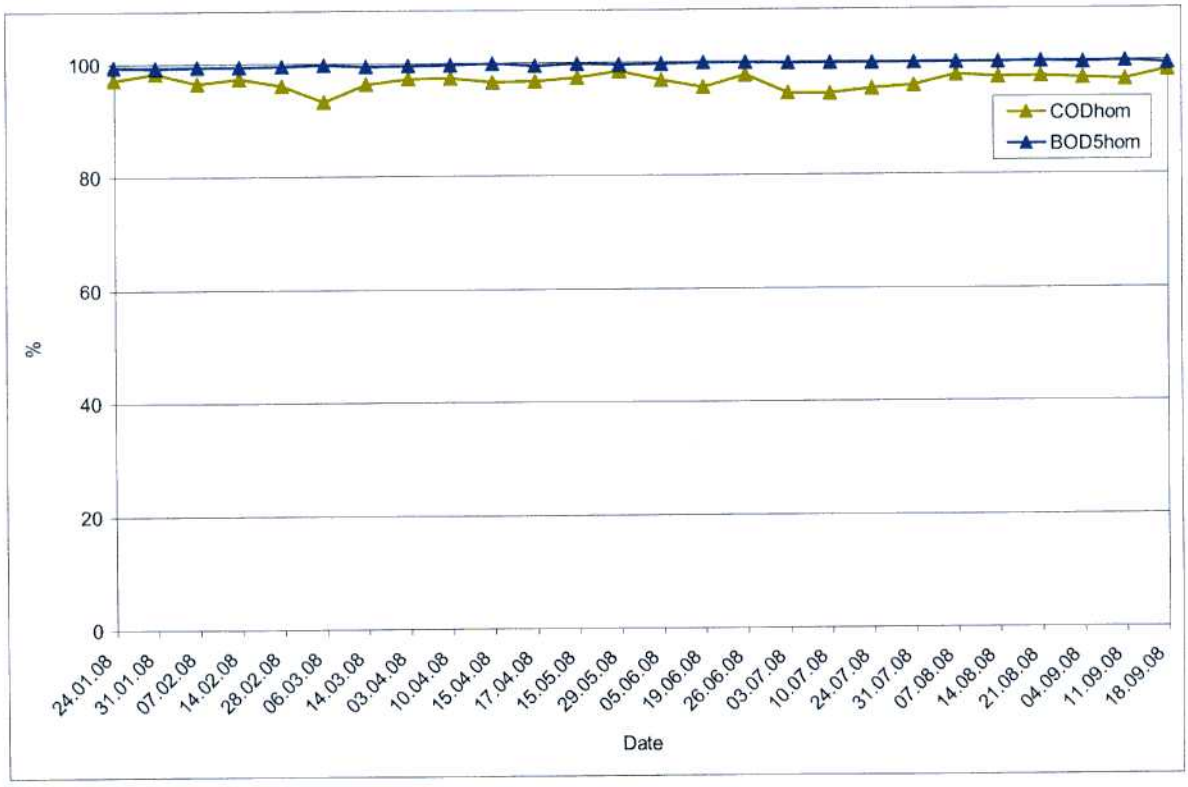

Figure 10: BOD_5 and COD treatment efficiency percentages

As per regard to the entire test period (sequences 1 to 9) the average overall BOD_5 and COD treatment efficiencies are as follows:

	%
COD	96.6
BOD_5	99.7

Raw influent and treated effluent NH_4-N, NO_3-N, $N_{inorganic}$ and the related bioreactor temperatures are shown in Figure 11.

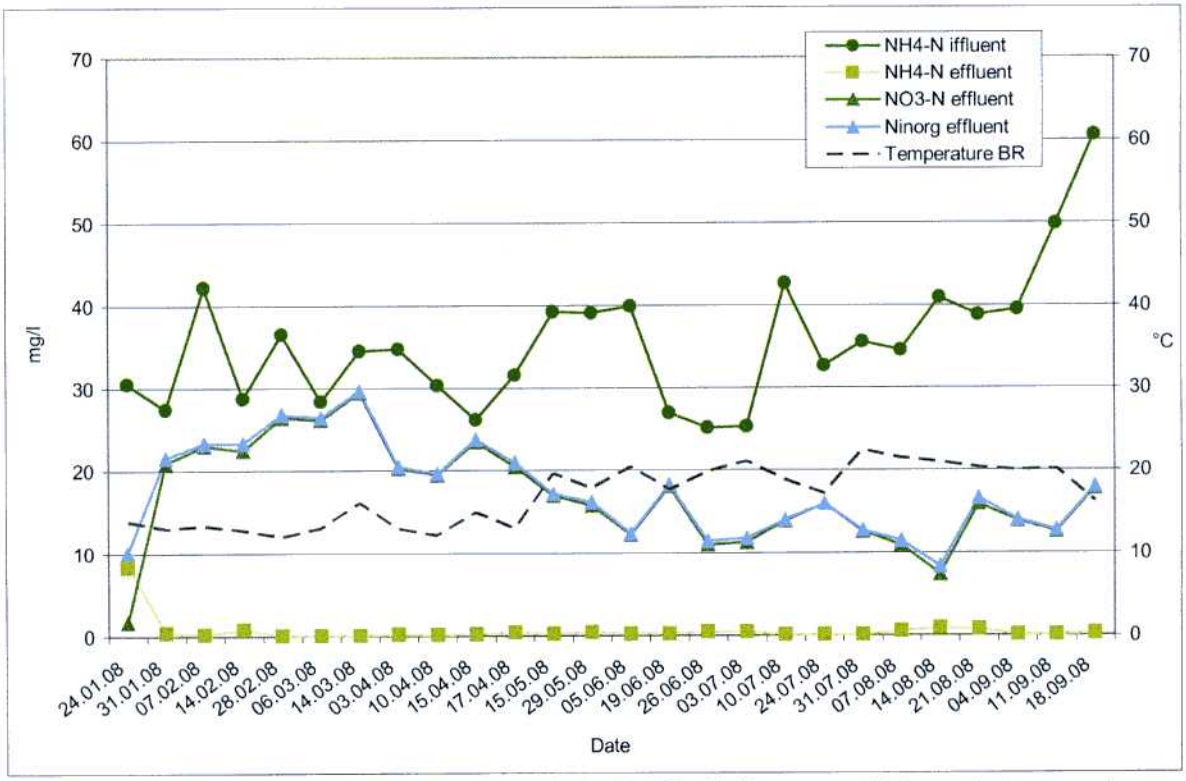

Figure 11: Raw influent and treated effluent NH_4-N, NO_3-N, $N_{inorganic}$ and bioreactor temperatures

The NH_4-N -effluent values varied between 0.1 mg / l in the nominal phase to 8.4 mg / l at the beginning of the test.

Nitrification and nitrogen removal efficiencies are presented in Figure 12:

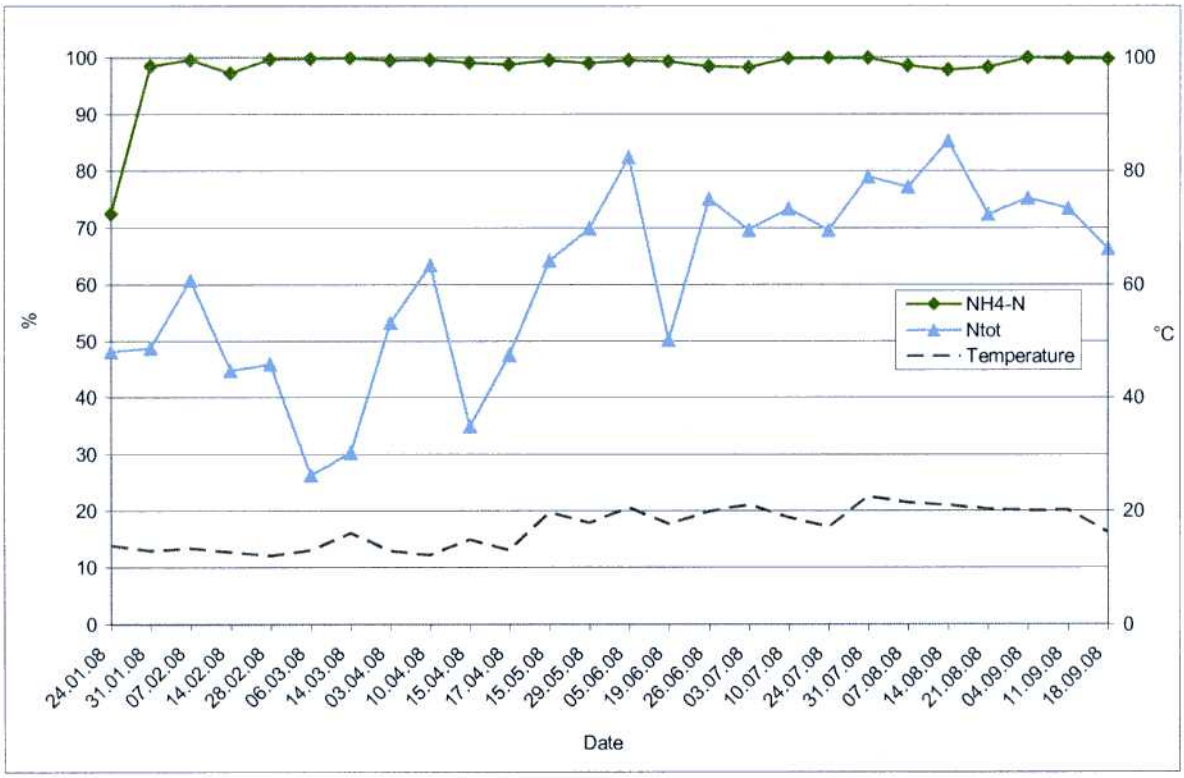

Figure 12: Nitrification and nitrogen removal efficiencies

As per regard to the entire test period (sequences 1 to 9), the average overall nitrification and nitrogen removal efficiencies are as follows:

	%
NH_4-N	98.1
N_{total}	61.0

In Figure 13 the influent and treated effluent suspended solids concentrations are shown and in Figure 14 the P_{tot}-concentrations of the system are shown.

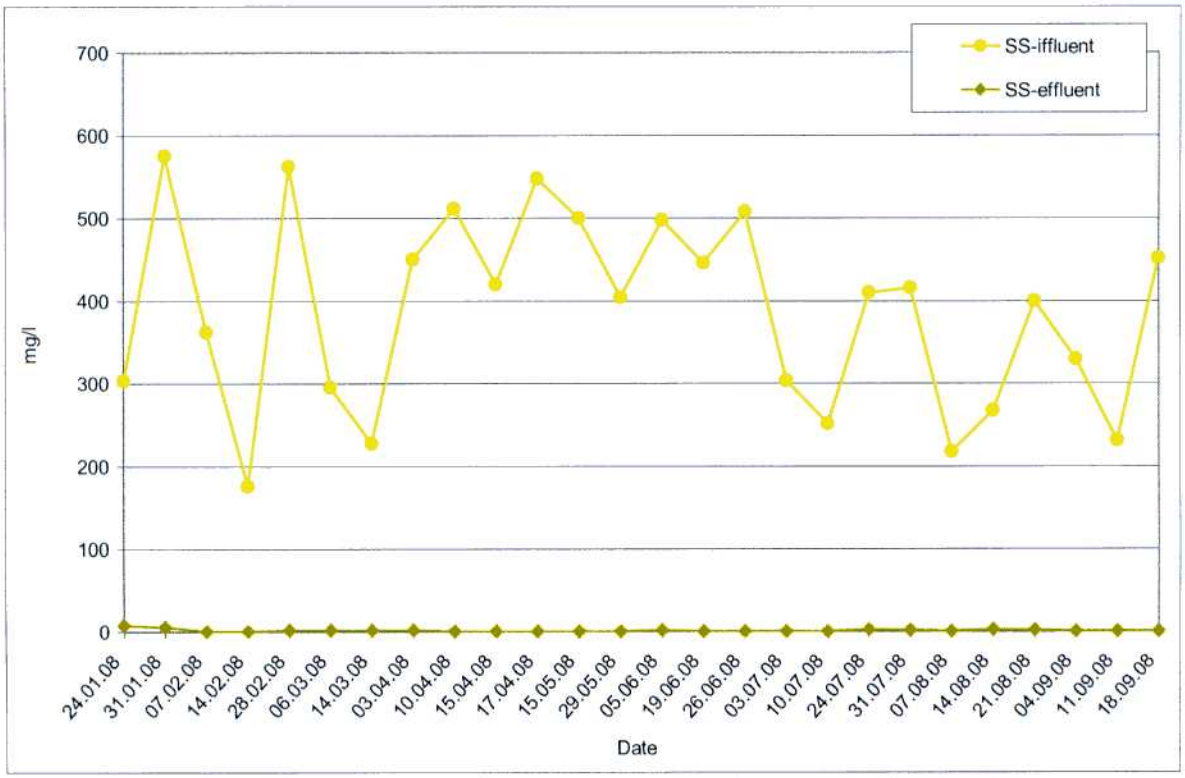

Figure 13: Raw influent and treated effluent suspended solids concentrations

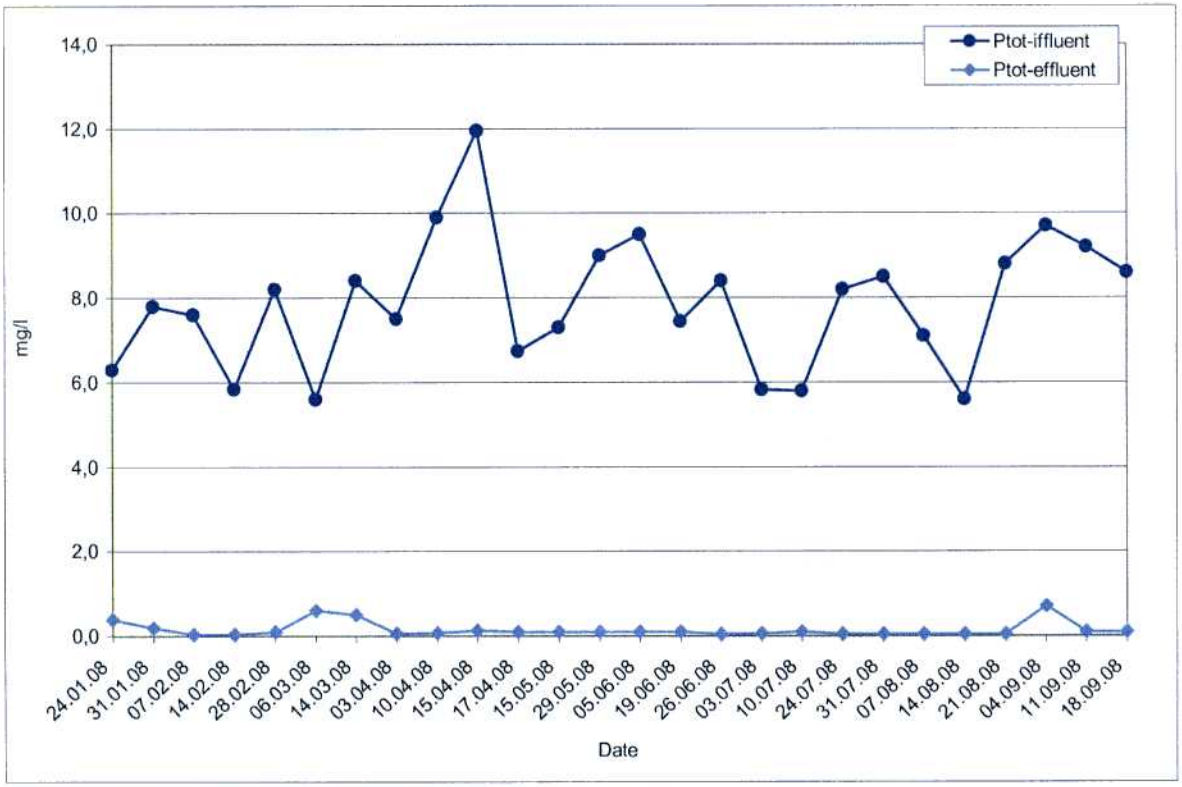

Figure 14: Concentrations of P_{tot} in influent and effluent

Suspended solids and total phosphorus removal efficiencies are shown in Figure 15.

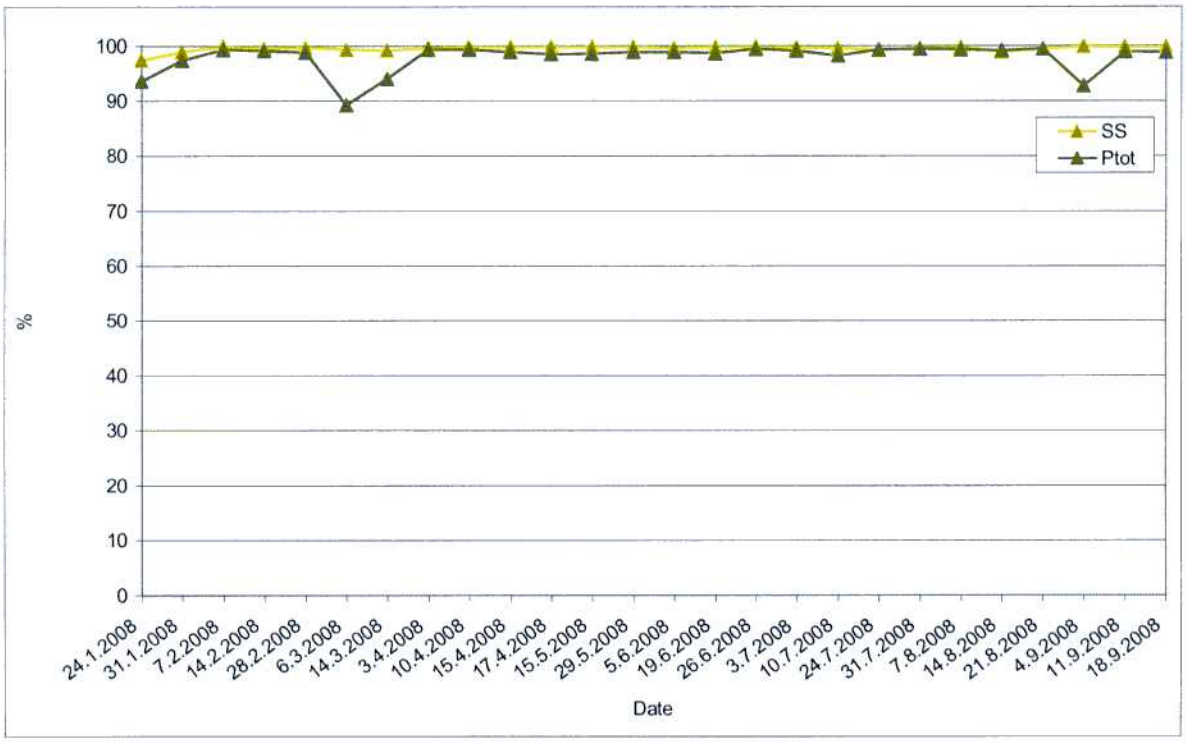

Figure 15: Suspended solids and total phosphorus removal efficiencies

As per regard to the entire test period (sequences 1 to 9) according to EN 12566-3, the average overall suspended solids and total phosphorus removal efficiencies are as follows:

	%
SS	99.5
P_{total}	98.0

6 Assessment of the operational safety

6.1 Operational reliability of the system

An alarm acoustical and with an optical alarm device was existent and network-independent. There were no mechanical or electrical malfunctions/failures during the entire 38-week test period.
The added modules to the phosphor-elimination also worked reliably and undisturbed.

6.2 Sludge level measurement and sludge removal

The measuring of the sludge level in the pre-settlement tank was difficult because of the low space in the insulating container. In order to asses the sludge volume of the pre-settlement precisely, the sludge was pumped into a tank with a comparable size at the end of the test. At the end of the test the whole content of sludge in the pre-settlement was pumped into a provided comparably big for more exact assessment. After an adequate settling time, the sludge level was < 20 cm on the 17th of October 2008.

The following sludge levels were taken in the pre-settlement tank during the test:

29.09.2008	:	< 20 cm
27.10.2008	:	< 20 cm

Therefore the wastewater treatment plant had a ventilated pre-settlement, the sludge level was at a very low level up to the end of the test. It rarely had to be controlled and desludging was not necessary. For this reason the sludge concentration in the bioreactor increased in the course of the test. The MLSS in the bioreactor rose considerably to more than 10 g/l. The manufacturer has to specify when and how much activated sludge is to be removed.

6.3 Maintenance and self monitoring

Time and effort to operate and maintain the tested system met the usual time and effort to operate a small wastewater treatment plant of this type.

6.4 Accessibility

All plant components were accessible in a satisfactory manner. When planning the installation of the system it should be made sure that there is enough space for service work. No unpleasant smells appeared in the insulating container. The access manhole diameters at the GRP-Tanks were ca. 45 x 55 cm. The Polyethylene tanks were equipped with lids of the size 41 x 35 cm.

7 Annex

BusseMF-HKA 4 P plus small wastewater treatment system technical drawings and design / sizing information (manufacturer's information in German):