

Summary Results of Dynamic Openloop Simulations of the COST 624 Benchmark

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In this document the results from five different simulation platforms that have been applied to perform the COST 624 Benchmark exercise are summarised. The results are based on the so called openloop case, i.e. no active controllers, no noise, no measurement delays, etc., and include all three weather files (dry weather, rain weather and storm weather). This means that theoretically all results should be identical. Note that the influent and effluent quality indices are based on the new weighting values, i.e. $B_{SS} = 2$, $B_{COD} = 1$, $B_{BOD5} = 2$, $B_{NKj} = 20$, $B_{NO} = 20$. The calculations are performed as follows:

- implement the plant layout with the models described on the COST web-site;
- calculate (or simulate at least 100 days) the steady states of all state variables using the defined constant input file;
- use this defined steady state as the initial condition and simulate the plant for 14 days using the defined dry weather input file;
- use the final values of this simulation as initial conditions and simulate the weather file of your choice (14 days);
- calculate the various performance criteria exactly as defined on the web-site based on the data of the last 7 days of simulation.

In order to achieve correct results make sure of the following:

- set the numeric tolerances of your simulator to low values to ensure accurate results. You may later increase the tolerances to improve the computational speed but you should always compare these less accurate results with the ones achieved with low tolerances before you accept them;
- your simulator should read data from the input files and write data to the output files with exactly 15 minutes intervals. If your simulator makes some kind of interpolation instead then your results will not be correct;
- when calculating the different integrals that are required for the performance criteria use a simple Euler forward approximation, i.e. discrete calculation and zero-order hold between the sampling instants (sample every 15 minutes);
- the integral calculations are based on the last 7 seven days, i.e. the first sample used should be the one at time 7.0000000 days and the last sample used should be the one at time 13.989583333 d (i.e. 13 days 23 hours and 45 minutes). The sample at time 14 d should *not* be included in the integral since you are using a forward Euler approximation.

The results have been collected from five different platforms – GPS-X, Fortran, Simulink, SIMBA and WEST. The Simulink and SIMBA implementations have worked without any apparent problems. After several coding errors in the Fortran implementation it also works properly. With regard to GPS-X (version 2.3.1) it should be noted that a patch from Hydromantis is required in order to solve a problem with reading and writing data at exactly the required time instants. The GPS-X settler model also have a problem since it only use 1 layer (i.e. the entire settler) to describe the behaviour of the soluble material (10 layers should be used according to the COST Benchmark). The first problem has been solved for the results presented in the following pages whereas the second problem remains. Similar problems were also encountered for the WEST simulator (varying time step for output data and 0 layers for the solubles in the settler) but have been corrected.

The results have been provided by several research groups and their work should be acknowledged:

- GPS-X results – John Copp and Henri Spanjers, Wageningen, The Netherlands;
- FORTRAN results – Marie-Noëlle Pons, Nancy, France;
- SIMULINK results – myself (SIMULINK_1) and Antonio Salterain, San Sebastian, Spain (SIMULINK_2);
- SIMBA results – Jens Alex, Magdeburg, Germany;
- WEST results – Peter Vanrolleghem, Henk Vanhooren and Matty Janssen, Gent, Belgium.

The results clearly indicate that we have more or less reached identical results and we can now ‘guarantee’ that they are correct. They provide a basis for comparison for those of you who are interested in setting up and performing your own benchmark simulations. If anyone has results like the ones presented here (maybe for another platform) I would appreciate if you could send them to me so that they may be incorporated.

A similar summary document have been compiled with the results of the closed-loop simulations for all platforms including noise and delays of sensor signals.

Lund, 7 September 1999

Ulf Jeppsson

Performance Criteria for DRYWEATHER Dynamic Openloop Simulations

Effluent average concentrations based on load

	GPS-X	FORTTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
Q =	18061.332	18061	18061.3326	18061.3874	18062.1	18078.75086	m3/d	18064.31714	17.75086
S_I =	30	30	30	30	30	30	g COD/m3	30	0
S_S =	0.9694425	0.973	0.97362	0.9767	0.973516	0.973833509	g COD/m3	0.973352002	0.0072575
X_I =	4.5877576	4.58	4.5779	4.5803	4.5795	4.586472095	g COD/m3	4.581988283	0.0098576
X_S =	0.2250142	0.229	0.22288	0.22293	0.222858	0.222857566	g COD/m3	0.224256628	0.006142434
X_BH =	10.221916	10.2	10.2206	10.2218	10.2209	10.22246257	g COD/m3	10.21794643	0.02246257
X_BA =	0.5412252	0.542	0.54199	0.5421	0.542172	0.54214778	g COD/m3	0.541939163	0.0009468
X_P =	1.7579831	1.76	1.756	1.7572	1.75716	1.756991459	g COD/m3	1.75755576	0.004
S_O =	0.7978007	0.7453	0.74629	0.7464	0.746332	0.746184847	g (-COD)/m3	0.756601509	0.051615853
S_NO =	8.8463954	8.80	8.8231	8.8181	8.82368	8.818226362	g N/m3	8.821583627	0.0463954
S_NH =	4.8571217	4.8	4.7632	4.7653	4.75903	4.774649563	g N/m3	4.786550211	0.0980917
S_ND =	0.7259504	0.731	0.72909	0.7291	0.729005	0.729223471	g N/m3	0.728894812	0.0050496
X_ND =	0.0158308	0.0157	0.015693	0.01569	0.0156918	0.015693973	g N/m3	0.015716596	0.0001408
S_ALK =	n/a	4.46	4.4565	4.4569	4.4562	n/a	kmol HCO3/m3	4.4574	0.0038
TSS =	13.000411	12.978	12.9895	12.9933	12.9919	12.9981986	g SS/m3	12.99188493	0.022411
N_TKN =	6.8406986	6.79	6.749	6.7518	6.74497	6.761343649	g N/m3	6.772968708	0.0957286
N_tot =	15.687094	15.6	15.5721	15.5699	15.5687	15.57957001	g N/m3	15.59622734	0.118394
COD_tot =	48.303339	48.3	48.293	48.3012	48.2961	48.30476498	g COD/m3	48.299734	0.01176498
BOD5_tot =	2.7741367	2.78	2.7745	2.7756	2.7746	2.775033149	g/m3	2.775644975	0.0058633

Effluent average loads

	GPS-X	FORTTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
S_I =	541.83996	542	541.84	541.8416	541.862	542.3625258	kg COD/d	541.957681	0.5225658
S_S =	17.509423	17.6	17.5848	17.6405	17.5837	17.60569338	kg COD/d	17.58735273	0.131077
X_I =	82.861012	82.7	82.6833	82.7265	82.7153	82.91768633	kg COD/d	82.76729972	0.23438633
X_S =	4.0640566	4.03	4.0255	4.0264	4.02528	4.028986418	kg COD/d	4.033370503	0.0387766
X_BH =	184.62142	185	184.598	184.6198	184.611	184.8093539	kg COD/d	184.709929	0.402
X_BA =	9.7752488	9.79	9.7891	9.791	9.79275	9.801354643	kg COD/d	9.789908907	0.026105843
X_P =	31.751515	31.7	31.7151	31.7374	31.7379	31.76421084	kg COD/d	31.73435431	0.06421084
S_O =	14.409344	13.46	13.4791	13.481	13.4803	13.49008995	kg (-COD)/d	13.66796679	0.930244
S_NO =	159.77768	159	159.3566	159.267	159.374	159.4225174	kg N/d	159.3662996	0.77768
S_NH =	87.726086	86.6	86.0291	86.0678	85.9579	86.31969989	kg N/d	86.45009765	1.768186
S_ND =	13.111632	13.2	13.1682	13.1685	13.1673	13.18344946	kg N/d	13.16651358	0.088368
X_ND =	0.2859248	0.284	0.28343	0.2833	0.283426	0.283727436	kg N/d	0.283968039	0.0026248
S_ALK =	n/a	80.5	80.491	80.4977	80.4882	n/a	kmol HCO3/d	80.494225	0.0118
TSS =	234.80473	234.92	234.6081	234.6769	234.661	234.9911941	kg N/d	234.7769874	0.3830941
N_TKN =	123.55213	122.63	121.8956	121.9468	121.828	122.2366473	kg N/d	122.3481962	1.72413
N_tot =	283.32981	281.75	281.2522	281.2138	281.202	281.6591647	kg N/d	281.7344958	2.12781
COD_tot =	872.42263	871.7	872.2357	872.3863	872.327	873.2898113	kg COD/d	872.3935736	1.5898113
BOD5_tot =	50.104604	50.21	50.1116	50.1311	50.115	50.16913293	kg/d	50.14023949	0.105396

Other quality variables

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
I.Q.-index =	42042.81	42000	42042.8148	42044.7979	42042.81	42042.81572	kg poll.units/d	42036.00807	44.7979
E.Q.-index =	7108.84	7040	7066.7187	7066.7522	7065.17	7066.684054	kg poll.units/d	7069.027492	68.84
P_sludge =	17071.1	17052	17051.7894	17109.5057	17050.58	17056.26335	kg SS	17065.20641	58.9257
P_sludge per day =	2438.7	2436	2435.9699	2444.2151	2435.80	2436.60905	kg SS/d	2437.882342	8.4151
P_sludge_eff =	1643.6	1631	1642.257	1642.7453	1642.63	1644.938359	kg SS	1641.19511	13.938359
P_sludge_eff per day =	234.8	233	234.6081	234.6779	234.66	234.9911941	kg SS/d	234.456199	1.9911941
P_total_sludge =	18714.8	18683	18694.0464	18752.251	18693.21	18701.20171	kg SS	18706.41819	69.251
P_total_sludge per day =	2673.5	2669	2670.5781	2678.893	2670.46	2671.600244	kg SS/d	2672.338557	9.893
Aeration energy =	6476	6476	6476.112	6476.112	6476.11	6476.112	kWh/d	6476.074333	0.112
Pumping energy =	2967	2967	2966.76	2966.76	2966.76	2966.76	kWh/d	2966.84	0.24
The max effluent N_tot level (18 g N/m3) was violated during:	0.0623	0.576	0.57292	0.57291	0.5729	0.5775	d	0.489088333	0.5152
i.e.:	0.89	8.23	8.1845	8.1967	8.18	8.25	% of the time	6.988533333	7.36
The limit was violated at:	1	5	5	5	5	5	occasions	4.333333333	4
The max effluent S_NH level (4 g N/m3) was violated during:	4.032	4.40	4.375	4.375	4.3750	4.3545	d	4.318583333	0.368
i.e.:	57.6	62.9	62.5	62.59	62.50	62.2071	% of the time	61.71618333	5.3
The limit was violated at:	5	7	7	7	7	7	occasions	6.666666667	2

Performance Criteria for RAINWEATHER Dynamic Openloop Simulations

Effluent average concentrations based on load

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
Q =	23808.179	23810	23808.1776	23816.798	23808.6	23830.00976	m ³ /d	23813.62739	21.83216
S_I =	22.832871	22.8	22.8388	22.8308	22.8388	22.84597613	g COD/m ³	22.83120786	0.04597613
S_S =	1.1366922	1.13	1.1345	1.1372	1.13432	1.134495754	g COD/m ³	1.134534659	0.0072
X_I =	5.6457577	5.65	5.6372	5.6409	5.63892	5.646002223	g COD/m ³	5.643129987	0.0128
X_S =	0.3493172	0.346	0.34481	0.3449	0.344746	0.344787032	g COD/m ³	0.345760039	0.0045712
X_BH =	12.850036	12.9	12.8567	12.8602	12.8565	12.85675603	g COD/m ³	12.86336534	0.049964
X_BA =	0.6408525	0.643	0.64263	0.6429	0.64284	0.642673604	g COD/m ³	0.642482684	0.0021475
X_P =	2.0681118	2.07	2.0666	2.0685	2.06799	2.067498163	g COD/m ³	2.068116661	0.0034
S_O =	0.8859643	0.8473	0.84718	0.8473	0.847039	0.846764004	g (-COD)/m ³	0.854849461	0.039200296
S_NO =	6.9683288	6.93	6.9585	6.9536	6.95955	6.958116491	g N/m ³	6.954682549	0.0383288
S_NH =	5.1016255	5.01	4.9862	4.9868	4.98202	4.993533418	g N/m ³	5.01002982	0.1196055
S_ND =	0.8150522	0.818	0.8157	0.8158	0.815592	0.815707313	g N/m ³	0.815975252	0.0029478
X_ND =	0.0238838	0.0237	0.023599	0.0236	0.0235949	0.02359984	g N/m ³	0.023662923	0.0002889
S_ALK =	n/a	5.15	5.1435	5.1444	5.14312	n/a	kmol HCO ₃ /m ³	5.145255	0.00688
TSS =	16.165561	16.21	16.161	16.1682	16.1633	16.16828779	g SS/m ³	16.1727248	0.049
N_TKN =	7.4826648	7.4	7.3677	7.3609	7.36357	7.375604965	g N/m ³	7.391739961	0.1217648
N_tot =	14.450994	14.3	14.3262	14.3145	14.3231	14.33372146	g N/m ³	14.34141924	0.150994
COD_tot =	45.523638	45.5	45.5213	45.5256	45.5242	45.53818894	g COD/m ³	45.52215449	0.03818894
BOD5_tot =	3.4744066	3.48	3.4747	3.4762	3.47462	3.474689512	g/m ³	3.475769352	0.0055934

Effluent average loads

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
S_I =	543.60907	544	543.7504	543.928	543.76	544.4198342	kg COD/d	543.9112174	0.8107642
S_S =	27.06257	27	27.01	27.0844	27.0066	27.0350449	kg COD/d	27.03310248	0.0844
X_I =	134.41521	135	134.2121	134.3481	134.255	134.5442881	kg COD/d	134.4624497	0.7879
X_S =	8.3166071	8.24	8.2094	8.2144	8.20792	8.216278339	kg COD/d	8.234100907	0.1086871
X_BH =	305.93594	307	306.0952	306.2887	306.095	306.3766216	kg COD/d	306.2985769	1.06406
X_BA =	15.257532	15.3	15.2998	15.3118	15.3051	15.31491825	kg COD/d	15.29819171	0.05738625
X_P =	49.237975	49.3	49.2025	49.265	49.2359	49.26850141	kg COD/d	49.25164607	0.0975
S_O =	21.093197	20.20	20.1699	20.1799	20.1668	20.17839448	kg (-COD)/d	20.3576383	0.926397
S_NO =	165.90322	165	165.6694	165.1837	165.697	165.8119839	kg N/d	165.5442173	0.90322
S_NH =	121.46041	120	118.7122	118.7696	118.615	118.9959501	kg N/d	119.4255267	2.84541
S_ND =	19.404909	19.5	19.4204	19.4297	19.4181	19.43831324	kg N/d	19.43523704	0.095091
X_ND =	0.5686301	0.564	0.56184	0.562	0.561762	0.562384408	kg N/d	0.563436085	0.0068681
S_ALK =	n/a	123	122.4574	122.5231	122.451	n/a	kmol HCO ₃ /d	122.607875	0.549
TSS =	384.87255	386.13	384.7643	385.0747	384.824	385.2904558	kg N/d	385.1593343	1.3657
N_TKN =	178.14862	176.2	175.4109	175.313	175.316	175.7607383	kg N/d	176.0248764	2.83562
N_tot =	344.05184	340.48	341.0803	340.9255	341.013	341.5727222	kg N/d	341.5205604	3.57184
COD_tot =	1083.8349	1082.6	1083.7794	1084.274	1083.87	1085.175487	kg COD/d	1083.922298	2.575487
BOD5_tot =	82.719294	82.86	82.7257	82.7919	82.7257	82.80188497	kg/d	82.7707465	0.140706

Other quality variables

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
I.Q.-index =	42042.81	42000	42042.8148	42044.7979	42042.81	42042.81571	kg poll.units/d	42036.00807	44.7979
E.Q.-index =	8900.06	8800	8840.3659	8842.4408	8838.6	8843.961797	kg poll.units/d	8844.238083	100.06
P_sludge =	16492.6	16457	16469.128	17743.208	16467.86	16536.96849	kg SS	16694.46075	1286.208
P_sludge per day =	2356.1	2351	2352.7326	2534.744	2352.55	2362.42407	kg SS/d	2384.925112	183.744
P_sludge_eff =	2694.1	2688	2693.3498	2695.5173	2693.77	2697.03319	kg SS	2693.628382	9.03319
P_sludge_eff per day =	384.9	384	384.7643	385.0739	384.82	385.2904558	kg SS/d	384.8081093	1.2904558
P_total_sludge =	19186.7	19145	19162.4778	20438.7253	19161.63	19234.00168	kg SS	19388.08913	1293.7253
P_total_sludge per day =	2741.0	2735	2737.4968	2919.8179	2737.38	2747.714526	kg SS/d	2769.734871	184.8179
Aeration energy =	6476	6476	6476.112	6476.112	6476.11	6476.112	kWh/d	6476.074333	0.112
Pumping energy =	2967	2967	2966.76	2966.76	2966.76	2966.76	kWh/d	2966.84	0.24
The max effluent N_tot level (18 g N/m3) was violated during:	0	0.314	0.3125	0.3021	0.3021	0.315	d	0.257616667	0.315
i.e.:	0	4.49	4.4643	4.3219	4.32	4.5	% of the time	3.6827	4.5
The limit was violated at:	0	3	3	3	3	3	occasions	2.5	3
The max effluent S_NH level (4 g N/m3) was violated during:	4.382	4.46	4.4375	4.42708	4.4271	4.452	d	4.430946667	0.078
i.e.:	62.6	63.8	63.3929	63.3383	63.24	63.6	% of the time	63.32853333	1.2
The limit was violated at:	7	7	7	7	7	7	occasions	7	0

Performance Criteria for STORMWEATHER Dynamic Openloop Simulations

Effluent average concentrations based on load

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
Q =	20658.1	20658	20658.1004	20662.0253	20658.2	20677.34084	m ³ /d	20661.96109	19.34084
S_I =	26.277833	26.3	26.2999	26.2954	26.3	26.30148618	g COD/m ³	26.29576986	0.02365318
S_S =	1.1053817	1.11	1.1131	1.1158	1.11294	1.113009846	g COD/m ³	1.111705258	0.0104183
X_I =	5.6397838	5.64	5.6355	5.6391	5.63696	5.642995242	g COD/m ³	5.639056507	0.007495242
X_S =	0.326567	0.324	0.32265	0.3228	0.322596	0.322381903	g COD/m ³	0.323499151	0.004185097
X_BH =	11.8591	11.9	11.8802	11.8832	11.8801	11.8711536	g COD/m ³	11.87895893	0.0409
X_BA =	0.5859899	0.589	0.58825	0.5884	0.588439	0.587867698	g COD/m ³	0.5879911	0.0030101
X_P =	1.9113356	1.92	1.9125	1.914	1.91368	1.911850396	g COD/m ³	1.913894333	0.0086644
S_O =	0.7990191	0.7633	0.76351	0.7636	0.763439	0.763242643	g (-COD)/m ³	0.770562149	0.035776457
S_NO =	7.5002184	7.45	7.48	7.4749	7.48088	7.479140005	g N/m ³	7.477523068	0.0502184
S_NH =	5.4755221	5.39	5.3539	5.3557	5.34954	5.361014572	g N/m ³	5.380946112	0.1259821
S_ND =	0.7980812	0.806	0.80351	0.8036	0.80342	0.803585947	g N/m ³	0.803032858	0.0079188
X_ND =	0.0229266	0.0227	0.022649	0.02266	0.0226452	0.022638646	g N/m ³	0.022703241	0.000287954
S_ALK =	n/a	4.88	4.8726	4.8734	4.87223	n/a	kmol HCO ₃ /m ³	4.8745575	0.00777
TSS =	15.24211	15.28	15.2543	15.2607	15.2563	15.25218663	g SS/m ³	15.25759944	0.03789
N_TKN =	7.7452041	7.669	7.6305	7.633	7.62612	7.637251606	g N/m ³	7.656845951	0.1190841
N_tot =	15.245423	15.12	15.1105	15.1079	15.107	15.116391611	g N/m ³	15.13453577	0.138423
COD_tot =	47.705991	47.76	47.752	47.7589	47.7546	47.75074486	g COD/m ³	47.74703931	0.054009
BOD5_tot =	3.2203578	3.23	3.2267	3.2281	3.22664	3.224422836	g/m ³	3.226036773	0.0096422

Effluent average loads

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
S_I =	542.85008	543	543.3052	543.3162	543.311	543.8447943	kg COD/d	543.2712124	0.9947143
S_S =	22.835086	23	22.9939	23.0546	22.9914	23.01408395	kg COD/d	22.98151166	0.219514
X_I =	116.50722	117	116.4188	116.5152	116.45	116.682136	kg COD/d	116.5955593	0.5812
X_S =	6.7462533	6.69	6.6654	6.6697	6.66426	6.666000491	kg COD/d	6.683602299	0.0819933
X_BH =	244.98647	246	245.4223	245.5309	245.421	245.4638892	kg COD/d	245.4707599	1.01353
X_BA =	12.105439	12.2	12.1522	12.1575	12.1561	12.15554076	kg COD/d	12.15446329	0.094561
X_P =	39.484562	39.6	39.5078	39.5471	39.5333	39.53198228	kg COD/d	39.53412405	0.115438
S_O =	16.506216	15.78	15.7727	15.7775	15.7713	15.78182828	kg (-COD)/d	15.92190886	0.734916
S_NO =	154.94026	154	154.523	154.4465	154.542	154.6487271	kg N/d	154.5167479	0.94026
S_NH =	113.11388	111	110.6024	110.6596	110.512	110.8515256	kg N/d	111.1232343	2.60188
S_ND =	16.48684	16.7	16.599	16.604	16.5972	16.61602051	kg N/d	16.60051009	0.21316
X_ND =	0.4736192	0.469	0.46788	0.4682	0.46781	0.468106994	kg N/d	0.469102699	0.0058092
S_ALK =	n/a	101	100.6591	100.6943	100.652	n/a	kmol HCO ₃ /d	100.75135	0.348
TSS =	314.87303	316.12	315.1249	315.3169	315.168	315.3746615	kg N/d	315.3295819	1.24697
N_TKN =	160.0012	158.43	157.6308	157.7132	157.542	157.9180546	kg N/d	158.2058758	2.4592
N_tot =	314.94146	312.35	312.1538	312.084	312.084	312.5667816	kg N/d	312.6966736	2.85746
COD_tot =	985.51511	986.56	986.4656	986.7956	986.526	987.3584269	kg COD/d	986.5367895	1.8433169
BOD5_tot =	66.526473	66.73	66.657	66.699	66.6566	66.67248999	kg/d	66.65692717	0.203527

Other quality variables

	GPS-X	FORTRAN	SIMULINK_1	SIMULINK_2	SIMBA	WEST	unit	Average	max-min
I.Q.-index =	43758.11	43800	43758.1149	43762.6545	43758.11	43758.11618	kg poll.units/d	43765.85093	41.89
E.Q.-index =	8047.14	7960	7993.1057	7994.0429	7991.19	7994.785574	kg poll.units/d	7996.710696	87.14
P_sludge =	18223.6	18200	18197.3807	17926.776	18196.14	18188.32677	kg SS	18155.37058	296.824
P_sludge per day =	2603.4	2600	2599.6258	2560.968	2599.45	2598.332395	kg SS/d	2593.629366	42.432
P_sludge_eff =	2204.1	2191	2205.874	2207.2309	2206.18	2207.62263	kg SS	2203.667922	16.62263
P_sludge_eff per day =	314.9	313	315.1249	315.3187	315.17	315.3746615	kg SS/d	314.8147103	2.3746615
P_total_sludge =	20427.7	20391	20403.2548	20134.0069	20402.31	20395.9494	kg SS	20359.03685	293.6931
P_total_sludge per day =	2918.2	2913	2914.7507	2876.2867	2914.62	2913.707057	kg SS/d	2908.42741	41.9133
Aeration energy =	6476	6476	6476.112	6476.112	6476.11	6476.112	kWh/d	6476.074333	0.112
Pumping energy =	2967	2967	2966.76	2966.76	2966.76	2966.76	kWh/d	2966.84	0.24
The max effluent N_tot level (18 g N/m3) was violated during:	0.1666	0.597	0.59375	0.59375	0.5938	0.5775	d	0.5204	0.4304
i.e.:	2.38	8.53	8.4821	8.4947	8.48	8.25	% of the time	7.436133333	6.15
The limit was violated at:	3	4	4	4	4	4	occasions	3.833333333	1
The max effluent S_NH level (4 g N/m3) was violated during:	4.466	4.55	4.5104	4.5104	4.5104	4.515	d	4.510366667	0.084
i.e.:	63.8	65	64.4345	64.53	64.43	64.5	% of the time	64.44908333	1.2
The limit was violated at:	6	7	7	7	7	7	occasions	6.833333333	1
The max effluent TSS level (30 g SS/m3) was violated during:	0	0.0105	0.010417	0.010417	0.0104	0.0105	d	0.008705667	0.0105
i.e.:	0	0.15	0.14881	0.149	0.15	0.15	% of the time	0.124635	0.15
The limit was violated at:	0	1	1	1	1	1	occasions	0.833333333	1