

APPENDIX A

SOURCE DATA for manuscript

Biomass Concentration as VSS per g media

C Column

		First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
FRACTION	time in cycle Port	Begin lower	Begin middle	End lower	End middle	Begin lower	Begin middle	End lower	End middle	End lower
		detached	1.96	1.87	1.83	1.60	2.30	2.14	2.63	2.44
	detachable	0.63	0.46	0.70	0.45	0.71	0.61	0.67	0.63	0.68
	strongly attached	8.20	5.85	9.90	9.70	8.65	6.10	10.00	6.90	10.30
	total	10.80	8.18	12.42	11.75	11.67	8.85	13.30	9.97	13.11

N Column

		First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
FRACTION	time in cycle Port	Begin lower	Begin middle	End lower	End middle	Begin lower	Begin middle	End lower	End middle	End lower
		detached	1.85	1.65	2.22	1.48	1.24	1.71	2.07	1.10
	detachable	0.53	0.46	0.50	0.42	0.46	0.47	0.53	0.30	0.47
	strongly attached	4.85	3.54	4.55	3.22	4.45	3.40	4.70	4.60	6.20
	total	7.23	5.65	7.28	5.12	6.15	5.58	7.31	6.01	7.77

Average VSS concentration per port and per column (see figure 1)

C column

Port	Average lower	Average middle	Error lower	Error middle
	detached	2.17	2.01	0.31
detachable	0.68	0.54	0.03	0.10
strongly attached	9.41	7.14	0.92	1.77
all biofilm	12.26	9.69	1.04	1.56

N column

Port	Average lower	Average middle	Error lower	Error middle
	detached	1.70	1.49	0.50
detachable	0.50	0.41	0.03	0.08
strongly attached	4.95	3.69	0.72	0.62
all biofilm	7.15	5.59	0.60	0.36

Average VSS concentration per port, per column along a cycle (mg VSS per g media)

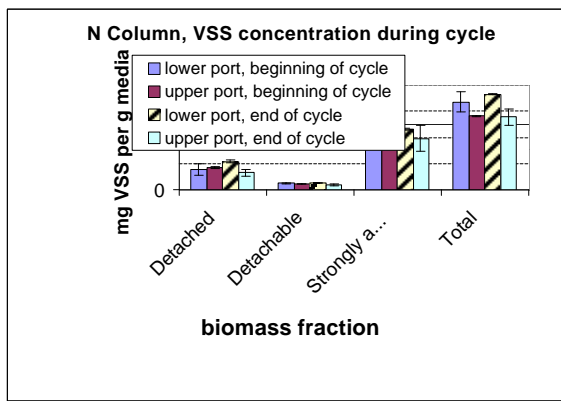
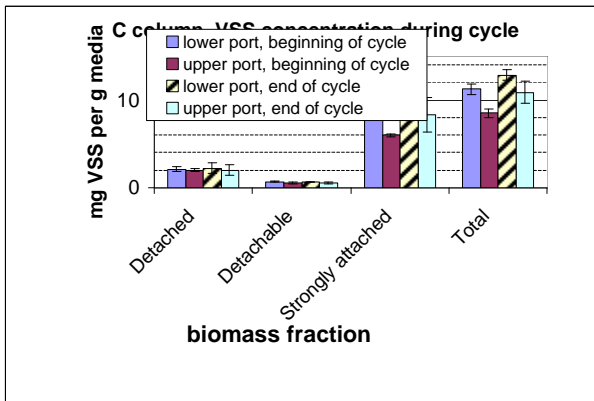
C column

		Average per port per time in cycle				Standard deviation				
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	
Port		lower	middle	lower	middle	lower	middle	lower	middle	
FRACTION	Detached	2.13	2.01	2.23	2.02	0.24	0.19	0.57	0.59	average C column
	detachable	0.67	0.53	0.68	0.54	0.06	0.11	0.02	0.13	
	strongly attached	8.43	5.98	9.95	8.30	0.32	0.18	0.07	1.98	
	Total	11.23	8.52	12.86	10.86	0.62	0.48	0.62	1.26	

N column

		Average per port per time in cycle				Standard deviation				
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	
Port		lower	middle	lower	middle	lower	middle	lower	middle	
FRACTION	Detached	1.55	1.68	2.15	1.29	0.44	0.04	0.11	0.27	average N column
	detachable	0.50	0.47	0.52	0.36	0.05	0.01	0.02	0.08	
	strongly attached	4.65	3.47	4.63	3.91	0.28	0.10	0.11	0.98	
	Total	6.69	5.62	7.29	5.57	0.76	0.05	0.02	0.62	

evolution of Biomass concentration (as VSS) during a cycle



Ratio of proteinto VSS (g BSA / g VSS)

C column

		First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	End
Port		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	Detached	0.45	0.69	0.52	0.58	0.93	0.70	0.63	0.55	0.77
	detachable	0.36	0.58	0.25	0.67	1.12	0.71	0.73	0.41	0.59
	strongly attached	1.33	1.88	1.11	0.99	1.42	2.08	1.37	1.76	1.12

N column

		First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	End
Port		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	Detached	0.61	0.69	0.43	0.59	0.65	0.34	0.58	1.06	0.78
	detachable	0.62	0.78	0.86	0.81	1.13	0.99	0.85	*	0.93
	strongly attached	0.76	0.93	0.79	1.02	1.31	1.29	1.35	1.08	0.83

* : protein data inconsistent (concentration per g media 5 times average)

average ratio Protein/VSS per port, per column (figure 2 in text).

		C column				N column			
		Average		Standard error		Average		Standard error	
Port		lower	middle	lower	middle	lower	middle	lower	middle
FRACTION	Detached	0.66	0.63	0.19	0.07	0.61	0.67	0.13	0.30
	detachable	0.61	0.59	0.34	0.13	0.88	0.86	0.19	0.11
	strongly attached	1.27	1.68	0.15	0.48	1.01	1.08	0.29	0.15

Ratio of carbohydrate to protein (g glucose / g BSA)

C column

		First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	End
Port		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	Detached	0.38	0.42	0.49	0.47	0.39	0.37	0.48	0.58	0.39
	detachable	0.40	0.40	0.55	0.44	0.22	0.28	0.24	0.56	0.48
	strongly attached	0.01	0.01	0.01	0.01	0.03	0.01	0.03	0.01	0.06
	total	0.05	0.06	0.06	0.07	0.09	0.06	0.08	0.07	0.11

N column

		First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
Time in cycle		Begin	Begin	End	End	Begin	Begin	End	End	End
Port		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	Detached	0.51	0.58	0.52	0.42	0.35	0.69	0.33	0.14	0.20
	detachable	0.36	0.46	0.26	0.34	0.23	0.36	0.34	*	0.23
	strongly attached	0.13	0.10	0.13	0.09	0.06	0.06	0.06	0.08	0.11
	total	0.23	0.24	0.21	0.17	0.11	0.15	0.12	0.07	0.13

* : protein data inconsistent (5 times average, on a per g media basis)

Average ratio carbohydrate/protein per port, per column (Figure 3 in text)

		C column				N column			
		average		standard error		average		standard error	
port		lower	middle	lower	middle	lower	middle	lower	middle
FRACTION	detached	0.42	0.46	0.06	0.09	0.38	0.46	0.13	0.24
	detachable	0.38	0.42	0.14	0.11	0.28	0.39	0.06	0.06
	strongly attached	0.03	0.01	0.02	0.00	0.10	0.08	0.03	0.02
	all biofilm	0.08	0.07	0.03	0.01	0.16	0.16	0.06	0.07

Specific Oxygen Uptake Rate (mg O₂ / min / g protein).

C column

		First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
time in cycle	port	Begin	Begin	End	End	Begin	Begin	End	End	End
		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	detached	1.14	0.70	1.34	0.85	0.88	0.75	1.98	1.39	0.98
	detachable	1.79	1.40	2.34	1.25	1.01	0.91	2.08	1.45	-
	strongly attached	0.38	0.24	0.37	0.29	0.46	0.19	0.30	0.05	-

bold italic : data inconsistent, discarded

N column

		First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
time in cycle	port	Begin	Begin	End	End	Begin	Begin	End	End	End
		lower	middle	lower	middle	lower	middle	lower	middle	lower
FRACTION	detached	0.74	0.48	0.86	0.45	1.40	0.42	1.19	0.58	1.12
	detachable	0.81	0.58	1.34	0.69	1.42	0.39	1.55	0.71	1.29
	strongly attached	0.57	1.19	0.64	0.78	0.53	0.58	0.54	0.24	0.81

Average Specific Oxygen Uptake Rate, per port and per column (figure 4 in text)

		C column				N column			
		average		standard error		average		standard error	
port		lower	middle	lower	middle	lower	middle	lower	middle
FRACTION	detached	1.26	0.92	0.44	0.32	1.06	0.48	0.26	0.07
	detachable	1.80	1.25	0.58	0.24	1.28	0.59	0.28	0.15
	strongly attached	0.38	0.24	0.07	0.05	0.62	0.70	0.12	0.40

Effects of spiking on Specific Oxygen Uptake RateUnits for SOUR are mg O₂ / min / protein

C column	time in cycle port	First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
		Begin	Begin	End	End	Begin	Begin	End	End	End
		lower	middle	lower	middle	lower	middle	lower	middle	lower
unspiked	detached	1.14	0.70	1.34	0.85	0.88	0.75	1.98	1.39	0.98
	detachable	1.79	1.40	2.34	1.25	1.01	0.91	2.08	1.45	
	strongly attached	0.38	0.24	0.37	0.29	0.46	0.19	0.30	0.05	
COD spike	detached	1.89	0.91	1.79	1.24	0.91	0.89	1.89	1.24	1.38
	detachable	2.81	1.63	3.34	1.75	1.03	1.14	1.53	1.72	2.29
	strongly attached	0.36	0.26	0.42	0.38	0.30	0.21	0.20	0.17	0.16
Ratio C- Spike / Unspiked	detached	1.65	1.31	1.34	1.46	1.04	1.18	0.95	0.89	1.41
	detachable	1.57	1.16	1.43	1.40	1.02	1.25	0.74	1.19	
	strongly attached	0.93	1.05	1.12	1.30	0.65	1.07	0.65	3.59	

*In bold italic : data out of normal range (discarded when calculating average)***Average ratio COD-spike / unspiked per port for the C column**

port	average		standard error	
	lower	middle	lower	middle
detached	1.28	1.21	0.29	0.24
detachable	1.19	1.25	0.38	0.11
strongly attached	0.84	1.14	0.23	0.14

N column	time in cycle port	First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
		Begin	Begin	End	End	Begin	Begin	End	End	End
		N1 beg	N3 beg	N1 end	N3 end	N1 beg	N3 beg	N1 end	N3 end	N1 end
unspiked	detached	1.21	0.69	2.01	0.76	2.15	1.24	2.07	0.55	1.44
	detachable	1.32	0.73	1.56	0.85	1.25	0.40	1.82		1.38
	strongly attached	0.75	1.28	0.81	0.76	0.41	0.45	0.40	0.22	0.98
Ammonia Spike	detached	1.36	0.75	2.03	0.68	2.14	1.32	2.05	0.55	1.51
	detachable	1.29	0.86	1.72	0.77	1.13	0.41	1.90	0.10	
	strongly attached	0.75	0.72	0.75	0.76	0.38	0.44	0.38	0.26	
COD + Ammonia spike	detached	*	*	2.32	0.78	2.23	1.51	2.13	0.64	1.62
	detachable	*	*	1.73	0.83	1.10	0.54	1.99	0.10	1.39
	strongly attached	*	*	0.75	0.77	0.36	0.43	0.57	0.26	
ratio Ammonia spike / unspiked	detached	1.13	1.09	1.01	0.89	0.99	1.06	0.99	1.02	1.05
	detachable	0.98	1.17	1.10	0.91	0.90	1.03	1.05		
	strongly attached	1.00	0.56	0.92	0.99	0.93	0.97	0.95	1.14	
ratio COD spike / unspiked	detached			1.15	1.02	1.04	1.22	1.03	1.17	1.13
	detachable			1.11	0.97	0.88	1.36	1.09		1.01
	strongly attached			0.93	1.01	0.88	0.94	1.43	1.16	

* : COD spike too acidic, inhibition of activity

Percentage of activity per volume of reactor

C column : specific oxygen uptake rate, unspiked, mg O₂ / min / g media

time in cycle	First test (10/20/98)				Second test (10/24/98)				3rd test (11/11/98)
	Begin	Begin	End	End	Begin	Begin	End	End	End
	lower	middle	lower	middle	lower	middle	lower	middle	lower
Detached	1.00E-03	9.00E-04	1.28E-03	7.94E-04	1.89E-03	1.12E-03	3.31E-03	1.87E-03	1.60E-03
detachable	4.12E-04	3.71E-04	4.07E-04	3.73E-04	8.05E-04	3.93E-04	1.03E-03	3.76E-04	
strongly attached	4.18E-03	2.68E-03	4.09E-03	2.78E-03	5.64E-03	2.47E-03	4.12E-03	6.E-04	
all biofilm	5.60E-03	3.95E-03	5.78E-03	3.95E-03	8.33E-03	3.98E-03	8.45E-03	2.81E-03	

Data SOUR too low, discarded.

N column : specific oxygen uptake rate, unspiked, mg O₂ / min / g media

time in cycle Port	First test(10/11/98)				Second test (10/28/98)				3rd test (11/10/98)
	Begin	Begin	End	End	Begin	Begin	End	End	End
	lower	middle	lower	middle	lower	middle	lower	middle	lower
Detached	1.38E-03	7.86E-04	1.91E-03	6.65E-04	1.74E-03	7.23E-04	2.47E-03	6.39E-04	1.23E-03
detachable	4.31E-04	2.65E-04	6.71E-04	2.91E-04	6.58E-04	1.84E-04	8.22E-04	2.16E-04	6.01E-04
strongly attached	2.76E-03	4.21E-03	2.92E-03	2.52E-03	2.36E-03	1.98E-03	2.52E-03	1.11E-03	5.03E-03
all biofilm	4.57E-03	5.26E-03	5.50E-03	3.48E-03	4.76E-03	2.89E-03	5.81E-03	1.97E-03	6.86E-03

Percentage of activity, based on SOUR per g media

time in cycle Port		First test				Second test				3rd test
		Begin	Begin	End	End	Begin	Begin	End	End	End
		lower	middle	lower	middle	lower	middle	lower	middle	lower
C column	Detached	17.91%	22.76%	22.16%	20.10%	22.65%	28.16%	39.13%	66.56%	
	detachable	7.35%	9.39%	7.05%	9.45%	9.67%	9.87%	12.15%	13.37%	
	strongly attached	74.74%	67.85%	70.80%	70.45%	67.68%	61.97%	48.72%	20.07%	
	detached+ detachable	25.26%	32.15%	29.20%	29.55%	32.32%	38.03%	51.28%		
N column	Detached	30.15%	14.94%	34.76%	19.11%	36.51%	25.03%	42.56%	32.49%	17.94%
	detachable	9.43%	5.04%	12.20%	8.37%	13.84%	6.35%	14.14%	11.01%	8.76%
	strongly attached	60.42%	80.02%	53.03%	72.52%	49.64%	68.62%	43.30%	56.50%	73.29%
	detached+ detachable	39.58%	19.98%	46.97%	27.48%	50.36%	31.38%	56.70%	43.50%	26.71%

bold italic : data SOUR on strongly attached too low, points are discarded

Percentage activity, average per port and per column (figure 5 in text).

C column

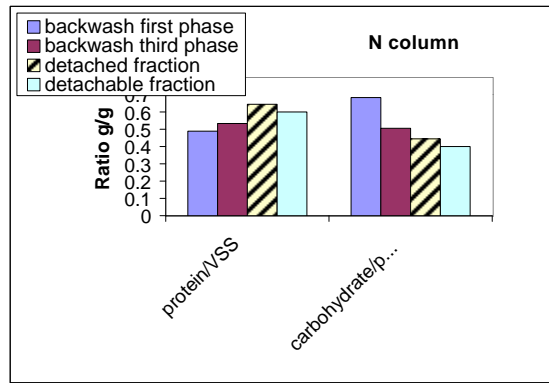
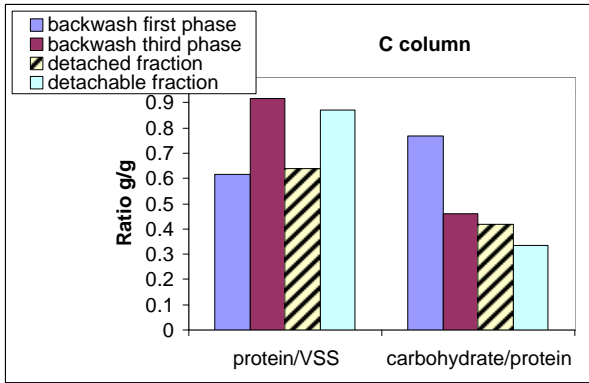
port	average		variation	
	lower	lower	middle	middle
strongly attached	65.48%	66.76%	11.54%	4.35%
detached+ detachable	34.52%	33.24%	11.54%	4.35%

N column

port	average		variation	
	lower	lower	middle	middle
strongly attached	55.94%	69.42%	11.50%	9.82%
detached+ detachable	44.06%	30.58%	11.50%	9.82%

Comparison solids backwashed to detached - detachable fractions

		N column				C column			
		backwash sample		biomass fraction		backwash sample		biomass fraction	
ratio	protein/VSS	BW1	BW3	detached	detachable	BW1	BW3	detached	detachable
		carbohydrate/protein	0.77	0.46	0.42	0.34	0.68	0.50	0.44



Example of recovery after backwash (backwash C2), figure 6 in text

		min	gpm	l/min	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Sample		duration composite	Flow	Flow	SS	VSS	COD total	COD soluble	cBOD5 total	cBOD5 soluble
COMPOSITE	Influent	615.0	12.0	45.4	81.0	64.0	301.0	183.0	76.0	47.0
	Effluent backwash water (N-effluent)	615.0	12.0	45.4	81.0	64.0	206.0	114.0	25.0	11.0
BACKWASH	BW1	2.8	20.0	75.7	933.0	684.0	1237.0	138.0	339.0	
	BW2	4.3	20.0	75.7	961.0	746.0	1315.0	144.0	360.0	
	BW3	13.9	20.0	75.7	588.0	462.0	827.0	108.0	159.0	
	Water-to-Waste	19.9	12.0	45.4	196.0	151.0	304.0	82.0	45.0	5.6
OPERATION	operation sample 1	15.0	12.0	45.4	84.0	68.0	194.0	83.0	34.0	
	operation sample 2	6.0	12.0	45.4	54.0	44.0	184.0	87.0	26.0	

Mass balance on VSS during backwash (results quoted in Table 1 in text)

		Backwash C column (5/5/98)				Backwash N Column (8/23/98)			
		Flow l/min	duration of composite (min)	VSS mg/l	total (g VSS) in or out of column	Flow l/min	duration of composite (min)	VSS mg/l	total (g VSS) in or out of column
COMPOSITE	Influent	41.6	656.0	35.4	967.7	39.7	1272.0	20.2	1018.7
	Effluent backwash water (N-effluent)	41.6	656.0	10.4	284.1	39.7	1272.0	10.7	538.4
						7.1			
BACKWASH	BW1	94.6	3.5	771.4	255.5	94.6	4.5	134.0	54.0
	BW2	94.6	4.5	738.0	314.3	94.6	4.0	526.5	196.6
	BW3	94.6	19.0	312.2	561.4	94.6	18.7	295.8	510.0
	Water-to-Waste	41.6	10.0	107.5	44.8	39.7	19.0	82.7	54.4
OPERATION	operation sample 1					39.7	15.0	38.8	16.8
	operation sample 2					39.7	4.0	27.3	2.6
		total flushed by backwash -----> 1176.0 (g VSS)				total flushed by backwash ----- 815.0 (g VSS)			

		Backwash C Column (9/9/98)				Backwash C Column (9/22/98)			
		Flow l/min	duration of composite (min)	VSS mg/l	total (g VSS) in or out of column	Flow l/min	duration of composite (min)	VSS mg/l	total (g VSS) in or out of column
COMPOSITE	Influent	45.4	595.0	52.2	1410.6	45.4	615.0	64.0	1787.9
	Effluent water (N-effluent)	45.4	595.0	38.2	1032.5	45.4	615.0	64.0	1787.9
		7.4				3.8			
BACKWASH	BW1	94.6	3.2	594.1	178.0	75.7	2.8	684.0	142.4
	BW2	94.6	4.5	658.9	280.6	75.7	4.3	746.0	244.7
	BW3	94.6	19.1	246.1	444.4	75.7	13.9	462.0	485.6
	Water-to-Waste	45.4	20.2	75.5	69.2	45.4	19.9	151.0	136.4
OPERATION	operation sample 1	45.4	14.0	38.3	24.4	45.4	15.0	68.0	46.3
	operation sample 2	45.4	3.3	29.8	4.5	45.4	6.0	44.0	12.0
		total flushed by backwash -----> 972.2 (g VSS)				total flushed by backwash ----- 1009.1 (g VSS)			

APPENDIX B

RESULTS FROM TESTS ON BIOMASS FRACTIONS

Test on N column, 10/28/98**Performance of system**

type of sample	time in cycle	port	COD		cBOD		SS	VSS	Ammonia
			total	soluble	total	soluble			
composite	-	C-effluent	112	88	15.5	9.6	19	14	19.6
composite	-	N-effluent	76	59	7.7	3.4	11	8.8	2.9
grab	begin	C-effluent		103					15
grab	end	C-effluent		102					16
dilution liquid	begin	lower		81					12.8
dilution liquid	begin	middle		64					10.3
dilution liquid	end	lower		86.5					15.9
dilution liquid	end	middle		64					10.9

"begin of cycle" : 30 minutes after backwash

"end of cycle" : 1274 minutes after backwash

Specific Oxygen Uptake Rate (mg O₂ / min / l)

SOUR are conducted in BOD bottle (300ml)

time in cycle	Port	fraction	Spike	SOUR	R2	temperature
begin	lower	dilution liquid	none	3.00E-04	0.675	17.7
begin	lower	dilution liquid	ammonia	9.50E-03	0.937	17.7
begin	lower	dilution liquid	COD	1.30E-02	0.975	17.7
begin	lower	detached	none	1.98E-01	0.999	17.8
begin	lower	detached	ammonia	2.06E-01	1.000	17.8
begin	lower	detached	COD	2.18E-01	1.000	17.9
begin	lower	detachable	none	7.53E-02	0.999	18.1
begin	lower	detachable	ammonia	7.73E-02	0.997	18.1
begin	lower	detachable	COD	7.87E-02	0.999	18.1
begin	lower	attached	none	1.19E-01	0.999	18.0
begin	lower	attached	ammonia	1.20E-01	1.000	17.7
begin	lower	attached	COD	1.17E-01	1.000	17.7
begin	middle	dilution liquid	none	5.70E-03	0.714	16.9
begin	middle	dilution liquid	ammonia	7.50E-03	0.939	16.8
begin	middle	dilution liquid	COD	8.00E-03	0.939	17.0
begin	middle	detached	none	9.00E-02	0.999	17.1
begin	middle	detached	ammonia	9.71E-02	1.000	17.0
begin	middle	detached	COD	1.11E-01	1.000	17.2
begin	middle	detachable	none	2.71E-02	0.992	17.5
begin	middle	detachable	ammonia	2.95E-02	0.995	17.6
begin	middle	detachable	COD	3.70E-02	0.996	17.6
begin	middle	attached	none	1.23E-01	0.995	17.7
begin	middle	attached	ammonia	1.21E-01	0.999	17.6
begin	middle	attached	COD	1.19E-01	0.999	17.7
end	lower	dilution liquid	none	5.70E-03	0.892	19.3
end	lower	dilution liquid	ammonia	4.80E-03	0.905	19.1
end	lower	dilution liquid	COD	9.30E-03	0.917	19.0
end	lower	detached	none	3.78E-01	1.000	19.1
end	lower	detached	ammonia	3.74E-01	1.000	19.0
end	lower	detached	COD	3.92E-01	1.000	19.1
end	lower	detachable	none	1.29E-01	1.000	19.2
end	lower	detachable	ammonia	1.34E-01	0.999	19.1
end	lower	detachable	COD	1.44E-01	1.000	18.9
end	lower	attached	none	1.30E-01	1.000	18.9
end	lower	attached	ammonia	1.24E-01	0.998	18.9
end	lower	attached	COD	1.87E-01	0.993	18.8

Test on N column (11/28/98) continued

Specific Oxygen Uptake Rate (mg O₂ / min / l) (continued)

	time in cycle	Port	fraction	Spike	SOUR	R2	temperature
	end	middle	dilution liquid	none	6.00E-03	0.750	17.5
	end	middle	dilution liquid	ammonia	1.70E-03	0.583	17.4
	end	middle	dilution liquid	COD	5.10E-03	0.835	17.4
	end	middle	detached	none	8.36E-02	0.997	17.8
	end	middle	detached	ammonia	8.05E-02	0.998	17.8
	end	middle	detached	COD	9.60E-02	0.998	17.8
	end	middle	detachable	none	3.23E-02	0.975	17.9
	end	middle	detachable	ammonia	2.83E-02	0.987	17.9
	end	middle	detachable	COD	3.19E-02	0.994	17.9
	end	middle	attached	none	8.48E-02	0.998	17.8
	end	middle	attached	ammonia	9.18E-02	0.999	17.6
	end	middle	attached	COD	9.67E-02	1.000	17.5
sample with column running	begin	lower	dilution liquid	none	1.20E-01	0.998	16.7
	begin	lower	dilution liquid	ammonia	1.27E-01	1.000	16.5
	begin	lower	dilution liquid	COD	1.37E-01	1.000	16.6
	begin	lower	detached	none	4.86E-02	0.998	17.6
	begin	lower	detached	ammonia	5.29E-02	0.999	17.8
	begin	lower	detached	COD	5.87E-02	0.997	17.8
	begin	lower	detachable	none	7.75E-02	0.999	18.2
	begin	lower	detachable	ammonia			
	begin	lower	detachable	COD			
	begin	lower	attached	none	2.03E-01	1.000	18.4

temperature of water at top of n column 19.0

mass of media used in tests

time in cycle	port	mass of media used (g)	
		"strongly attached"	"detached and detachable"
begin	lower	15.06	56.96
begin	middle	17.81	58.29
begin, column running	lower	18.902	94.842
end	lower	14.83	75.2
end	middle	21.28	60.75

-----> 420 ml of liquid and 239g of media were collected during this sample

"strongly attached" : mass of media used in SOUR test for strongly attached fraction

"detached or detachable" : mass of media used to collect these fractions

"column running" : sample taken while column is still running. Liquid spraying out of the sampler is collected

Test on N column (11/28/98) continued

VSS and SS measurement

		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
time in cycle	Port	liquid	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	9.1	150	62	4.45	13	581	141
Begin	middle	6.3	206	61	3.4	7.7	1548	244
begin, column running	lower	120	85	42	7.6	244	101	56
end	lower	14	326	94	4.7	19	1190	267
end	middle	5.1	139	42	4.6	8.6	987	165

VSS and SS corrected for the use of dilution liquid.

		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
time in cycle	Port	liquid (**)	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	9.1	140.9	52.9	4.45	13	568	128
Begin	middle	6.3	199.7	54.7	3.4	7.7	1540.3	236.3
begin, column running (*)	lower	230.9	75.9	32.9	7.6	475	88	43
end	lower	14	312	80	4.7	19	1171	248
end	middle	5.1	133.9	36.9	4.6	8.6	978.4	156.4

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Protein concentration

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower	66	158	126	5.81
Begin	middle	44	112	98	4.38
begin, column running	lower	134	106	88	6.82
end	lower	56	236	124	6.34
end	middle	34	176	306	4.96

Protein corrected for the use of dilution liquid.

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower	66	92	60	5.81
Begin	middle	44	68	54	4.38
begin, column running (*)	lower	202	40	22	6.82
end	lower	56	180	68	6.34
end	middle	34	142	272	4.96

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on N column (11/28/98) *continued***Carbohydrates**

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid	detached	detachable	strongly attached
Begin	lower	22	54	36	0.36
Begin	middle	13	60	32.5	0.26
begin, column running	lower	52	32	43	0.46
end	lower	21	80	44	0.41
end	middle	17.5	37	20	0.4

Carbohydrate corrected for the use of dilution liquid.

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid (**)	detached	detachable	strongly attached
Begin	lower	22	32	14	0.36
Begin	middle	13	47	19.5	0.26
begin, column running (*)	lower	82	10	21	0.46
end	lower	21	59	23	0.41
end	middle	17.5	19.5	2.5	0.4

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid"), same level as media sample

Test on N column, 10/11/98

Performance of system

type of sample	time in cycle	port	COD	Ammonia
			soluble	
composite grab	-	C-effluent	88	
	end	C-effluent		14
dilution liquid	begin	lower		12.4
dilution liquid	end	lower		13.8
dilution liquid	end	middle		5.4

"begin of cycle" : 70 minutes after backwash

"end of cycle" : 1260 minutes after backwash

Specific Oxygen Uptake Rate (mg O2 / min / l)

SOUR are conducted in BOD bottle (300ml)

COD spike for sample at beginning of cycle was too acidic (result bias)

"upper port" is above the middle port in the column

time in cycle	Port	fraction	Spike	SOUR	R2	temperature
begin	lower	dilution liquid	none	8.70E-03	0.939	19.5
begin	lower	dilution liquid	ammonia	8.60E-03	0.900	19.7
begin	lower	dilution liquid	COD			
begin	lower	detached	none	1.56E-01	0.997	19.6
begin	lower	detached	ammonia	1.75E-01	1.000	19.6
begin	lower	detached	COD			
begin	lower	detachable	none	5.49E-02	0.997	19.5
begin	lower	detachable	ammonia	5.39E-02	0.999	19.0
begin	lower	detachable	COD			
begin	lower	attached	none	8.81E-02	0.996	18.9
begin	lower	attached	ammonia	8.79E-02	0.999	19.1
begin	lower	attached	COD			
begin	middle	dilution liquid	none	2.10E-03	0.619	19.4
begin	middle	dilution liquid	ammonia	2.90E-03	0.571	19.4
begin	middle	dilution liquid	COD	4.50E-03	0.847	19.5
begin	middle	detached	none	8.48E-02	0.996	20.1
begin	middle	detached	ammonia	9.33E-02	1.000	20.1
begin	middle	detached	COD	4.30E-02	0.997	20.2
begin	middle	detachable	none	3.00E-02	0.991	20.1
begin	middle	detachable	ammonia	3.55E-02	0.997	20.0
begin	middle	detachable	COD	2.88E-02	0.996	20.2
begin	middle	attached	none	1.49E-01	0.977	19.9
begin	middle	attached	ammonia	8.59E-02	0.994	20.1
begin	middle	attached	COD	6.48E-02	0.994	20.2
begin	upper	dilution liquid	none	0.00E+00	1.000	
begin	upper	dilution liquid	ammonia	3.70E-03	0.698	
begin	upper	dilution liquid	COD	5.60E-03	0.802	20.7
begin	upper	detached	none	7.40E-02	0.999	20.7
begin	upper	detached	ammonia	7.26E-02	0.999	20.8
begin	upper	detached	COD	4.30E-02	0.998	20.8
begin	upper	detachable	none	2.80E-02	0.995	20.9
begin	upper	detachable	ammonia	2.74E-02	0.995	21.0
begin	upper	detachable	COD	1.36E-02	0.960	21.1
begin	upper	attached	none	6.17E-02	0.999	21.1
begin	upper	attached	ammonia	5.87E-02	0.997	21.2
begin	upper	attached	COD	4.81E-02	0.993	21.2

italic : COD spike was too acidic

Test on N column, 10/11/98 (continued)**Specific Oxygen Uptake Rate (mg O₂ / min / l) (continued)**

time in cycle	Port	fraction	Spike	SOUR	R2	temperature
end	lower	dilution liquid	none	0.00E+00	1.000	19.5
end	lower	dilution liquid	ammonia	4.90E-03	0.860	
end	lower	dilution liquid	COD	8.80E-03	0.954	19.7
end	lower	detached	none	1.95E-01	0.999	19.8
end	lower	detached	ammonia	2.02E-01	1.000	19.8
end	lower	detached	COD	2.34E-01	1.000	19.8
end	lower	detachable	none	6.86E-02	0.996	20.3
end	lower	detachable	ammonia	8.04E-02	0.999	20.5
end	lower	detachable	COD	8.50E-02	0.999	20.7
end	lower	attached	none	1.36E-01	0.999	
end	lower	attached	ammonia	1.30E-01	0.998	21.1
end	lower	attached	COD	1.35E-01	0.999	21.1
end	middle	dilution liquid	none	0.00E+00	1.000	19.1
end	middle	dilution liquid	ammonia	5.10E-03	0.901	19.6
end	middle	dilution liquid	COD	5.50E-03	0.889	19.8
end	middle	detached	none	5.64E-02	0.999	19.4
end	middle	detached	ammonia	5.53E-02	0.999	
end	middle	detached	COD	6.33E-02	1.000	
end	middle	detachable	none	2.47E-02	0.990	20.3
end	middle	detachable	ammonia	2.75E-02	0.995	20.4
end	middle	detachable	COD	2.95E-02	0.999	20.5
end	middle	attached	none	1.08E-01	0.996	
end	middle	attached	ammonia	1.12E-01	0.997	20.7
end	middle	attached	COD	1.14E-01	0.998	20.9

temperature of water at top of n column 20.6

mass of media used in tests

time in cycle	port	mass of media used (g)	
		"strongly attached"	"detached and detachable"
begin	lower	8.63	53.63
begin	middle	10.48	52.59
begin	upper	9.58	64.13
end	lower	13.93	51.08
end	middle	12.82	42.42

"strongly attached" : mass of media used in SOUR test for strongly attached fraction

"detached or detachable" : mass of media used to collect these fractions

Test on N column, 10/11/98 (continued)**VSS and SS measurement**

time in cycle	Port	VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid	detached	detachable	strongly attached	liquid	detached	detachable
begin	lower	8.2	207	65	4.85	10	829	187
begin	middle	9.5	183	58	3.54	11	1440	269
begin	upper	9.5	156	44	3.44	13.5	1380	360
end	lower	7.8	235	59	4.55	7	845	166
end	middle	7.2	133	43	3.22	6.7	1010	206

VSS and SS corrected for the use of dilution liquid.

time in cycle	Port	VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid (**)	detached	detachable	strongly attached	liquid	detached	detachable
begin	lower	8.2	198.8	56.8	4.85	10	819	177
begin	middle	9.5	173.5	48.5	3.54	11	1429	258
begin	upper	9.5	146.5	34.5	3.44	13.5	1366.5	346.5
end	lower	7.8	227.2	51.2	4.55	7	838	159
end	middle	7.2	125.8	35.8	3.22	6.7	1003.3	199.3

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Protein concentration

time in cycle	Port	Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid	detached	detachable	strongly attached
begin	lower	49	171	84	3.7
begin	middle	37	157	75	3.3
begin	upper	26	92	67	3.4
end	lower	39	136	83	3.6
end	middle	22	96	51	3.3

Protein corrected for the use of dilution liquid.

time in cycle	Port	Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid (**)	detached	detachable	strongly attached
begin	lower	49	122	35	3.7
begin	middle	37	120	38	3.3
begin	upper	26	66	41	3.4
end	lower	39	97	44	3.6
end	middle	22	74	29	3.3

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on N column, 10/11/98 (continued)**Carbohydrates**

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid	detached	detachable	strongly attached
begin	lower	26	88	38.5	0.48
begin	middle	21	90	38.5	0.32
begin	upper	21	69	42	0.32
end	lower	26	76	37.5	0.46
end	middle	27	58	37	0.3

carbohydrate corrected for the use of dilution liquid.

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid (**)	detached	detachable	strongly attached
begin	lower	26	62	12.5	0.48
begin	middle	21	69	17.5	0.32
begin	upper	21	48	21	0.32
end	lower	26	50	11.5	0.46
end	middle	27	31	10	0.3

(**) liquid collected a liquid port ("dilution liquid"), same level as media sample

Test on C column, 10/20/98

Performance of system

type of sample	time in cycle	port	COD		cBOD		SS	VSS
			total	soluble	total	soluble		
composite	-	Influent	295.5	168	64	19	73	65
composite	-	C-effluent	131.5	105	12	7.4	16	15
grab	begin	Influent		150			67.5	50.5
grab	end	Influent		162			73	62
dilution liquid	begin	lower		131				
dilution liquid	begin	middle		123				
dilution liquid	end	lower		157.5				
dilution liquid	end	middle		133.5				

"begin of cycle" : 15 minutes after backwash, "end of cycle" : 440 minutes after backwash

Specific Oxygen Uptake Rate (mg O2 / min / l)

SOUR are conducted in BOD bottle (300ml)

	time in cycle	Port	fraction	Spike	SOUR	R2	temperature
	begin	lower	dilution liquid	none	8.64E-02	0.999	18.6
	begin	lower	dilution liquid	COD	1.69E-01	1.000	19.0
	begin	lower	detached	none	2.17E-01	0.999	19.3
	begin	lower	detached	COD	3.85E-01	0.999	19.7
	begin	lower	detachable	none	1.40E-01	1.000	19.4
	begin	lower	detachable	COD	2.54E-01	1.000	19.3
	begin	lower	attached	none	2.29E-01	0.997	19.6
	begin	lower	attached	COD	3.01E-01	1.000	19.7
	begin	middle	dilution liquid	none	4.00E-02	1.000	16.9
	begin	middle	dilution liquid	COD	6.71E-02	0.999	17.8
	begin	middle	detached	none	1.42E-01	0.999	18.0
	begin	middle	detached	COD	2.01E-01	1.000	18.4
	begin	middle	detachable	none	8.21E-02	0.997	19.2
	begin	middle	detachable	COD	1.16E-01	0.999	19.1
	begin	middle	attached	none	1.49E-01	0.997	18.9
	begin	middle	attached	COD	1.82E-01	0.999	18.6
	end	lower	dilution liquid	none	9.09E-02	0.999	19.4
	end	lower	dilution liquid	COD	1.81E-01	0.999	19.4
	end	lower	detached	none	2.38E-01	0.999	19.3
	end	lower	detached	COD	3.78E-01	1.000	19.3
	end	lower	detachable	none	1.38E-01	0.995	19.2
	end	lower	detachable	COD	2.47E-01	1.000	19.1
	end	lower	attached	none	2.33E-01	0.999	18.9
	end	lower	attached	COD	3.40E-01	1.000	18.6
	end	middle	dilution liquid	none	4.60E-02	0.999	18.3
	end	middle	dilution liquid	COD	6.00E-02	1.000	18.2
	end	middle	detached	none	1.36E-01	1.000	18.2
	end	middle	detached	COD	1.92E-01	1.000	18.2
	end	middle	detachable	none	8.85E-02	0.999	18.5
	end	middle	detachable	COD	1.20E-01	0.999	18.7
	end	middle	attached	none	1.44E-01	0.999	18.6
	end	middle	attached	COD	1.88E-01	1.000	18.7
sample with column running	begin	lower	dilution liquid	none	4.44E-01	1.000	18.2
	begin	lower	dilution liquid	COD	1.02E+00	1.000	18.1
	begin	lower	detached	none	1.37E-01	0.997	18.4
	begin	lower	detached	COD	2.34E-01	0.999	18.5
	begin	lower	detachable	none	1.40E-01	0.999	18.6
	begin	lower	detachable	COD	2.33E-01	1.000	19.1
	begin	lower	attached	none	2.03E-01	0.998	19.0
	begin	lower	attached	COD	2.87E-01	0.999	18.8

temperature of water at top of n column ----->

19.2

Test on C column, 10/20/98 (continued)

mass of media used in tests

time in cycle port		mass of media used (g)	
		"strongly attached"	"detached and detachable"
begin	lower	10.2	65.12
begin	middle	12.22	56.67
end, column running	lower	13.89	71.92
end	lower	10.43	57.45
end	middle	10.55	56.92

-----> 250 ml of liquid and 174g of media were collected during this sampling.

"strongly attached" : mass of media used in SOUR test for strongly attached fraction
 "detached or detachable" : mass of media used to collect these fractions
 "column running" : sample taken while column is still running. Liquid spraying out of the sampler is collected.

VSS and SS measurement

time in cycle Port		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	70.5	326	153	8.2	87	1070	358
Begin	middle	14	226	66	5.85	16	1418	340
end	lower	62	272	142	9.9	74	726	268
end	middle	21	203	72	10.9	24	955	260
end, column running	middle	959	132	122	9.7	1385	173	148

VSS and SS corrected for the use of dilution liquid.

time in cycle Port		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid (**)	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	70.5	255.5	82.5	8.2	87	983	271
Begin	middle	14	212	52	5.85	16	1402	324
end	lower	62	210	80	9.9	74	652	194
end	middle	21	182	51	10.9	24	931	236
end, column running	middle	1856	70	60	9.7	2696	99	74

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.
 (**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on C column, 10/20/98 (continued)**Protein concentration**

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower	128	242	158	10.9
Begin	middle	86	232	116	11
end	lower	148	258	168	11
end	middle	90	196	124	9.6
end, column running	middle	606	160	156	11.1

Protein corrected for the use of dilution liquid.

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower	128	114	30	10.9
Begin	middle	86	146	30	11
end	lower	148	110	20	11
end	middle	90	106	34	9.6
end, column running	middle	1064	12	8	11.1

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid"), same level as media sample

Carbohydrates

		Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower	21	64	33	0.13
Begin	middle	15	76	27	0.14
end	lower	29	83	40	0.16
end	middle	16	66	31	0.135
end, column running	middle	178	52	33	0.155

Carbohydrate corrected for the use of dilution liquid.

		Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower	21	43	12	0.13
Begin	middle	15	61	12	0.14
end	lower	29	54	11	0.16
end	middle	16	50	15	0.135
end, column running	middle	327	23	4	0.155

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid"), same level as media sample

Test on C column, 10/24/98

Performance of system

type of sample	time in cycle	port	COD		cBOD		SS	VSS
			total	soluble	total	soluble		
composite	-	Influent	245	140	61	29	63	56
composite	-	C-effluent	127	92	14	6.1		
grab	begin	Influent		210				
grab	end	Influent		142			22	19
dilution liquid	begin	lower		183				
dilution liquid	begin	middle		169				
dilution liquid	end	lower		127				
dilution liquid	end	middle		130				

"begin of cycle" : 40 minutes after backwash

"end of cycle" : 480 minutes after backwash

Specific Oxygen Uptake Rate (mg O₂ / min / l)

SOUR are conducted in BOD bottle (300ml)

time in cycle	Port	fraction	Spike	SOUR	R2	temperature
begin	lower	dilution liquid	none	1.15E-01	1.000	17.9
begin	lower	dilution liquid	COD	1.26E-01	1.000	18.1
begin	lower	detached	none	3.96E-01	1.000	18.1
begin	lower	detached	COD	4.19E-01	1.000	18.3
begin	lower	detachable	none	2.35E-01	1.000	18.5
begin	lower	detachable	COD	2.48E-01	1.000	18.4
begin	lower	attached	none	3.26E-01	0.995	18.1
begin	lower	attached	COD	2.64E-01	0.999	18.1
begin	middle	dilution liquid	none	6.37E-02	0.999	17.1
begin	middle	dilution liquid	COD	6.06E-02	0.996	17.3
begin	middle	detached	none	2.20E-01	1.000	17.1
begin	middle	detached	COD	2.45E-01	1.000	17.1
begin	middle	detachable	none	1.19E-01	0.999	17.7
begin	middle	detachable	COD	1.29E-01	1.000	17.7
begin	middle	attached	none	1.43E-01	0.997	17.5
begin	middle	attached	COD	1.45E-01	0.993	17.5
end	lower	dilution liquid	none	1.81E-01	0.998	18.6
end	lower	dilution liquid	COD	2.20E-01	0.996	18.3
end	lower	detached	none	5.70E-01	1.000	18.9
end	lower	detached	COD	5.90E-01	1.000	18.9
end	lower	detachable	none	3.02E-01	1.000	18.7
end	lower	detachable	COD	3.09E-01	1.000	18.8
end	lower	attached	none	3.04E-01	0.999	18.8
end	lower	attached	COD	3.00E-01	1.000	18.9
end	middle	dilution liquid	none	1.32E-01	0.997	19.4
end	middle	dilution liquid	COD	9.17E-02	0.999	19.2
end	middle	detached	none	3.12E-01	0.998	19.0
end	middle	detached	COD	2.52E-01	1.000	19.0
end	middle	detachable	none	1.68E-01	1.000	19.1
end	middle	detachable	COD	1.35E-01	0.999	19.1
end	middle	attached	none	1.48E-01	0.998	18.9
end	middle	attached	COD	1.49E-01	1.000	18.7

temperature of water at top of n column ----->

19.0

Test on C column, 10/24/98 (continued)

mass of media used in tests

time in cycle port		mass of media used (g)	
		"strongly attached"	"detached and detachable"
begin	lower	11.23	74.52
begin	middle	9.63	69.75
end	lower	8.92	58.73
end	middle	8.46	48.19

"strongly attached" : mass of media used in SOUR test for strongly attached fraction

"detached or detachable" : mass of media used to collect these fractions

"column running" : sample taken while column is still running. Liquid spraying out of the sampler is collected

VSS and SS measurement

time in cycle Port		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	42.5	386	149	8.65	48.5	1394	326
Begin	middle	19	318	104	6.1	23	1214	254
end	lower	83	392	162	10	100	1074	314
end	middle	13	248	74	6.9	15	1096	247

VSS and SS corrected for the use of dilution liquid.

time in cycle Port		VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid (**)	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower	42.5	343.5	106.5	8.65	48.5	1345.5	277.5
Begin	middle	19	299	85	6.1	23	1191	231
end	lower	83	309	79	10	100	974	214
end	middle	13	235	61	6.9	15	1081	232

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on C column, 10/24/98 (continued)

Protein concentration

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower	88	408	207	12.25
Begin	middle	104	312	164	12.69
end	lower	116	312	174	13.73
end	middle	90	220	115	12.17

protein corrected for the use of dilution liquid.

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower	88	320	119	12.25
Begin	middle	104	208	60	12.69
end	lower	116	196	58	13.73
end	middle	90	130	25	12.17

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Carbohydrates

		Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower	30	154	56	0.31
Begin	middle	21	97	38	0.19
end	lower	49	143	63	0.4
end	middle	18	94	32	0.09

carbohydrate corrected for the use of dilution liquid.

		Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower	30	124	26	0.31
Begin	middle	21	76	17	0.19
end	lower	49	94	14	0.4
end	middle	18	76	14	0.09

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on backwash : N column (11/10/98) and C column (11/11/98)**Performance of system (10 november for N column, 11 november for C column)**

type of sample	time in cycle	port	COD	
			total	soluble
dilution liquid	end (10 nov)	lower N col.		55
dilution liquid	end (11 nov)	lower C col.		138
grab	end (10 nov)	C-effluent		66
grab	end (11 nov)	Influent		167

cycle duration for N column = 1040 minutes

cycle duration for C column = 660 minutes

BW1 is a sample taken during the first 5 minutes the column overfills during backwash

BW3 is taken approximately 20 minutes after BW1 (air scour stopped)

Specific Oxygen Uptake Rate (mg O₂ / min / l)

SOUR are conducted in BOD bottle (300ml)

	time in cycle	Port	fraction	Spike	SOUR	R2	temperature
N column (10 november)	end	lower	dilution liquid	none	2.90E-03	0.571	17.2
	end	lower	dilution liquid	ammonia	8.50E-03	0.952	17.1
	end	lower	dilution liquid	COD	1.39E-02	0.975	17.2
	end	lower	detached	none	2.43E-01	0.999	18.0
	end	lower	detached	ammonia	2.61E-01	1.000	17.9
	end	lower	detached	COD	2.85E-01	1.000	17.8
	end	lower	detachable	none	1.20E-01	1.000	18.1
	end	lower	detachable	ammonia			
	end	lower	detachable	COD	1.32E-01	1.000	17.8
	end	lower	attached	none	3.22E-01	1.000	18.1
	end	lower	attached	ammonia			
end	lower	attached	COD				
N column (10 november), column running	end	lower	liquid from core	none	1.26E-01	1.000	17.3
	end	lower	sampler (*)	ammonia	1.23E-01	1.000	17.3
	end	lower		COD	1.63E-01	1.000	17.5
N column (10 november) - backwash	backwash	top of column	BW1 (*)	none	6.00E-02	1.000	17.0
	backwash	top of column	BW1 (*)	ammonia	6.29E-02	0.999	17.1
	backwash	top of column	BW1 (*)	COD	9.61E-02	0.999	17.1
	backwash	top of column	BW3 (*)	none	1.15E-01	1.000	17.1
	backwash	top of column	BW3 (*)	ammonia	1.21E-01	1.000	17.0
	backwash	top of column	BW3 (*)	COD	1.54E-01	1.000	17.1
C column (11 november)	end	lower	dilution liquid	none	7.26E-02	0.998	18.4
	end	lower	dilution liquid	COD	1.58E-01	0.998	18.3
	end	lower	detached	none	3.14E-01	0.999	17.9
	end	lower	detached	COD	4.98E-01	1.000	18.0
	end	lower	detachable	none			
	end	lower	detachable	COD	2.95E-01	1.000	18.5
	end	lower	attached	none			
end	lower	attached	COD	3.24E-01	1.000	18.5	
C column (11 november) - column running	end	lower	liquid from core	none	3.23E-01	0.999	17.0
	end	lower	sampler (*)	COD	6.14E-01	1.000	17.1
Column (11 november) - backwash	backwash	top of column	BW1 (*)	none	3.62E-01	0.999	17.1
	backwash	top of column	BW1 (*)	COD	5.82E-01	1.000	17.3
	backwash	top of column	BW3 (*)	none	3.97E-01	0.996	17.3
	backwash	top of column	BW3 (*)	COD	5.26E-01	1.000	17.3

(*) liquid fraction has been diluted 1:2 with dilution liquid collected at lower port of the same column

BW1 = collected 5 minutes after column start to overflow during backwash

BW3 = collected 20 minutes after BW1

Test on backwash : N column (11/10/98) and C column (11/11/98) *continued***mass of media used in tests**

time in cycle	port	mass of media used (g)	
		"strongly attached"	"detached and detachable"
end N column	lower	19.01	97.34
end N column	lower (column running)		84.85
end C column	lower	26.89	76.05
end C column	lower (column running)		69.11

-----> 700 ml of liquid and 199g of media were collected during this sampling.

-----> 400 ml of liquid and 246g of media were collected during this sampling.

"strongly attached" : mass of media used in SOUR test for strongly attached fraction

"detached or detachable" : mass of media used to collect these fractions

"column running" : sample taken while column is still running. Liquid spraying out of the sampler is collected

VSS and SS measurement

time in cycle	Port	VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower, N column	16	230	107	6.2	22	646.5	210
end, column running (*)	lower, N column	191	92	91	8	346	127	131
backwash BW1	top of N column	296				400		
backwash BW3	top of N column	380				520		
end	lower, C column	50	374	153	10.3	64	1016	294
end, column running (*)	lower, C column	489	138	112	12	697	189	146
backwash BW1	top of C column	952				1254		
backwash BW3	top of C column	755				1005		

VSS and SS corrected for the use of dilution liquid.

time in cycle	Port	VSS (mg/l for liquid fractions, mg/g media for strongly attached fraction)				SS (mg/l)		
		liquid (**)	detached	detachable	strongly attached	liquid	detached	detachable
Begin	lower, N column	16	214	91	6.2	22	624.5	188
end, column running (*)	lower, N column	366	76	75	8	670	105	109
backwash BW1	top of N column	296				400		
backwash BW3	top of N column	380				520		
end	lower, C column	50	324	103	10.3	64	952	230
end, column running (*)	lower, C column	928	88	62	12	1330	125	82
backwash BW1	top of C column	952				1254		
backwash BW3	top of C column	755				1005		

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample or liquid from backwash

Test on backwash : N column (11/10/98) and C column (11/11/98) *continued*

Protein concentration

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid	detached	detachable	strongly attached
Begin	lower, N column	13	180	98	5.16
end, column running (*)	lower, N column	161	64	76	6.1
backwash	top of N column	182			
BW1	top of N column	348			
BW3	column				
end	lower, C column	77	325	138	11.49
end, column running (*)	lower, C column	320	98	106	12.02
backwash	top of C column	463			
BW1	top of C column	402			
backwash	column				
BW3	column				

protein corrected for the use of dilution liquid.

		Protein (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
time in cycle	Port	liquid (**)	detached	detachable	strongly attached
Begin	lower, N column	13	167	85	5.16
end, column running (*)	lower, N column	309	51	63	6.1
backwash	top of N column	182			
BW1	top of N column	348			
BW3	column				
end	lower, C column	77	248	61	11.49
end, column running (*)	lower, C column	563	21	29	12.02
backwash	top of C column	463			
BW1	top of C column	402			
backwash	column				
BW3	column				

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.
 (**) liquid collected a liquid port ("dilution liquid") , same level as media sample

Test on backwash : N column (11/10/98) and C column (11/11/98) *continued*

Carbohydrates

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid	detached	detachable	strongly attached
Begin	lower, N column	40	74	59.5	0.59
end, column running (*)	lower, N column	92	75	70	0.85
backwash	top of N column	140			
BW1	top of N column				
backwash	top of N column	160			
BW3	column				
end	lower, C column	32	128	61	0.71
end, column running (*)	lower, C column	125	70	38	0.77
backwash	top of C column				
BW1	top of C column	316			
backwash	top of C column				
BW3	column	203			

carbohydrate corrected for the use of dilution liquid.

time in cycle	Port	Carbohydrate (mg/l for liquid fractions, mg/g media for strongly attached fraction)			
		liquid (**)	detached	detachable	strongly attached
Begin	lower, N column	40	34	19.5	0.59
end, column running (*)	lower, N column	144	35	30	0.85
backwash	top of N column	140			
BW1	top of N column				
backwash	top of N column	160			
BW3	column				
end	lower, C column	32	96	29	0.71
end, column running (*)	lower, C column	218	38	6	0.77
backwash	top of C column				
BW1	top of C column	316			
backwash	top of C column				
BW3	column	203			

(*) the liquid collected during sampling is diluted 1:2 with liquid collected at same port.

(**) liquid collected a liquid port ("dilution liquid") , same level as media sample

APPENDIX C

RESULTS FROM TESTS ON BACKWASH

Backwash phases

Phases	Duration (min)		Sample	Flow (gpm)
	C column	N column		
Quick drain	5	3		-
Air cushion	0.33	0.33		-
Air scour only	1	1		-
Air & water 1	1	1		-
Air & water 2	3	3		-
Water only	2	2 BW1		25
Air & water 3	3	3 BW1		25
Water only	2	2		-
Air & water 4	3	3 BW2		25
Air cushion relief	1	1		-
Air cour stopped	1	1		-
Water only	20	20 BW3		25
Backwash complete	5	5		-
Water to Waste	20	20 WW		operation
Return to filter operation	0.25	0.25	G1, G2	operation

Samples are composite, during the time the column is overfilling (does not correspond exactly to phases).

Test on C column, 9/22/98

type of sample	Sample	Duration of sample (min)	Flow (gpm)	Flow (l/min)	SS (mg/l)	VSS (mg/l)	COD total (mg/l)	COD soluble (mg/l)	cBOD5 total (mg/l)	cBOD soluble (mg/l)	TKN total	TKN soluble	NH3
composite	Influent(I)	615.0	12	45.4	81	64	301	183	76	47	24.6	22.4	16.2
composite	Effluent(C)	615.0	12	45.4	81	64	206	114	25	11	21.8	19.4	15.5
clear well	WaterUsed				5	3.8	53	49	3	2.2	3.6	3.5	
Backwash	BW1	2.8	20	75.7	933	684	1237	138	339		70.9	21.8	
Backwash	BW2	4.3	20	75.7	961	746	1315	144	360				
Backwash	BW3	13.9	20	75.7	588	462	827	108	159				
Backwash	WW	19.9	12	45.4	196	151	304	82	45	5.6			5.1
Operation	G1	15.0	12	45.4	84	68	194	83	34				
Operation	G2	6.0	12	45.4	54	44	184	87	26				

Log

phase of water only was 15 minutes long instead 20 minutes, Water flow during backwash was only 20 gpm
 Head loss at end of cycle : 65 inches water flow during cycle : 12 gpm
 head loss after backwash : 60 inches. air flow during cycle : 5 scfm
 Cycle duration time : 615 minutes Temperature of water : 73 to 76.1 F

Test on C column, 9/9/98

type of sample	Sample	Duration of sample (min)	Flow (gpm)	Flow (l/min)	SS (mg/l)	VSS (mg/l)	COD total (mg/l)	COD soluble (mg/l)	cBOD5 total (mg/l)	cBOD soluble (mg/l)	TKN total	TKN soluble	NH3
composite	Influent(I)	595.0	12	45.4	65.8	52.2	220.5	150	89.8		23.4	20.2	8.8
composite	Effluent(C)	595.0	12	45.4	50.6	38.2	128	101.5	36.5		18.7	17	10.6
clear well	WaterUsed				9.2	7.4	44.3	51	6.7		7.5	7.3	6.4
Backwash	BW1	3.2	25	94.6	761.8	594.1	1035	132	239.4		56.5	18.3	
Backwash	BW2	4.5	25	94.6	856.3	658.9	1083	130	306		59.2	16.7	
Backwash	BW3	19.1	25	94.6	315.8	246.1	442	76.7	126.5		27.2	10.8	
Backwash	WW	20.2	12	45.4	96.0	75.5	180	62.5	45.3		17.8	9.4	7.9
Operation	G1	14.0	12	45.4	48.8	38.3	133	99.1	25.5		17.2	12.4	
Operation	G2	3.3	12	45.4	39.6	29.8	121	72.1	22.1		18.3	17	

Log

Head loss before backwash : 69 inches Water Flow during cycle : 12 gpm
 Head loss after backwash : 57 inches Air flow during cycle : 5 scfm
 Cycle duration time : 595 minutes

Test on C column, 5/5/98

type of		Duration of (min)	Flow (gpm) Flow (l/min)		SS (mg/l)	(mg/l)	soluble (mg/l)	BOD5 total	soluble (mg/l)	Protein
composite	Influent(I)		11.5	43.5		35.4	162		45	26
composite	Effluent(C)		11.5	43.5		10.4	65		8.5	5
clear well	WaterUsed									
Backwash	BW1		25	94.6		771.4	1298		290	10.5
Backwash	BW2		25	94.6		738.0	1179.5		234	
Backwash	BW3	8		94.6	588.5		744	74.5		0.371
Backwash	BW3(bis)	11		94.6	241		313.5	53.5		0.258
Backwash		10	11.5		132.5	107.5		47	35	0.099

Log

Water flow during cycle 11.5 gpm
 head loss at end of cycle : 62 inches
 Head loss after backwash : 43 inches
 Length of cycle : 656 minutes
 BODs measured include non carbonaceous BODs

Test on N column, 9/30/98

sample		sample (min)	Flow (l/min)		SS (mg/l)	VSS (mg/l)	COD total	COD (mg/l)	total (mg/l)	cBOD5 soluble (mg/l)	NH3
composite		1260.0	10.5		25.0	19.0		104.0	21.5		16.6
composite		1260.0	10.5		8.7	7.0		60.0	7.3		1.8
clear well					7.0	5.4		60.0	6.1		2.1
Backwash		4.3	25.0		257.0	201.0		59.6			
Backwash	BW2	4.7		94.6	594.0		891.0	60.7			
Backwash	BW3		25.0	94.6		213.0	408.0		61.0		
Backwash		18.7	10.5		101.0	79.0		57.6	30.0		0.3
operation		13.0	10.5		44.0	34.6		55.3	18.0		
operation	G2	5.0		39.7	33.0		97.0	53.7			

Log

Cycle duration time : 1260 minutes
 Air flow during cycle : 6 scfm

Test on N column, 8/23/98

sample		sample (min)	Flow (l/min)		SS (mg/l)	VSS (mg/l)	COD total	COD (mg/l)	total (mg/l)	cBOD soluble	Protein (mg/ml)	TKN total (mg/l as N)	soluble (mg/l as N)	NH4 (mg/l as N)	NO3 (mg/l as N)
composite	Effluent(c)	1272.0	10.5	39.7	24.7	20.2	113.3	68.7	29.3	13.6	0.02	23.3	19.9	14.7	0.27
composite	Effluent(N)	1272.0	10.5	39.7	9.5	10.7	36.3	22.7	5.6	2.4	0.005	4.3	3.1	1.3	8.94
clear well	WaterUsed				8.6	7.1	47.7	32.0	6.3		0.005	6.8	6.3	1.7	9.72
Backwash	BW1	4.5	25.0	94.6	171.1	134.0	288.0	45.0	102.0		0.097	14.2	2.8	0.38	12.6
Backwash	BW2	4.0	25.0	94.6	679.9	526.5	937.0	54.0	348.0		0.3	52.6	4	0.28	11.04
Backwash	BW3	18.7	25.0	94.6	389.6	295.8	538.0	44.0	178.0		0.168	30.1	4	0.12	11.82
Backwash	WW	19.0	10.5	39.7	115.2	82.7	317.0	35.5	63.5		0.071	10.8	3.1	0.08	11.77
Operation	G1	15.0	10.5	39.7	52.1	38.8	124.0	45.5	23.0	3.3	0.031	5.1	6.8	0.34	10.6
Operation	G2	4.0	10.5	39.7	34.5	27.3	116.5	51.0	15.2		0.02	4	4	0.13	9.62

Log

Head loss after backwash : 30 inches
 Total cycle duration : 1272 minutes
 Water flow during cycle 10.5 gpm
 Air flow during cycle : 6 scfm

Test on N column, 5/15/98

type of	Sample	sample (min)	Flow (l/min)		SS (mg/l)	VSS (mg/l)	COD total	COD (mg/l)	total (mg/l)	cBOD soluble	Protein (mg/ml)
composite	Effluent(C)	2737.0	10.0	37.8	14.4	14.5	90.0	59.0	12.5	5.0	0.00527
composite	Effluent(N)	2737.0	10.0	37.8	3.4	3.9	49.0	41.0	4.0	2.0	0.00238
clear well	WaterUsed							35.0		1.5	
Backwash	BW1	4.0	25.0	94.6	166.0	140.3	248.0	39.5	43.5	3.0	0.063
Backwash	BW2	4.4	25.0	94.6	837.5	678.0	1165.0	50.0	178.0		0.33
Backwash	BW3	8.9	25.0	94.6	506.0	427.1	733.5	49.0	108.5		0.204
Backwash	WW	10.0	10.0	37.8	248.5	209.6	369.5	46.5	51.5		0.109

Log

Head loss at end of cycle : 32 inches
 Head loss at end of backwash : 19 inches
 Total cycle duration time : 2737 minutes
 Phases Water Only and Water to Waste were set to 10 minutes instead of 20 minutes.
 Water flow during cycle : 10 gpm
 Air flow during cycle : 6 scfm