

Electronic Supplementary Material

Aerobic granular sludge sequencing batch reactors (AGS-SBRs) performance summary

S1: Performance summary of AGS-SBR-1

Parameters	Units	Period				
		I	II	III	IV	V
Operating Duration	d	1 - 61	71 - 99	106 - 120	134-155	162 - 183
Cycle Time	hrs	6	6	4	4	4
HRT	hrs	12	12	8	8	8
SRT	d	31 ± 17	23 ± 9	32 ± 21	14 ± 8	13 ± 9
<i>Mixed Liquor</i>						
MLSS	g/L	3 ± 1	2 ± 0.8	3 ± 0.1	2 ± 1	2 ± 1
MLVSS	g/L	2 ± 0.7	2 ± 0.6	2 ± 0.2	2 ± 0.5	2 ± 0.4
MLVSS/MLSS Ratio	-	0.73 ± 0.07	0.73 ± 0.04	0.81 ± 0.03	0.71 ± 0.17	0.70 ± 0.12
<i>Influent</i>						
NH ₃ -N	mg/L	123 ± 5	180 ± 17	182 ± 9	255 ± 7	292 ± 11
Alkalinity (as CaCO ₃)	mg/L	485 ± 2	815 ± 109	850 ± 109	1027 ± 103	1088 ± 98
<i>Effluent</i>						
NH ₃ -N	mg/L	0.9 ± 2	5 ± 6	0.8 ± 00	29.6 ± 00	8 ± 7
NO ₂ -N	mg/L	97 ± 49	185 ± 8	196 ± 10	200 ± 00	49 ± 6
NO ₃ -N	mg/L	26 ± 45	<0.2	<0.2	15 ± 00	245 ± 27
Alkalinity (as CaCO ₃)	mg/L	41 ± 25	66 ± 52	101 ± 15	154 ± 00	98 ± 53
TSS	mg/L	48 ± 14	59 ± 21	37 ± 17	65 ± 18	61 ± 9
VSS	mg/L	31 ± 10	41 ± 16	25 ± 12	50 ± 16	43 ± 4
NH ₃ -N removal	%	96 ± 11	97 ± 4	100 ± 00	49 ± 55	97 ± 2
NH ₃ -N Loading	g/L.d	0.3 ± 0.01	0.4 ± 0.03	0.6 ± 0.03	0.8 ± 0.02	0.9 ± 0.03
Nitrite Accumulation Rate (NAR)	%	23 ± 36	<0.2	<0.2	15 ± 12	83 ± 00
Ammonia Removal Rate	mg NH ₄ -N/L.h	24 ± 3	36 ± 4	57 ± 3	39 ± 43	90 ± 1
Specific Ammonia Removal Rate	mg NH ₄ -N/gVSS.h	13 ± 6	22 ± 8	26 ± 3	37 ± 37	58 ± 13

S2: Performance summary of AGS-SBR-2

Parameters	Units	Period		
		I	II	III
Operating Duration	d	1 - 14	24 - 51	58 - 72
Cycle Time	hrs	6	6	4
HRT	hrs	12	12	8
SRT	d	26 ± 0.05	25 ± 6	10 ± 2
<i>Mixed Liquor</i>				
MLSS	g/L	4 ± 2	3 ± 0.6	3 ± 0.1
MLVSS	g/L	3 ± 1	2 ± 0.4	2 ± 0.1
MLVSS/MLSS Ratio	-	0.71 ± 0.02	0.64 ± 0.05	0.64 ± 0.02
<i>Influent</i>				
NH ₃ -N	mg/L	84 ± 2	187 ± 7	192 ± 13
Alkalinity (as CaCO ₃)	mg/L	747 ± 25	858 ± 158	828 ± 26
<i>Effluent</i>				
NH ₃ -N	mg/L	<0.02	18 ± 38	0.43 ± 0.38
NO ₂ -N	mg/L	<0.02	0.06 ± 0.06	0.94 ± 1
NO ₃ -N	mg/L	83 ± 3	166 ± 42	184 ± 4
Alkalinity (as CaCO ₃)	mg/L	143 ± 5	138 ± 126	157 ± 13
TSS	g/L	0.07 ± 0.03	0.06 ± 0.02	0.09 ± 0.02
VSS	g/L	0.05 ± 0.01	0.03 ± 0.01	0.04 ± 0.01
NH ₃ -N removal	%	100 ± 00	90 ± 21	100 ± 00
NH ₃ -N Loading	g/L.d			
Nitrite Accumulation Rate (NAR)	%	<0.2	<0.2	1% ± 00
Ammonia Removal Rate	mg NH ₄ -N/L.h	17 ± 0.43	35 ± 9	60 ± 4
Specific Ammonia Removal Rate	mg NH ₄ -N/gVSS.h	7 ± 3	18 ± 5	35 ± 4

S3: Performance summary of AGS-SBR-3

Parameters	Units	Period						
		I	II	III	IV	V		
Operating Duration	d	1 - 38	38 - 72	79 - 93	100 - 114	121 - 135	149 - 156	163 - 212
Cycle Time	h	6	4	4	4	4	4	4
HRT	h	12	8	8	8	8	8	8
SRT	d	59 ± 19	22 ± 10	16 ± 5	42 ± 40	58 ± 26	130 ± 8	109 ± 55
<i>Mixed Liquor</i>								
MLSS	g/L	7 ± 1	7 ± 2	7 ± 0.6	7 ± 0.6	8 ± 1	12 ± 0.1	9 ± 1
MLVSS	g/L	6 ± 1	6 ± 2	6 ± 0.4	6 ± 0.5	8 ± 1	11 ± 0.2	8 ± 1
MLVSS/MLSS Ratio	-	0.85 ± 0.03	0.89 ± 0.02	0.89 ± 0.02	0.9 ± 0.01	0.91 ± 0.00	0.91 ± 0.01	0.89 ± 0.03
<i>Influent</i>								
NH ₃ -N	mg/L	77 ± 12	88 ± 3	84 ± 2	74 ± 11	149 ± 7	131 ± 00	121 ± 5
sCOD	mg/L	2.09 ± 0.15	2.20 ± 0.07	1.52 ± 0.01	0.95 ± 0.06	0.72 ± 0.05	0.54 ± 0.06	1.39 ± 0.05
Phosphorus (PO ₄ ³⁻)	mg/L	21 ± 2	21 ± 1	19 ± 5	21 ± 0.08	36 ± 20	37 ± 3	46 ± 17
Alkalinity (as CaCO ₃)	mg/L	444 ± 217	242 ± 86	309 ± 34	1096 ± 103	1274 ± 85	1710 ± 28	1758 ± 141
<i>Effluent</i>								
NH ₃ -N	mg/L	9 ± 6	16 ± 3	8 ± 11	0.4 ± 0.6	0.5 ± 0.6	0.1 ± 0.2	2 ± 1.55
NO ₂ -N	mg/L	3 ± 4	3 ± 0.9	7 ± 2	6 ± 5	0.1 ± 0.2	0.04 ± 0.05	3 ± 3
NO ₃ -N	mg/L	3 ± 2	0.6 ± 0.2	2 ± 0.5	8 ± 4	121 ± 19	104 ± 2	33 ± 23
sCOD	mg/L	93 ± 70	35 ± 12	41 ± 14	58 ± 26	53 ± 21	89 ± 12	128 ± 34
Phosphorus (PO ₄ ³⁻)	mg/L	5 ± 3	2 ± 2	7 ± 2	4 ± 0.4	33 ± 16	26 ± 3	38 ± 12
Alkalinity (as CaCO ₃)	mg/L	72 ± 37	120 ± 77	72 ± 12	178 ± 142	79 ± 47	122 ± 38	201 ± 145
TSS	g/L	0.07 ± 0.03	0.10 ± 0.02	0.16 ± 0.03	0.09 ± 0.06	0.05 ± 0.02	0.03 ± 0.00	0.04 ± 0.02
VSS	g/L	0.06 ± 0.02	0.07 ± 0.02	0.12 ± 0.03	0.07 ± 0.06	0.04 ± 0.02	0.01 ± 0.00	0.05 ± 0.08

NH ₃ -N Removal	%	88 ± 8	81 ± 3	91 ± 12	100 ± 1	100 ± 00	100 ± 00	98 ± 1
sCOD Removal	%	95 ± 4	98 ± 1	97 ± 1	94 ± 2	93 ± 3	84 ± 00	91 ± 2
Phosphorus (PO ₄ ³⁻) Removal	%	79 ± 14	93 ± 10	66 ± 2	79 ± 2	26 ± 9	31 ± 14	15 ± 5
NH ₃ -N Loading	g/L.d	0.15 ± 0.02	0.17 ± 0.01	0.17 ± 0.00	0.15 ± 0.02	0.30 ± 0.01	0.26 ± 0.00	0.24 ± 0.01
COD/N Ratio	mg sCOD/mg NH ₃ -N	27 ± 3	25 ± 1	18 ± 0.32	13 ± 1	5 ± 0.43	4 ± 0.46	12 ± 0.47
F/M	gCOD/gVSS.h	0.71 ± 0.10	1 ± 0.37	0.72 ± 0.05	0.40 ± 0.03	0.26 ± 0.02	0.14 ± 0.02	0.45 ± 0.06
Organic Loading Rate	gCOD/L.d	4 ± 0.4	7 ± 0.2	5 ± 0.02	3 ± 0.2	2 ± 0.1	2 ± 0.2	4 ± 0.2
Simultaneous Nitrification-Denitrification (SND) Efficiency	%	92 ± 6	95 ± 1	89 ± 4	81 ± 8	18 ± 16	21 ± 2	70 ± 17
