SUPPORTING INFORMATION

Pilot Scale Study of Sequencing Batch Reactor (SBR) Retrofit with Integrated Fixed Film Activated Sludge (IFAS): Nitrogen Removal and Design Consideration

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Materials and Methods

Statistical analysis was conducted with Stata/MP 14.0 (College Station, TX).

Results

1. Comparison of NH_4^+-N removal efficiencies in phase 2 and phase 1.

Data:

Phase 2	Phase 1
95%	95%
96%	96%
75%	98%
93%	100%
77%	100%
80%	100%
79%	98%
75%	99%
96%	96%
94%	98%

Stata Results:

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase2	10	0.86	0.0298515	0.0943987	0.7924713	0.9275287
phase1	10	0.98	0.0057735	0.0182574	0.9669394	0.9930606
combined	20	0.92	0.0202094	0.0903793	0.8777012	0.9622988
diff		-0.12	0.0304047		-0.1880582	-0.0519418

diff = mean(phase2) - mean(phase1) t = -3.9468

Ho: diff = 0 Satterthwaite's degrees of freedom = 9.67238

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0

Pr(T < t) = 0.0015 Pr(|T| > |t|) = 0.0029 Pr(T > t) = 0.9985

2. Comparison of TIN removal efficiencies in phase 1, 2, and 3.

Data:

TIN removal efficiency		
Phase 3	Phase 1	Phase 2
69.30%	59%	64%
80%	60%	68%
78.70%	47%	45%
83.30%	42%	70%
79%	46%	49%
78.30%	47%	58%
73%	23%	58%
69.30%	50%	55%
81.30%	52%	69%
	48%	65%

Stata Results:

2.1 Phase 3 and 1.

phase 3 and phase1
Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase3	9	0.7677778	0.0172222	0.0516667	0.7280633	0.8074923
phase1	10	0.474	0.0324619	0.1026537	0.400566	0.547434
combined	19	0.6131579	0.0391806	0.1707842	0.5308425	0.6954733
diff		0.2937778	0.0367476		0.2147272	0.3728284

diff = mean(phase32) - mean(phase12) t = 7.9945
Ho: diff = 0 Satterthwaite's degrees of freedom = 13.57

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 1.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 0.0000

2.2 Phase 3 and 2.

phase 3 and phase2
Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase3	9	0.7677778	0.0172222	0.0516667	0.7280633	0.8074923
phase2	10	0.601	0.0271805	0.0859522	0.5395135	0.6624865
combined	19	0.68	0.0253398	0.1104536	0.6267631	0.7332369
diff		0.1667778	0.0321774		0.0981789	0.2353766

diff = mean(phase32) - mean(phase22) t = 5.1831
Ho: diff = 0 Satterthwaite's degrees of freedom = 14.9639

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.9999 Pr(|T| > |t|) = 0.0001 Pr(T > t) = 0.0001

3. Comparison of CBOD removal efficiencies in phase 1, 2, and 3.

Data:

	CBOD removal efficiency		
	Phase 1	Phase 2	Phase 3
	71.67%	91.67%	90.83%
	93.89%	91.43%	93.00%
	91.58%	94.53%	88.24%
	91.92%	97.64%	97.72%
	95.67%	95.91%	93.33%
	93.10%	71.33%	69.74%
	92.31%	94.54%	83.13%
		94.47%	92.14%
		95.56%	93.55%
		94.88%	84.67%
Mean	90.02%	92.20%	88.64%

Stata results:

3.1 phase 1 and 2.

codes:
ttest phase1 == phase2, unpaired unequal

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase1	7	0.9002	0.03103	0.082097	0.824273	0.976127
phase2	10	0.92196	0.023905	0.075595	0.867882	0.976038
combined	17	0.913	0.018572	0.076576	0.873629	0.952372
diff		-0.02176	0.03917		-0.10685	0.063326

diff = mean(phase1) - mean(phase2) t = -0.5555
Ho: diff = 0 Satterthwaite's degrees of freedom = 12.3382

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.2942 Pr(|T| > |t|) = 0.5885 Pr(T > t) = 0.7058
cannot reject the null hypothesis, diff = 0
we do not find a statistically significant difference in the means of phase 1 and phase 2

3.2 phases 1 and 3.

. ttest phase1 == phase3, unpaired unequal

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase1	7	0.9002	0.0310298	0.0820971	0.8242729	0.9761271
phase3	10	0.88635	0.0251241	0.0794493	0.8295154	0.9431846
combined	17	0.8920529	0.0189852	0.078278	0.8518061	0.9322998

diff	0.01385	0.0399258		-0.0725534	0.1002534

diff = mean(phase1) - mean(phase3) t = 0.3469
Ho: diff = 0 Satterthwaite's degrees of freedom = 12.783

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.6328 Pr(|T| > |t|) = 0.7343 Pr(T > t) = 0.3672

we do not find a statistically significant difference in the means of phase 1 and phase 3

3.3 Phases 2 and 3.

. ttest phase2 == phase3, unpaired unequal

Two-sample t test with unequal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase2	10	0.92196	0.0239053	0.0755952	0.8678824	0.9760376
phase3	10	0.88635	0.0251241	0.0794493	0.8295154	0.9431846
combined	20	0.904155	0.0173647	0.0776571	0.8678104	0.9404996
diff		0.03561	0.0346797		-0.0372623	0.1084823

diff = mean(phase2) - mean(phase3) t = 1.0268
Ho: diff = 0 Satterthwaite's degrees of freedom = 17.9557

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.8409 Pr(|T| > |t|) = 0.3181 Pr(T > t) = 0.1591
we do not find a statistically significant difference in the means of phase 2 and phase 3

3.4 Comparison of CBOD removal efficiencies to 90% in phases 1, 2 and 3.

ttest phase1 == 0.9

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase1	7	0.9002	0.03103	0.082097	0.824273	0.976127

mean = mean(phase1)   t = 0.0064
Ho: mean = 0.9   degrees of freedom = 6

Ha: mean < 0.9   Ha: mean != 0.9   Ha: mean > 0.9
Pr(T < t) = 0.5025   Pr(|T| > |t|) = 0.9951   Pr(T > t) = 0.4975

cannot reject the null hypothesis, the mean of phase =90%

ttest phase2 == 0.9
One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
phase2	10	0.92196	0.023905	0.075595	0.867882	0.976038

mean = mean(phase2)   t = 0.9186
Ho: mean = 0.9   degrees of freedom = 9

Ha: mean < 0.9   Ha: mean != 0.9   Ha: mean > 0.9
Pr(T < t) = 0.8089   Pr(|T| > |t|) = 0.3823   Pr(T > t) = 0.1911

cannot reject the null hypothesis, the mean of phase =90%

ttest phase3 == 0.9
One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]

phase3	10	0.88635	0.025124	0.079449	0.829515	0.943185

mean = mean(phase3) t = -0.5433

Ho: mean = 0.9 degrees of freedom = 9

Ha: mean < 0.9	Ha: mean != 0.9	Ha: mean > 0.9
Pr(T < t) = 0.3001	Pr(|T| > |t|) = 0.6001	Pr(T > t) = 0.6999

cannot reject the null hypothesis, the mean of phase =90%