APPENDIX A

Demonstration of statistical analysis of significance Dunnett's method for multiple comparisons with a control. In all cases, the significance level tested was $\alpha = 0.05$. When an effect was significantly different, the probability was less than 0.05. In the text, this is designated by stating that $\alpha = 0.05$. Dunnett's critical t-values were supplied by the Virginia Tech Statistics Department, Blacksburg, VA .

Cycle	Control Reactor				IC15 Reactor				IC25 Reactor				IC50 Reactor				Cycle
	Avg MLSS mg/L	St.Dev. MLSS mg/L	Avg MLVSS mg/L	St.Dev. MLVSS mg/L	Avg MLSS mg/L	St.Dev. MLSS mg/L	Avg MLVSS mg/L	St.Dev. MLVSS mg/L	Avg MLSS mg/L	St.Dev. MLSS mg/L	Avg MLVSS mg/L	St.Dev. MLVSS mg/L	Avg MLSS mg/L	St.Dev. MLSS mg/L	Avg MLVSS mg/L	St.Dev. MLVSS mg/L	
2	5127	175	3370	145	5260	17	3457	35	5307	74	3477	40	5505	247	3615	179	2
5	5147	438	3327	264	5487	45	3517	51	5493	64	3493	40	5800	42	3700	20	5
9	4467	84	2863	64	4610	193	3010	209	4650	26	2990	44	4615	35	2970	23	9
13	4363	93	2900	56	4413	47	2953	107	4557	6	2987	15	4535	49	2990	38	13
17	4027	111	2707	68	4100	62	2697	42	4230	44	2780	26	4270	28	2765	40	17
21	3790	66	2473	42	3953	25	2567	15	4033	35	2627	49	4185	49	2750	21	21
25	3687	90	2353	15	3470	165	2227	162	3590	10	2337	25	3690	42	2400	31	25
29	3470	40	2327	47	3283	42	2190	20	3487	51	2313	31	3580	42	2375	17	29
33	3583	312	2400	289	3237	50	2120	56	3333	35	2207	15	3470	85	2265	50	33
37	3413	35	2267	23	3547	15	2337	12	3647	35	2390	10	3560	42	2335	46	37
45	3333	86	2230	66	3263	38	2203	25	3350	70	2267	40	3370	57	2260	26	45
53	3183	35	2127	86	2947	70	2007	32	3173	100	2120	75	3105	21	2075	72	53

Data from zinc-cyanide complex source-effect experimentwith 10 day SRT biomass

Control reactor is the basis for comparison

Assumption: Standard deviation is the same for all data series; a pooled standard deviation is determined

$$S_p = \frac{(n_c-1)xS_c + (n_{r1}-1)xS_{r1} + (n_{r2}-1)xS_{r2} + (n_{r3}-1)xS_{r3}}{(n_c-1) + (n_{r1}-1) + (n_{r2}-1) + (n_{r3}-1)}$$

Where:

S_p = pooled standard deviation

S_i = individual standard deviation

n = number of onservations

c = control reactor

r1, r2, r3 = shocked reactors

MLSS			MLVSS			tk-1, v, α/2 x Sp x ((1/nc) + (1/nr))^.5	tk-1, v, α/2 x Sp x ((1/nc) + (1/nr))^.5
IC15 - Control	IC25 - Control	IC50 - Control	IC15 - Control	IC25 - Control	IC50 - Control	MLSS	MLVSS
133	180	378	87	107	245	351	266
340	347	653	190	167	373	503	307
143	183	148	147	127	107	242	252
50	193	172	53	87	90	130	143
73	203	243	-10	73	58	154	105
163	243	395	93	153	277	104	78
-217	-97	3	-127	-17	47	217	188
-187	17	110	-137	-13	48	99	70
-347	-250	-113	-280	-193	-135	370	336
133	233	147	70	123	68	75	60
-70	17	37	-27	37	30	146	96
-237	-10	-78	-120	-7	-52	145	157

Difference between MLSS control and MLSS in the shocked reactor

Difference between MLVSS control and MLVSS in the shocked reactor

Quanitities tested are the differences to the control

$t_{k-1}, v, \alpha/2 \times S_p \times ((1/n_c) + (1/n_r))^{.5} = 2.88 \times S_p \times ((2/3))^{.5}$

Where:

$t_{k-1}, v, \alpha/2$ = Dummet's t value, 2.88 for $\alpha = 0.05$

(k-1) - number of treatments to be compared to the control, 3

v = degrees of freedom

α = significance level

n_c - number of observations for the control reactor

n_r - number of onservations for each of the shocked reactors

Cycle	IC15 Reactor MLSS	IC25 Reactor MLSS	IC50 Reactor MLSS	IC15 Reactor MLVSS	IC25 Reactor MLVSS	IC50 Reactor MLVSS
2	NORMAL	NORMAL	+ SIGNIFICANT	NORMAL	NORMAL	NORMAL
5	NORMAL	NORMAL	+ SIGNIFICANT	NORMAL	NORMAL	+ SIGNIFICANT
9	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
13	NORMAL	+ SIGNIFICANT	+ SIGNIFICANT	NORMAL	NORMAL	NORMAL
17	NORMAL	+ SIGNIFICANT	+ SIGNIFICANT	NORMAL	NORMAL	NORMAL
21	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT
25	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
29	- SIGNIFICANT	NORMAL	+ SIGNIFICANT	- SIGNIFICANT	NORMAL	NORMAL
33	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
37	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT	+ SIGNIFICANT
45	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
53	- SIGNIFICANT	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL

A 95% confidence interval for all the comparisons with the control is given by:

$$y_{ri} - y_c \pm t_{k-1,\,\nu,\,\alpha/2} \times S_p \times ((1/n_c) + (1/n_r))^{\wedge}.5$$

Therefore, all observations that have a difference to the control mean that is outside this confidence interval can be interpreted as being significantly different from the control, with 95% confidence.

- SIGNIFICANT means significantly lower than the control
+ SIGNFICANT means significantly higher than the control
NORMAL means no significant difference was statistically determined, and, therefore, the shocked reactor has returned to control levels

These results were then objectively used to determine when the reactor had permanently recovered to levels of the control.
It was decided that if three "NORMAL" values were see in three consecutive cycles than that reactor had recovered to the control reactor.

For example: The IC50 MLVSS levels would be considered "recovered" at cycle 17, despite one or two late unconsecutive "significant" results.

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