

Appendix L

Statistical Comparison of Water Quality Indicator Data for River Sites Located East of the San Joaquin River

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Objective

The purpose of this work is to statistically compare the water quality indicator data from various river sites located east of the San Joaquin River (SJR) and determine if significant similarities/differences exist between these sites.

Methods

Data was analyzed using JMP statistical software. Standard unpaired parametric (t-test) analyses comparing data from three river sampling sites located east of the SJR were done (Table 1). The hypothesis tested in these comparisons is:

H₀: There is no significant difference in the water quality data means of these sites.

H₁: There is a significant difference in the water quality data means of these sites.

The results of all analyses are reported in terms of the probability (P) that H₀ is true. For results where $P \geq 0.05$ (where there is a greater than or equal to 5% probability that H₀ is true), data is shown grouped together with a letter designation (A, B, C.), with different letters assigned to means that are statistically different. While the letters A, B, C are used to designate statistically different water quality data means for each analysis, data for each water quality indicator are compared separately, so the same letter designations between different water quality indicator comparisons do not suggest statistically similar means. Two-tailed P values are used, even when one-tailed P values are available, as the two-tailed P is more conservative. The JMP output – including boxplots for each water quality parameter compared – are in the Analyses section of this document.

Results

Data was analyzed for several water quality indicators including total phosphorous (total P), soluble phosphate, total nitrogen (total N), nitrate-nitrogen (NO₃-N), ammonia-nitrogen (NH₄-N), chlorophyll *a*, algal pigment, total organic carbon (TOC), dissolved organic carbon (DOC), biochemical oxygen demand (BOD), mineral suspended solids (MSS), and specific conductivity. Similarities in the t-test results between the sites were seen for:

1. total P, soluble phosphate, and algal pigment
2. total N and NO₃-N
3. chlorophyll *a*, TOC, DOC, BOD, and MSS

No similarities between the t-test results for specific conductivity or NH₄-N and any other indicator data were seen. Results from the statistical comparison of water quality indicator data for soluble phosphate, NO₃-N, and chlorophyll *a* indicate that significant differences exist between the sites, and are shown in Figures 1, 2, 3, and 4 and Tables 2, 3, 4, and 5.

Figure 1 shows a boxplot and Table 2 the results of the t-test analysis of the soluble phosphate data means. The analysis indicates that site DO-14 has significantly more

soluble phosphate than the other sites analyzed. Site DO-14 also has significantly more total P and algal pigment than the other sites (Analyses 10 and 12).

Figure 2 shows a boxplot and Table 3 the results of the t-test analysis of the NO₃-N data means. The analysis indicates that site DO-16 has significantly more NO₃-N than the other two sites, and site DO-14 has significantly more NO₃-N than site DO-12. A similar result is seen for total N (Analysis 7).

Figure 3 shows a boxplot and Table 4 the results of the t-test analysis of the chlorophyll *a* data means. The analysis indicates that no significant differences exist in the chlorophyll *a* data means of the three sites. The same result is seen for TOC, DOC, BOD, and MSS (Analyses 2, 5, 6, and 11).

Figure 4 shows a boxplot and Table 4 the results of the t-test analysis of the NH₄-N data means. The analysis indicates that there is a significant difference in the NH₄-N data means of sites DO-14 and 16, and that there is no significant difference between the NH₄-N data mean of site DO-12 and the other two sites.

Conclusions

A statistical comparison of water quality indicator data, including total P, soluble phosphate, total N, NO₃-N, NH₄-N, chlorophyll *a*, algal pigment, TOC, DOC, BOD, MSS, and specific conductivity, for river sites located east of the SJR show that significant differences exist between the three sites. Some conclusions that can be made based on the analyses in this report include:

1. A statistical comparison of the sample means for soluble phosphate (Figure 1; Table 2), total P, and algal pigment yields two groupings of east river sites. Site DO-14 (Tuolumne River at Shiloh Bridge) comprises the first group, containing significantly more soluble phosphate, total P, and algal pigment than the second group, which includes the other two east river sites.
2. A statistical comparison of the sample means for NO₃-N (Figure 2; Table 3) and total N yields three groupings of east river sites. The first group is comprised of site DO-16 (Merced River at River Road), and has significantly more NO₃-N and total N than the other sites; the second group is comprised of site DO-14 (Tuolumne River at Shiloh Bridge), and has significantly more NO₃-N and total N than site DO-12; and the third group is comprised of site DO-12 (Stanislaus River at Caswell Park), which has significantly less NO₃-N and total N than the other two sites.
3. A statistical comparison of the sample means for chlorophyll *a* (Figure 3; Table 4), TOC, DOC, BOD, and MSS yields one grouping of east river sites, as there were no significant differences between the three sites.
4. A statistical comparison of the sample means for NH₄-N (Figure 4; Table 5) yields two groupings of east river sites. The first group is comprised of sites DO-16 and 12, and the second group is comprised of sites DO-12 and 14. Site DO-16 (Merced River at River Road) has significantly more NH₄-N than site DO-14

(Tuolumne River at Shiloh Bridge), and site DO-12 (Stanislaus River at Caswell Park) is not significantly different from the other two sites.

Table 1: Sites used for this study

Site Name	DO Site No.	Location
Stanislaus River at Caswell Park	12	
Tuolumne River at Shiloh Bridge	14	
Merced River at River Road	16	

Figure 1: Boxplot of soluble phosphate results.

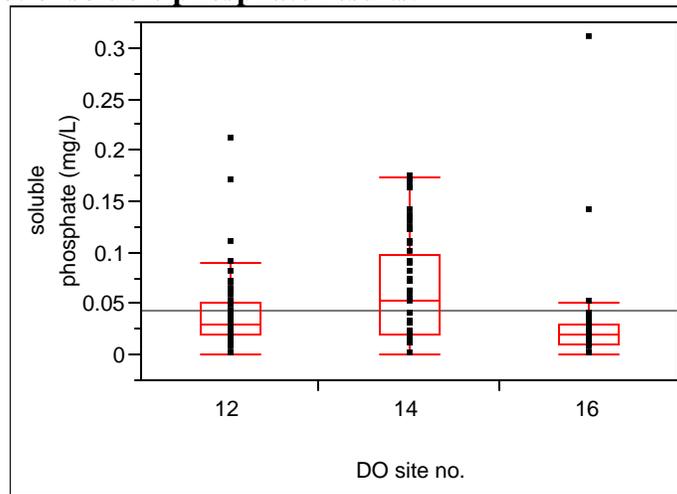


Table 2: Statistical analysis of soluble phosphate data, student's t-test comparison of all pairs of river sites east of the SJR. Statistically similar averages are grouped by letter designation.

Site		Mean (mg/L)
14	A	0.0623
12	B	0.0396
16	B	0.0262

Figure 2: Boxplot of NO₃-N results.

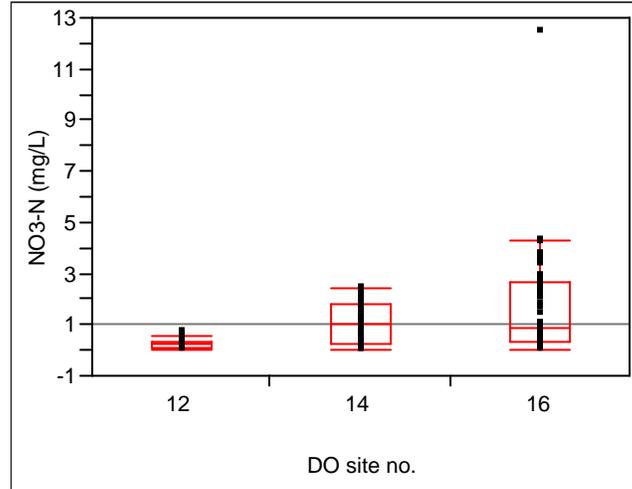


Table 3: Statistical analysis of NO₃-N data, student's t-test comparison of all pairs of river sites east of the SJR. Statistically similar averages are grouped by letter designation.

Site		Mean (mg/L)
16	A	1.65
14	B	1.10
12	C	0.23

Figure 3: Boxplot of chlorophyll *a* results.

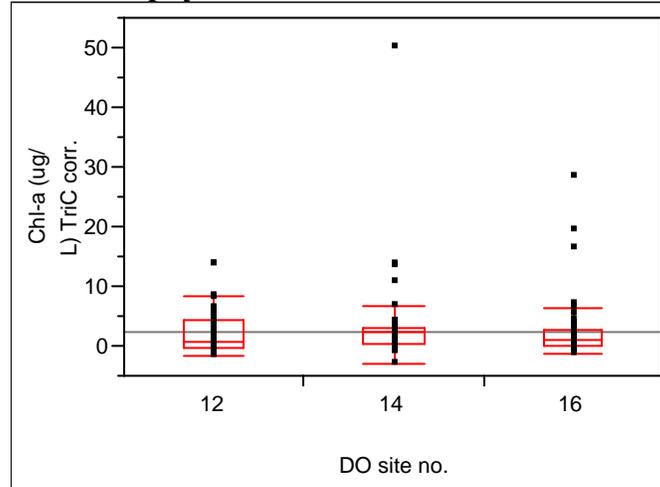


Table 4: Statistical analysis of chlorophyll *a* data, student's t-test comparison of all pairs of river sites east of the SJR. Statistically similar averages are grouped by letter designation.

Site		Mean ($\mu\text{g/L}$)
14	A	2.89
16	A	2.15
12	A	2.10

Figure 4: Boxplot of NH₄-N results.

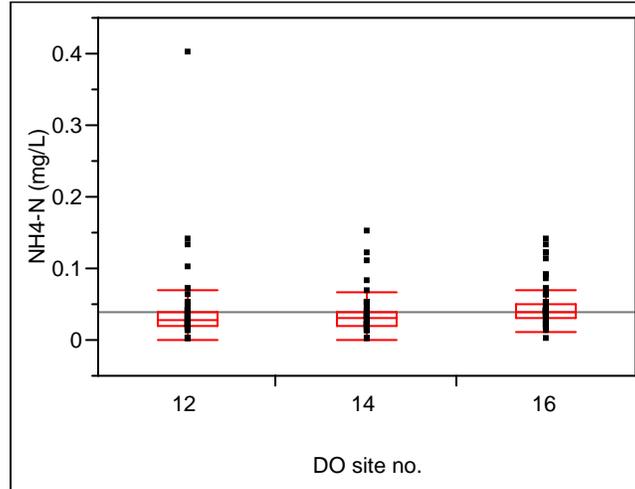
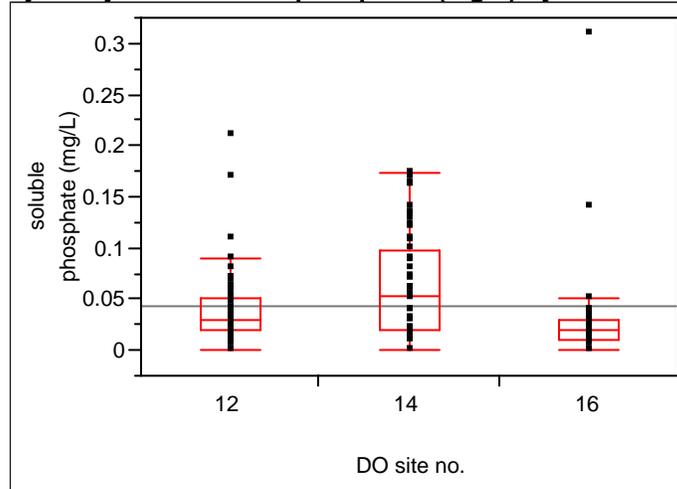


Table 5: Statistical analysis of NH₄-N data, student's t-test comparison of all pairs of river sites east of the SJR. Statistically similar averages are grouped by letter designation.

Site		Mean (mg/L)
16	A	0.0453
12	A B	0.0369
14	B	0.0324

**Analyses 1 - 12: Data from the Statistical
Comparison of Water Quality Indicators for
Rivers Located East of the SJR**

Analysis 1: East River Sites Soluble Phosphate
Oneway Analysis of soluble phosphate (mg/L) by DO site number.



Comparisons for each pair using Student's t

t Alpha
 1.97196 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
14	A	0.06227941
12	B	0.03955224
16	B	0.02622388

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	16	0.0360555	0.021806	0.0503053	<.0001	
14	12	0.0227272	0.008477	0.0369770	0.0019	
12	16	0.0133284	-0.000974	0.0276308	0.0676	

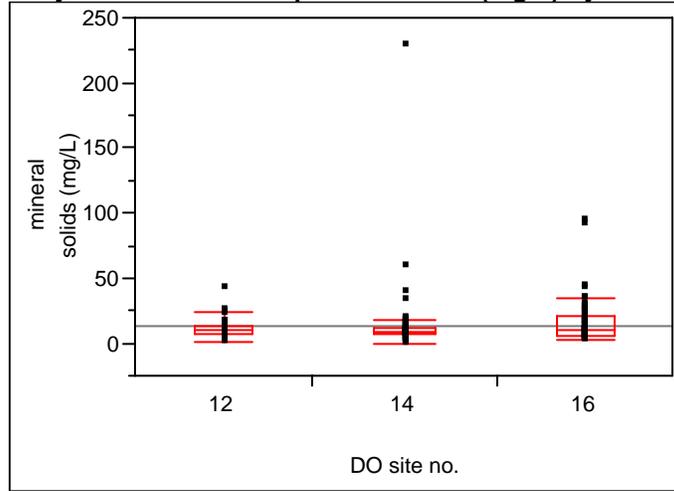
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	3999.50	59.6940	-2.457
14	68	5180.50	76.1838	2.457

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3999.5	-2.45734	0.0140

Analysis 2: East River Sites Mineral Suspended Solids
Oneway Analysis of mineral suspended solids (mg/L) by DO site number.



Missing Rows 8

Comparisons for each pair using Student's t

t Alpha
 1.97246 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
16	A	16.218413
14	A	13.530597
12	A	10.942656

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	12	5.275756	-1.57632	12.12784	0.1305	
16	14	2.687816	-4.08774	9.46337	0.4349	
14	12	2.587941	-4.16028	9.33616	0.4503	

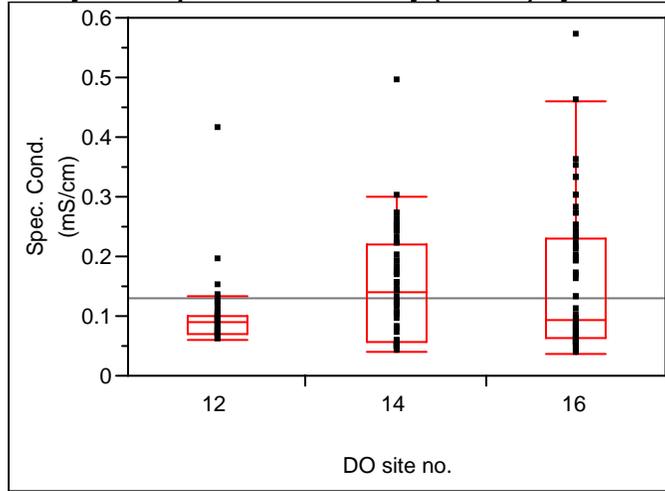
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	64	4534.00	70.8438	1.425
14	67	4112.00	61.3731	-1.425

2-Sample Test, Normal Approximation

S	Z	Prob> Z
4534	1.42508	0.1541

Analysis 3: East River Sites Specific Conductivity
Oneway Analysis of specific conductivity (mS/cm) by DO site number.



Comparisons for each pair using Student's t

t Alpha
 1.97196 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mS/cm)
16	A	0.15161194
14	A	0.14857353
12	B	0.09440299

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	12	0.0572090	0.027411	0.0870071	0.0002	
14	12	0.0541705	0.024482	0.0838590	0.0004	
16	14	0.0030384	-0.026650	0.0327268	0.8403	

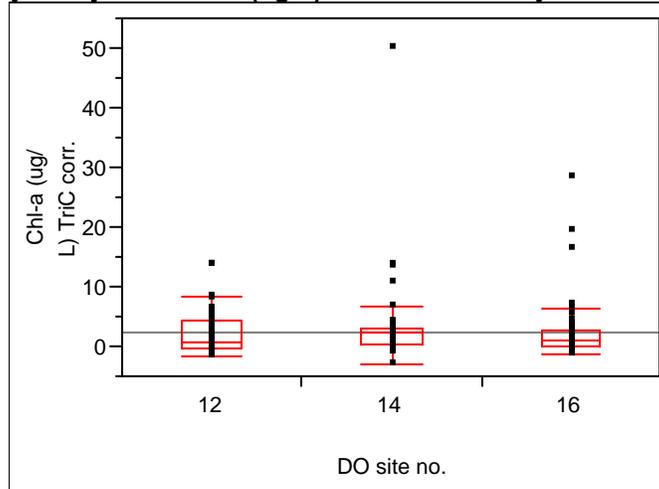
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	3801.00	56.7313	-3.322
14	68	5379.00	79.1029	3.322

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3801	-3.32153	0.0009

Analysis 4: East River Sites Chlorophyll *a*
Oneway Analysis of chl-*a* (ug/L) TriC corrected by DO site number.



Missing Rows 1

Comparisons for each pair using Student's t

t Alpha
 1.97202 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (µg/L)
14	A	2.8913235
16	A	2.1477273
12	A	2.1040299

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	12	0.7872937	-0.90977	2.484355	0.3614	
14	16	0.7435963	-0.95993	2.447122	0.3904	
16	12	0.0436974	-1.66608	1.753473	0.9599	

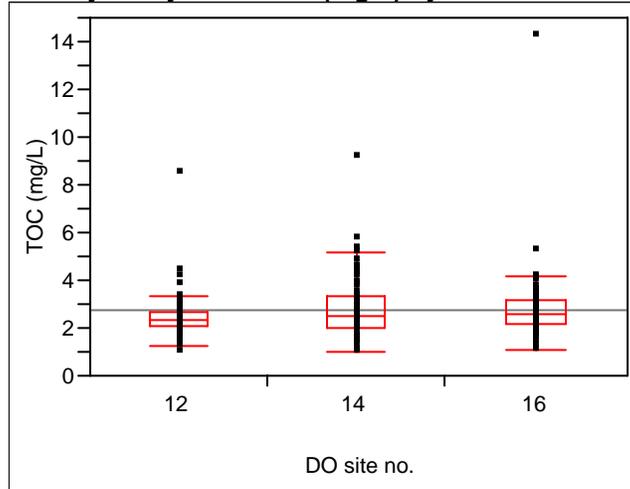
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	4351.50	64.9478	-0.898
14	68	4828.50	71.0074	0.898

2-Sample Test, Normal Approximation

S	Z	Prob> Z
4351.5	-0.89838	0.3690

Analysis 5: East River Sites TOC
Oneway Analysis of TOC (mg/L) by DO site number.



Missing Rows 5

Comparisons for each pair using Student's t

t Alpha
 1.97227 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
14	A	2.8360154
16	A	2.8278955
12	A	2.4992769

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	12	0.3367385	-0.123769	0.7972460	0.1509	
16	12	0.3286186	-0.128439	0.7856766	0.1578	
14	16	0.0081199	-0.448938	0.4651778	0.9721	

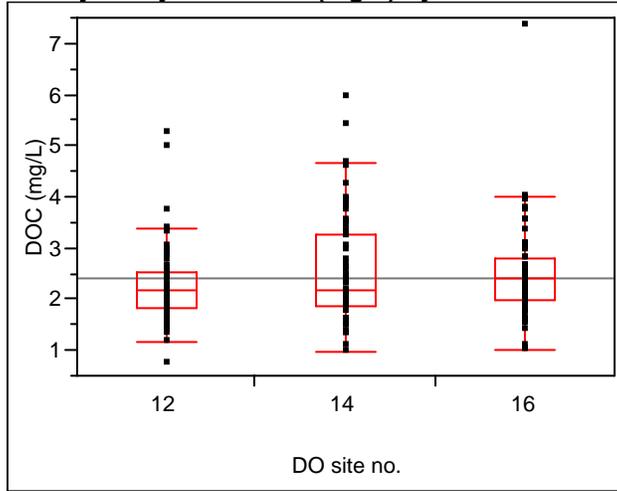
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	65	3995.50	61.4692	-1.218
14	65	4519.50	69.5308	1.218

2-Sample Test, Normal Approximation

S	Z	Prob> Z
4519.5	1.21765	0.2234

Analysis 6: East River Sites DOC
Oneway Analysis of DOC (mg/L) by DO site number.



Comparisons for each pair using Student's t

t Alpha
 1.97196 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
14	A	2.5179412
16	A	2.4777761
12	A	2.2605970

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	12	0.2573442	-0.054802	0.5694901	0.1056	
16	12	0.2171791	-0.096121	0.5304790	0.1732	
14	16	0.0401651	-0.271981	0.3523110	0.8000	

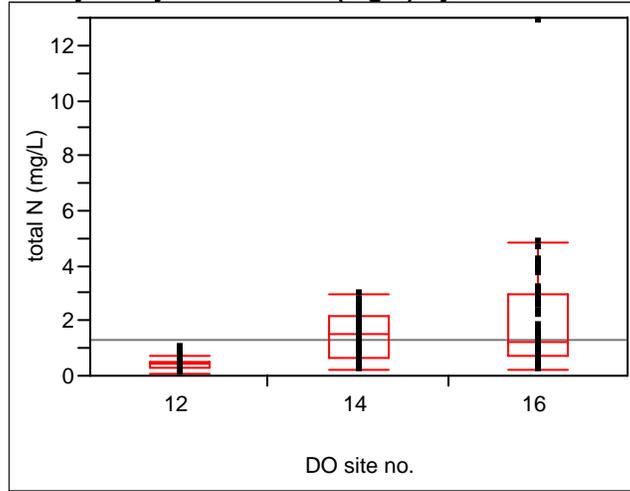
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	4318.00	64.4478	-1.045
14	68	4862.00	71.5000	1.045

2-Sample Test, Normal Approximation

S	Z	Prob> Z
4318	-1.04523	0.2959

Analysis 7: East River Sites Total N
Oneway Analysis of total N (mg/L) by DO site number.



Missing Rows 6

Comparisons for each pair using Student's t

t Alpha
 1.97233 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
16	A	1.9727846
14	B	1.4107424
12	C	0.4292462

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	12	1.543538	1.127406	1.959671	<.0001	
14	12	0.981496	0.566943	1.396049	<.0001	
16	14	0.562042	0.147489	0.976595	0.0081	

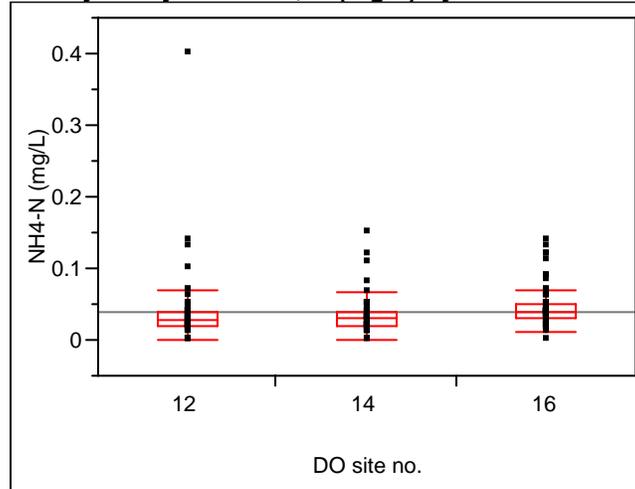
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	65	2835.50	43.6231	-6.694
14	66	5810.50	88.0379	6.694

2-Sample Test, Normal Approximation

S	Z	Prob> Z
2835.5	-6.69362	<.0001

Analysis 8: East River Sites NH₄-N
Oneway Analysis of NH₄-N (mg/L) by DO site number.



Comparisons for each pair using Student's t

t Alpha
 1.97196 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
16	A	0.04531343
12	A B	0.03691045
14	B	0.03241176

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	14	0.0129017	0.000341	0.0254618	0.0441	
16	12	0.0084030	-0.004204	0.0210096	0.1902	
12	14	0.0044987	-0.008061	0.0170589	0.4808	

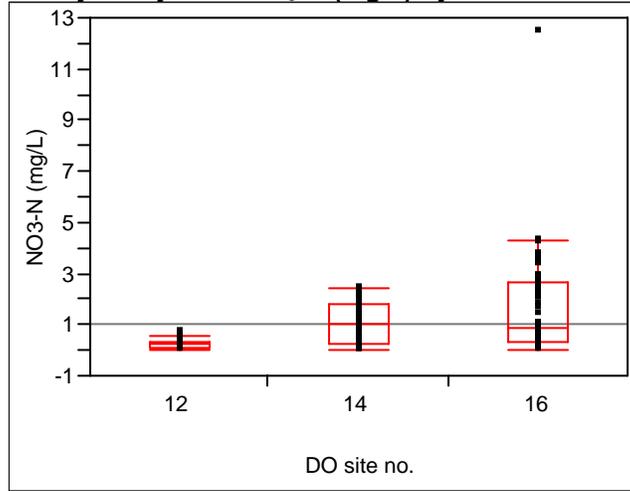
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	4505.50	67.2463	-0.221
14	68	4674.50	68.7426	0.221

2-Sample Test, Normal Approximation

S	Z	Prob> Z
4505.5	-0.22110	0.8250

Analysis 9: East River Sites NO₃-N
Oneway Analysis of NO₃-N (mg/L) by DO site number.



Comparisons for each pair using Student's t

t Alpha
 1.97196 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
16	A	1.6461791
14	B	1.0983824
12	C	0.2303284

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	12	1.415851	1.021025	1.810677	<.0001	
14	12	0.868054	0.474682	1.261426	<.0001	
16	14	0.547797	0.154425	0.941169	0.0066	

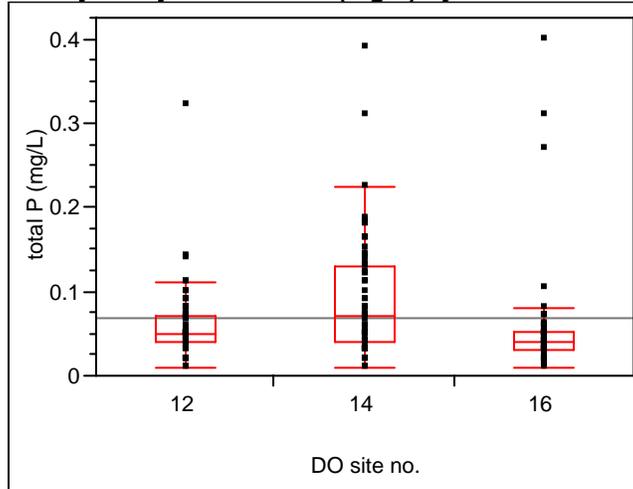
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	67	3215.00	47.9851	-5.900
14	68	5965.00	87.7206	5.900

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3215	-5.90046	<.0001

Analysis 10: East River Sites Total P
Oneway Analysis of total P (mg/L) by DO site number.



Missing Rows 6

Comparisons for each pair using Student's t

t Alpha
 1.97233 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
14	A	0.09157576
12	B	0.06020000
16	B	0.05578462

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	16	0.0357911	0.014959	0.0566234	0.0009	
14	12	0.0313758	0.010544	0.0522080	0.0034	
12	16	0.0044154	-0.016496	0.0253270	0.6775	

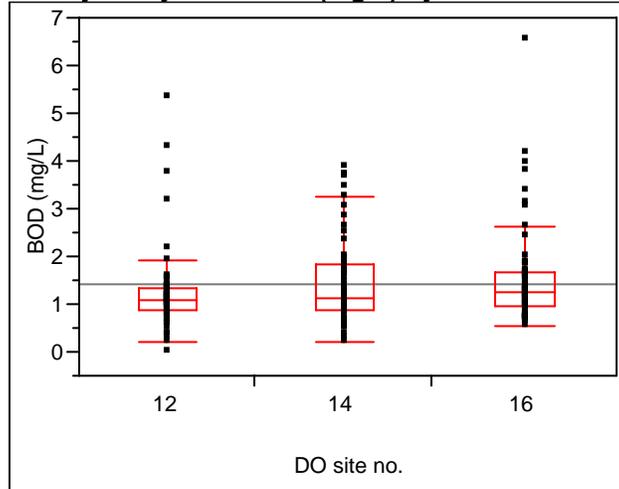
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	65	3748.50	57.6692	-2.496
14	66	4897.50	74.2045	2.496

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3748.5	-2.49574	0.0126

Analysis 11: East River Sites BOD
Oneway Analysis of BOD (mg/L) by DO site number.



Missing Rows 23

Comparisons for each pair using Student's t

t Alpha
 1.97353 0.05

Positive values show pairs of means that are significantly different.

Level		Mean (mg/L)
16	A	1.5563934
14	A	1.4770339
12	A	1.2593220

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
16	12	0.2970714	-0.052099	0.6462417	0.0949	
14	12	0.2177119	-0.134356	0.5697798	0.2239	
16	14	0.0793595	-0.269811	0.4285298	0.6543	

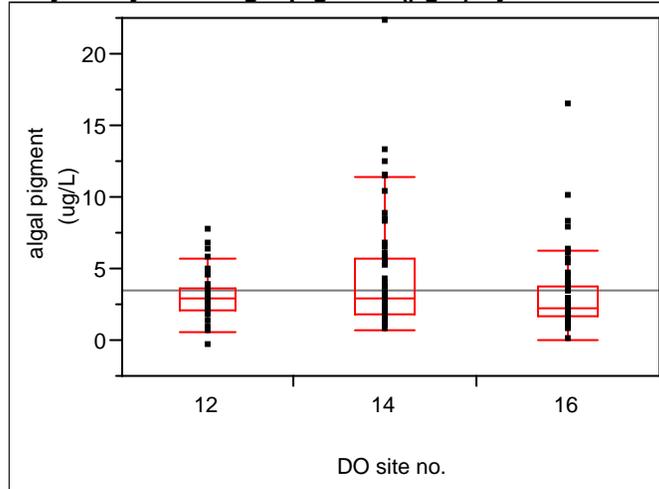
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	59	3306.50	56.0424	-1.095
14	59	3714.50	62.9576	1.095

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3714.5	1.09543	0.2733

Analysis 12: East River Sites Algal Pigment
Oneway Analysis of algal pigment ($\mu\text{g/L}$) by DO site number.



Missing Rows 20

Comparisons for each pair using Student's t

t Alpha
 1.97331 0.05

Positive values show pairs of means that are significantly different.

Level		Mean ($\mu\text{g/L}$)
14	A	4.3662903
16	B	3.0727419
12	B	2.9937931

Levels not connected by same letter are significantly different.

Level	- Level	Difference	Lower CL	Upper CL	p-Value	Difference
14	12	1.372497	0.342425	2.402569	0.0093	
14	16	1.293548	0.280790	2.306307	0.0126	
16	12	0.078949	-0.951123	1.109021	0.8800	

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
12	58	3385.50	58.3707	-0.646
14	62	3874.50	62.4919	0.646

2-Sample Test, Normal Approximation

S	Z	Prob> Z
3385.5	-0.64597	0.5183