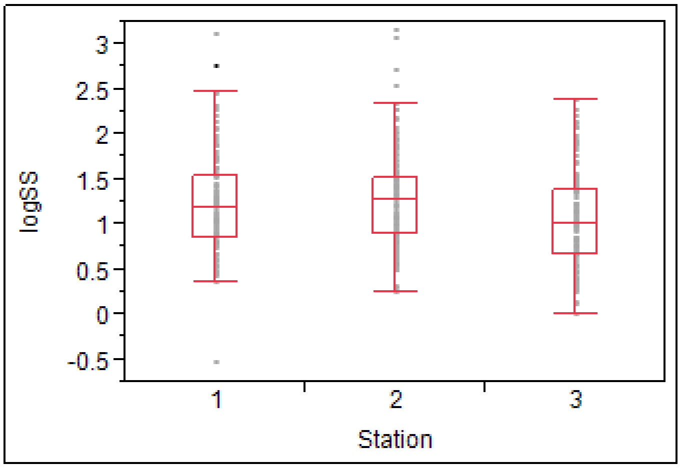
Problem 5: Compare more than two groups

When more than two groups are considered simultaneously, it is inappropriate to test all possible pairings in two-group tests such as Student's t because the variance of the entire population must be considered in a single test. To compare three or more groups, Analysis of Variance (ANOVA) or the comparable nonparametric test must be used.

a. ANOVA

Using Dataset 1 in file Sampledata.xlsx, and assuming that log-transformed data satisfy all requirements for parametric statistical analysis, apply ANOVA to test the hypothesis that mean SS concentrations (mean of log-transformed SS_1, SS_2, and SS_3) did not differ significantly among the three stations during the Treatment Period (Period=TRT).



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Station	2	4.69941	2.34970	8.6130	0.0002*
Error	453	123.58233	0.27281		
C. Total	455	128.28173			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
1	152	1.22820	0.04237	1.1449	1.3115
2	152	1.27403	0.04237	1.1908	1.3573
3	152	1.03945	0.04237	0.9562	1.1227

Although the box plot shown above seems to indicate that SS concentrations observed at the three stations fell in the same general range, ANOVA indicates that there was a significant difference among the three stations. In the above ANOVA results, the large F ratio (8.613) and low Prob>F (0.0002) indicate that we must reject the hypothesis of no significant difference in SS concentration among stations in the Treatment period. Note that ANOVA does not specify which of the group means were significantly higher or lower, only that a significant difference exists. To confirm where significant differences occur, use a multiple range test such as Duncan's, Tukey's, or Least Significant Difference (LSD). In the above example, Tukey's method showed that mean SS concentration at Station 3 was significantly lower than mean SS concentrations at Stations 1 and 2, which were not significantly different from each other.

b. Wilcoxon/Kruskal-Wallis

Using dataset #1, apply the nonparametric Wilcoxon/Kruskal-Wallace test on raw (non-transformed) data to test the hypothesis that mean SS concentrations did not differ significantly among the three stations during the Treatment Period.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
1	152	36541.5	34732.0	240.405	1.364
2	152	38437.5	34732.0	252.878	2.793
3	152	29217.0	34732.0	192.217	-4.157

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
17.9652	2	0.0001*

The large Chi-square value and $P < 0.001$ (Prob>ChiSq = 0.0001) for the nonparametric Wilcoxon/Kruskal-Wallis Test indicate that the hypothesis of no significant difference in SS concentration among stations in the Treatment period must be rejected. The score means suggest that SS concentration at Station 3 was lower than at either Station 1 or 2.