Problem 4: Compare input and output from an individual BMP

Some monitoring studies compare water quality input and output from an individual BMP such as a stormwater treatment device or a detention pond. In these cases, it is usually important to determine if a concentration or load leaving the BMP is significantly different from that entering the BMP, i.e., did the practice have a significant effect? If paired samples are collected simultaneously from input and output (e.g., for the same day or the same storm event), a paired t-Test (or comparable nonparametric test) that considers the differences between each pair of observations rather than the difference in group means can give a better interpretation of the difference between the two sampling points.

Dataset 2 in file Sampledata.xlsx represents event mean concentration data for inflow (TSS IN, EC IN) and outflow (TSS OUT, EC OUT) samples collected from a detention pond treating residential stormwater runoff during 32 individual storm events from 1992 to 1995.

a. Paired t-Test

Assume that the log-transformed data meet the requirements for parametric statistics. Use a paired t-Test to determine if total suspended solids (TSS) and *E. coli* (EC) concentrations were significantly different between inflow and outflow from the pond.

TSS

logTSS_OUT	0.99764	t-Ratio	-7.70661
logTSS_IN	1.84086	DF	31
Mean Difference	-0.8432	Prob > |t|	<.0001*
Std Error	0.10942	Prob > t	1.0000
N	32	Prob < t	<.0001*

EC

logEC_OUT	4.10307	t-Ratio	0.982301
logEC_IN	4.02099	DF	31
Mean Difference	0.08208	Prob > |t|	0.3336
Std Error	0.08356	Prob > t	0.1668
N	32	Prob < t	0.8332

The paired t-Test shows that TSS concentrations into and out of the pond differed significantly ($P \leq 0.001$); the one-tailed t statistic shows that TSS_OUT was significantly lower than TSS_IN (*P* of obtaining a lower t statistic ≤ 0.001). This is confirmed by comparing the mean logTSS_IN (1.84) against the mean logTSS_OUT (1.00). The mean difference between input/output pairs was 0.843, suggesting that the mean storm event treatment effect was about 7.0 mg/L TSS ($10^{0.8432}$).

In contrast, the paired t-Test shows that EC counts into and out of the pond did not differ significantly ($P = 0.33$). Mean EC count for outflow (12,679 col/100 ml, $10^{4.10307}$) tended to be somewhat higher than for inflow (10,495 col/100 ml, $10^{4.02099}$). The mean difference between input and output pairs was about 1 col/100 ml ($10^{0.08208}$).

b. Wilcoxon Rank Sum Test

Use the nonparametric Wilcoxon test on raw data in Dataset 2 to determine if TSS and EC concentrations differed significantly between inflow and outflow from the pond.

TSS

Wilcoxon Signed Rank

	TSS_OUT-TSS_IN
Test Statistic S	-239.00
Prob>|S|	<.0001*
Prob>S	1.0000
Prob<S	<.0001*

The result above yields the same conclusions as the paired t-Test: TSS concentrations were significantly lower in pond outflow compared to inflow (negative S statistic [TSS_OUT minus TSS_IN]).

EC

Wilcoxon Signed Rank

	EC_OUT-EC_IN
Test Statistic S	19.000
Prob>|S|	0.7284
Prob>S	0.3642
Prob<S	0.6358

The result for this test supports the same conclusions as the paired t-Test: EC counts did not differ significantly between pond inflow and outflow, although there was a slight tendency for EC counts to be higher in outflow (positive S statistic [EC_OUT minus EC_IN]).