

Attachment 1

Mann-Kendall Test for an Upward Trend

The Mann-Kendall Test is a non-parametric statistical trend test in which the increases and decreases in concentrations are compared to determine if a trend in concentrations is occurring.

The procedure for applying this test is as follows:

1. For n data points, assemble the data points in chronological order from earliest (x_1) to latest (x_n)
2. Form every possible combination of data pairs (x_j, x_k), such that $j < k$.
3. Assign a value to each pair according to the following rule:
 - a. $v(x_j, x_k) = +1$, if $x_j < x_k$
 - b. $v(x_j, x_k) = -1$, if $x_j > x_k$
 - c. $v(x_j, x_k) = 0$, if $x_j = x_k$

Mann Kendal Worksheet						
Data Points	x_1	x_2	x_{i+2}	x_{i+3}	x_n
		$v(x_1, x_2)$	$v(x_2, x_3)$	$v(x_3, x_4)$		$v(x_{n-1}, x_n)$
			$v(x_1, x_3)$	$v(x_2, x_4)$		$v(x_{n-2}, x_n)$
				$v(x_1, x_4)$		$v(x_{n-3}, x_n)$
					
						$v(x_1, x_n)$
Sum						$\sum v$

4. Sum the values of all of the pairs.
5. Compare the value of the sum to a critical value corresponding to the specified confidence level (e.g., 90% confidence level) and number of data points. Critical values are available in Tables in Gilbert¹ ($n \leq 10$) or in Hollander and Wolfe² ($n \leq 40$).

¹ Gilbert, R.O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York.

² Hollander, M. and Wolfe, D.A., 1973, Nonparametric Statistical Methods, Wiley, New York.

