Title: **Graphical and Statistical Methods to Assess the Effect of Landfills on Groundwater Quality (Study No. 15)**

Investigators: Principal Investigator

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Objectives: To develop graphical and statistical data evaluation procedures to analyze
                         contamination of landfills.

Methods: The investigators selected constituents for analysis, chose landfills for
                         detailed study and devised a method for viewing the data in order to put its
                         variability into context. Appropriate statistical tests were selected and the
                         responses of indicator parameters and health and welfare constituents
                         compared. The following constituents were selected for monitoring based on
                         availability of data: chloride, chemical oxygen demand (COD), pH,
                         alkalinity, hardness, conductivity and sulfate. Detailed studies were
                         conducted on landfill sites for which there was hydrologic information and at
                         which there existed multiple wells with relatively long records. The sites
                         included a variety of landfill designs. Comparisons were made between
                         apparent contamination by volatile organic compounds (VOCs) and
                         contamination based on analysis of COD and inorganic data.

Results/Conclusions: Data evaluation shows that conventional statistical frameworks which impose
                         an artificial upgradient/downgradient well classification as the basis for
                         analysis can lead to incorrect inferences. Traditional parametric statistical
                         methods are of questionable value because of non-normality and lack of
                         independence, as well as unequal sample sizes, data gaps and erratic values.
                         Sophisticated statistical techniques are available to account for serial
                         dependence or non-normal probability models, though they are not generally
                         applicable to typical landfill data sets. The recommended procedure
                         includes standardization of data using the landfill site median and median
                         interquartile range for each constituent. Graphic representations of the
                         standardized data illustrate distributional characteristics of the data and
                         facilitate identification of potentially contaminated wells by emphasizing the
                         relative spatial variability. Tests for trend and time-series plots can then
                         identify wells showing temporal degradation of groundwater quality based on
                         data for inorganic constituents and COD. The methods developed in this
                         study are tailored to the quality of the data and scarce hydrologic
                         information and are insensitive to distributional assumptions and erratic
                         values.

Recommendations/ Implications:	Investigators recommend further development of a control chart encompassing individual observations standardized by the median and median interquartile range. This would involve a simple, approximate control chart technique based on the non-parametric standardized values and time-series plots to monitor landfill sites in a time-efficient, routine manner.
Availability of Report:	This report is available for viewing and loan at: The Water Resources Center 1975 Willow Drive Madison, WI 53706 (608) 262-3069 Publication 050847
Related Publications:	Study No. 16
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