The Use of Geostatistical Models in the Determination of Whole Landfill Emission Rates

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Background

The use of kriging models to estimate the spatial distribution of environmental phenomenon is become increasing popular. Kriging models have been used in the application of spatial variability of soil properties (van Bergeijk, et al. 2001; Juang, et al. 2001) and carbon dioxide efflux rates from the surface of soils (Gerlach, et al. 2001). In addition, co-kriging and more recently regression kriging analyses have been used to limit the cost of field sampling by modeling natural relationships among the variable that is more expensive to measure (time + monetary) and those variables (co-variates) that are more easily measured and least expensive to obtain (Chappel, 1997; Shinn, et al. 2000; van Bergeijk, et al. 2001). Geostatistical models can deal with abnormally large skewness and deviation from normal distributions due to the robustness of appropriate semivariance equations and kriging algorithms (Cressie, 1993). Kriging algorithms on carbon dioxide soil efflux rates have been compared to more traditional triangulation models and it has indicated that the non-normal distribution of the surface efflux rates have not distorted the predictions made with the kriging models (Gerlach, et al. 2001).

Overview of Research

The main conclusions in landfill studies to date, is that the geospatial analysis can only be used for the qualitative analysis of the landfill emission rates (Borjesson, et al. 2000). The main goal of this research is to examine when geostatistics can be used in a quantitative manner. The utilization of geospatial analysis techniques were evaluated for their application for estimating the surface emission rate from spatially distributed flux chamber measurements. The estimation of the whole surface emission rate can be problematic when there are only limited discontinuous surface chamber measurements. The complication results from the heterogeneity in the resulting flux measurements across the surface of the landfill and the possibility of not having samples spaced at separation distances small enough to capture the spatial variability. Furthermore, in order to collect an adequate number of chamber flux measurements to describe the large surface area can take several days, which could mean changes in the spatial distribution of the flux during the course of the measurements. Extreme care must be used in the application of various geospatial models due to the lack of the model's ability to predict the spatial distribution. Therefore, a methodology was sought that did not make any assumptions on the distribution of the flux measurements, but still allow the interpolation of discrete flux measurements to evaluate the entire surface emission rate. The use of the site methane mass balance was used to assess the validity of the resulting surface methane flux rates.

Results

The particular landfill that was investigated for this presentation was the CGEA - Onyx Lapouyade landfill situated near Bordeaux in France. This site has been operating since October 1996, receiving approximately 160,000 metric tons of waste per year. This site consists of two different cover configurations: (i) a final covered zone since 1998 and (ii) an operating zone including temporary covered cells with or without biogas recovery. The two areas that were investigated with the geospatial analysis were the Phase I (final covered area) and cell A8 of the Phase II cells (operating zone) on two different dates December 2000 and September 2001. Figure 1 show the modeled variogram given the emission rates for December 2000 for cell A8. Spatial structure is weak but good enough to proceed with kriging.

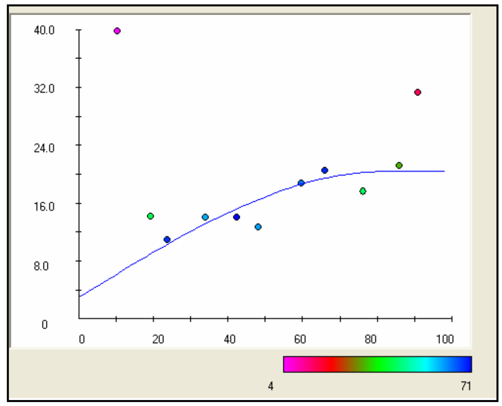

Figure 1. Methane Flux Variogram

Figure 2 illustrates the interpolated map of the kriged values based on the above variogram model conducted on cell A8 from Lapouyade site (France). Flux rates for specific flux intervals were calculated using the surface area function in Surfer and then these values were added to yield an overall methane flux for the landfill.

The modeled results do compare favorably to the whole landfill emission rates through the application of a landfill methane balance even though spatial structure (as seen in the variogram) is weak at best.

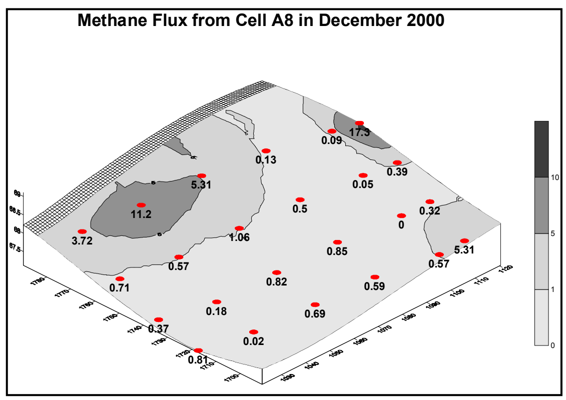

Figure 2. Interpolated Flux Values for December 2000

Additional work is needed in particular in the potential of using co-kriging models (example soil moisture or soil temperature) for increasing accurate spatial prediction of the methane flux rates.

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