Improving Weather Generation in HELP for Non-US Locations

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Abstract
- experiences in developing the HELP weather generator for use in Chile and New Zealand
- implications for others who use HELP in landfill research

Introduction
- HELP commonly used for leachate estimations; HELP technique; useful research tool as well as design/regulatory tool.
- WGEN used in HELP; WGEN methodology
- Only US data in standard HELP
- WHI provides international sites with Visual HELP
- Can use existing data with bootstrapping, but not enough or for extremes; need for stochastic weather; stochastic weather still requires data
- Other weather generators available, but similar
- Need to develop/check weather generators for other countries

Data Considerations
- data sources
- data errors and data filters
- data record length important

Weather Sensitivity
* sensitivity results for HELP; precipitation most important

Temperature Effects
- WGEN trap that some constants in program code only apply to US
- A and B matricies vary with latitude; big factor in Chile

Seasonal Precipitation Effects
- importance of winter precipitation for leachate generation (not news)
- annual precipitation poor statistic for judging leachate potential
- relatively similar %infiltration in spite of differences in precipitation for Chile

New Directions
- extreme precipitation events
- ET parameters currently extrapolated from N. American values
- local variations: slope, elevation, aspect
- sub-day time step?
- Consistent crudeness needed: no point in improving weather generator too much if HELP has other problems

References

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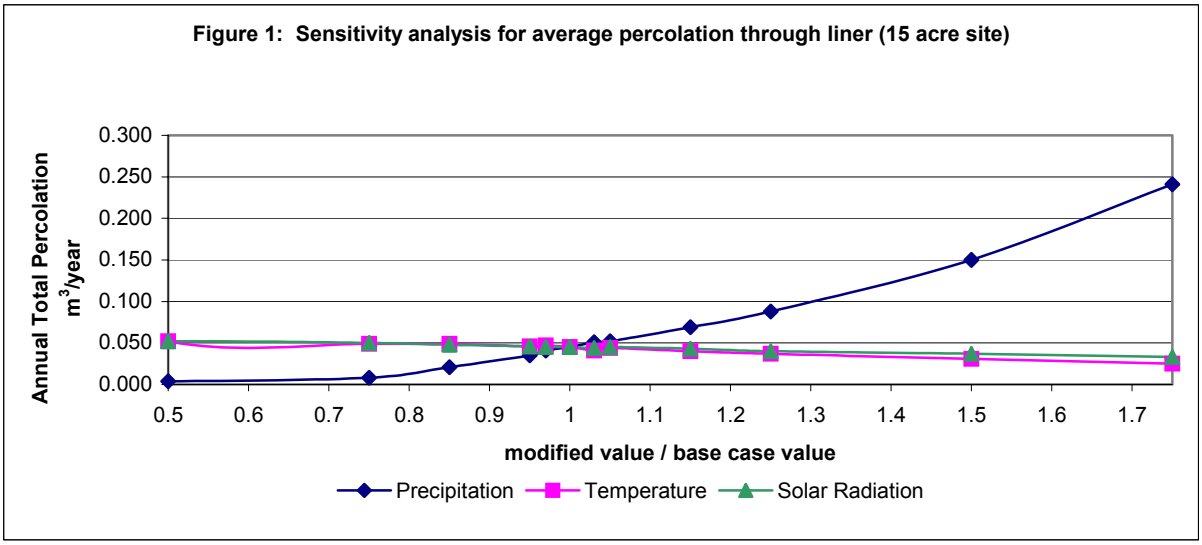
Our research has improved the Hydrologic Evaluation of Landfill Performance (HELP) program's weather options for use in Chile and New Zealand. The HELP model estimates leachate production and leakage from landfills under various design choices. Our experiences have implications for those who use HELP in design, regulatory, or research applications.

HELP requires daily weather inputs for precipitation, average temperature, and solar radiation. The program can use either measured data provided by the user or simulated values generated by a stochastic weather generator. The stochastic weather generator, WGEN, requires a number of monthly parameters. The standard version of HELP has data and WGEN parameters for 142 continental U.S. cities. Waterloo Hydrogeologic Inc. has developed Visual HELP with an ability to access weather data and statistics from a number of non-U.S. locations. The WHI weather generator has no locations in New Zealand, and inadequate coverage of locations in Chile.

The research found that the length and quality of the weather data are key to producing robust weather generation parameters. Precipitation and temperature data for the research were purchased or downloaded from the US National Climatic Data Center (located right here in Asheville!) (http://lwf.ncdc.noaa.gov/oa/ncdc.html) and the Direccion General de Aguas, Chile. Solar radiation data were downloaded from the World Radiation Data Centre (http://wrdc-mgo.nrel.gov/). The data sets needed preprocessing prior to their use for WGEN parameter generation. Missing data (less or far less than 1% of days) were identified and replaced based on qualitative weather description flags in the database. In some cases, daily precipitation values were created from 6 or 12 hour precipitation data. In addition, the data sets were screened for outliers by checking values against monthly averages. Outliers were identified in all data sets; we found that for dry locations, an erroneously high precipitation value in the data set can significantly affect the estimated weather parameter.

Figure 1: Sensitivity analysis for average percolation through liner (15 acre site)

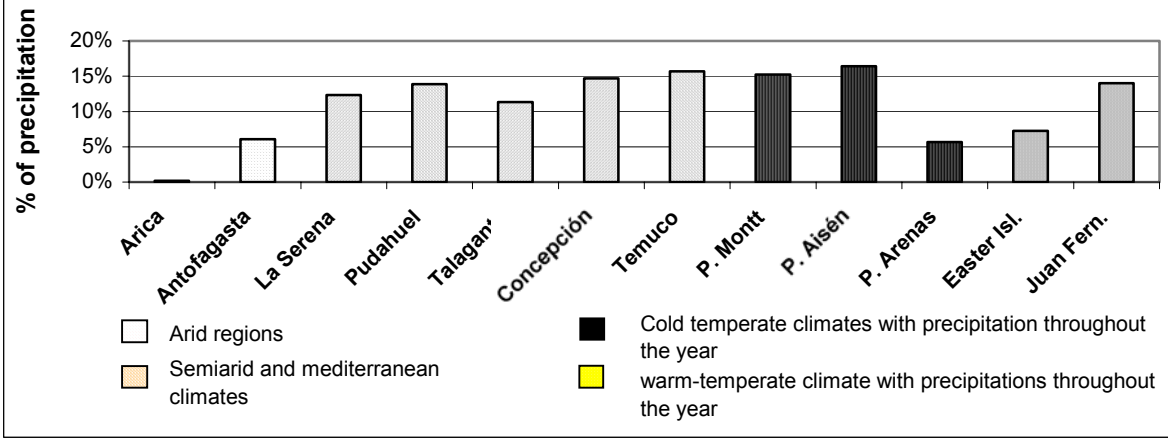


A one-way sensitivity analysis was conducted to see the relative impact of mean weather values on leachate leakage for a standard landfill design. The base-case used was the weather of San Diego, CA, USA. The results are shown above and indicate that precipitation means are key weather inputs, which implies that more effort should be focused on improving the reliability of simulated precipitation rather than simulated temperature or solar radiation. We conclude that 20 years of precipitation data and 10 years of temperature and solar radiation data are minimum requirements for developing reliable WGEN parameters. For dry climates, our results indicate that 20 years of data is not sufficient.

Although leachate and leakage estimates are not strongly dependent on simulated temperature, our research has indicated a number of factors that can contribute to poor temperature simulation when using the WGEN/HELP program. The WGEN program has both user-defined inputs and fixed constants. Some of the fixed temperature constants are particular to North America, and these constants need to be changed inside the program for locations with latitudes outside of the range of 30-50°. New "A" and "B" matrix constants were developed in this research for weather generation in Chile, where latitude varies from 19° to 52°.

Simulation results for a series of Chilean locations have highlighted the importance of the seasonality of precipitation, something previously seen (Blight, et al., 1992). The results of this research show that the amount of winter precipitation is more relevant to leachate generation than total annual precipitation. The results also show that the simulated percentage of precipitation that enters a landfill cap can be relatively constant over a wide range of Chilean climates, because in Chile, dry climates have winter rain, while wetter climates have progressively more non-winter rain, with little change in winter rain.

Figure 2: Leachate collected over a range of Chilean climates
(expressed as a % of precipitation)



Key future needs seem to be better modeling of:

- extreme precipitation events,
- evapotranspiration through use of measurement-based parameters,
- adjustment factors for weather parameters at weather stations to those at landfill sites, and
- finer time-steps than daily ones.

Because the modeling of moisture movement in soils and landfill are only crudely modeled within HELP, any future improvements in weather generation need to be aim to provide consistent crudeness in HELP modeling.