Leachate generation rate modeling using artificial intelligence algorithms aided by input optimization method for an MSW landfill

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Abstract
Leachate is one of the main surface water pollution sources in Selangor State (SS), Malaysia. The prediction of leachate amounts is elementary in sustainable waste management and leachate treatment processes, before discharging to surrounding environment. In developing countries, the accurate evaluation of leachate generation rates has often considered a challenge due to the lack of reliable data and high measurement costs. Leachate generation is related to several factors, including meteorological data, waste generation rates, and landfill design conditions. The high variations in these factors lead to complicating leachate modeling processes. This study aims at identifying the key elements contributing to leachate production and developing various AI-based models to predict leachate generation rates. These models included Artificial Neural Network (ANN)-Multi-linear perceptron (MLP) with single and double hidden layers, and support vector machine (SVM) regression time series algorithms. Various performance measures were applied to evaluate the developed model’s accuracy. In this study, input optimization process showed that three inputs were acceptable for modeling the leachate generation rates, namely dumped waste quantity, rainfall level, and emanated gases. The initial performance analysis showed that ANN-MLP2 model—which applies two hidden layers—achieved the best performance, then followed by ANN-MLP1 model—which applies one hidden layer and three inputs—while SVM model gave the lowest performance. Range and frequency of relative error (RE%) also demonstrate that ANN-MLP models outperformed SVM models. Furthermore, low and peak flow criterion (LFC and PFC) assessment of leachate inflow values in ANN-MLP model with two hidden layers made more accurate values than other models. Since minimizing data collection and processing efforts as well as minimizing modeling complexity are critical in the hydrological modeling process, the applied input optimization process and the developed models in this study were able to provide a good performance in the modeling of leachate generation efficiently.

Keywords Landfill leachate . Input optimization . Artificial neural network-multilayers perceptron (ANN-MLP) . Regression support vector machine (R-SVM)

Introduction
Background

In many developing countries, waste generation rates are rapidly increasing due to many factors such as rapid population growth and urbanization. For instance, the daily waste generation rates in Malaysia escalated gradually between 2000 and 2012 from 15,586 to 28,565 tons, and are expected to increase by around 1000 tons per year (Tiew et al. 2015). By far, the most applied method for the final disposal of these wastes in Malaysia is landfilling (Malakahmad et al. 2017), where about 95% of the generated waste is conventionally disposed into landfills (Tiew et al. 2015).

Various physical, chemical, and biological reactions occur in landfill sites during waste decomposition and result in extremely contaminated landfill leachate and landfill gases (LFG) (Vaverková and Adamcová 2015). Leachate management is among the key elements to be considered in landfill design and operation activities due to its various inorganic and organic contents as well as heavy metals (Vithanage et al. 2017).

Leachate is produced as an outcome of both waste moisture content and rainfall percolation into the landfill body, and contains high concentrations of conventional, non-conventional,