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Artificial Neural Network Modeling for Prediction of Bioenergy Production and Organic Pollutant Removal from Simulated Co-Disposed Landfills

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Extreme exploitation of fossil fuels has imposed catastrophic scarcity of energy sources, worldwide. Bioenergy is extremely pertinent to renewable energy alternatives. Municipal solid waste (MSW) and industrial organic waste has sufficient energy potential due to ample organic content. Moreover, landfilling being most economic disposal method offers incubated treatment of solid waste along with production of gases for energy generation. Bioreactor landfills are the new advancements to conventional landfills which accelerates the bioenergy production through incorporation of leachate recirculation. In this research, four simulated anaerobic landfill bioreactors co-disposed with paper mill sludge (PMS) as an industrial organic waste and MSW in three different proportions were installed. One reactor was kept as control (BRL1) with sole disposal of MSW along with other co-landfilled reactors with ratios of PMS and MSW as 1:3 (BRL2), 1:1 (BRL3) and 3:1 (BRL4). Leachate produced from each landfill reactors was utilized for moisture maintenance and degradation enhancement through its recirculation. Periodic analysis of leachate physico-chemical parameters and chromatographic analysis of landfill gas were performed until 300 days of landfilling. Artificial neural network (ANN) modeling was performed to predict biogas production and leachate organic pollutants removal from operating anaerobic landfill simulators. Experimented physico-chemical parameters including pH, electrical conductivity, volatile solids, volatile fatty acids, total alkalinity, ammoniacal and total nitrogen were used as input layer for neural network modeling. Different sets of output layers for leachate pollutants (chemical oxygen demand and total heavy metal concentrations) and biogas yield were decided for individual ANN training. Levenberg-Marquardt algorithm was used to train data sets with 10 number of hidden layers, 15% validation and 15% testing. Moreover, the performance of each landfill reactor was optimized statistically using back propagation network model. Over the completion of landfilling process, BRL3 with equal co-disposal ration of PMS and MSW fetched maximum biogas yield of 146.14 mL/VS/d, which was 1.53, 1.33 and 2.35 times more than that of BRL2, BRL4 and BRL1, respectively. The prediction model could forecast and statistically optimize the biogas content with excellent fitting with experimented data (R^2 > 0.95). This study expands the dimensions of experimental and mathematical investigations for co-landfilling practices for not only acquiring energy out of simultaneously co-landfilled solid wastes from distinct origins but also supports the attempts for diminishing its leachate pollutant concentrations.

Keywords: Artificial neural network, Bioenergy production, Landfills, Co-disposal, Municipal solid waste, Paper mill sludge