World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:18, No:07, 2024

An Evaluation of the Artificial Neural Network and Adaptive Neuro Fuzzy Inference System Predictive Models for the Remediation of Crude Oil-Contaminated Soil Using Vermicompost

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Abstract : Vermicompost is the product of the decomposition process using various species of worms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vemicast. This process is called vermicomposting, while the rearing of worms for this purpose is called vermiculture. Several works have verified the adsorption of toxic metals using vermicompost but the application is still scarce for the retention of organic compounds. This research brings to knowledge the effectiveness of earthworm waste (vermicompost) for the remediation of crude oil contaminated soils. The remediation methods adopted in this study were two soil washing methods namely, batch and column process which represent laboratory and in-situ remediation. Characterization of the vermicompost and crude oil contaminated soil were performed before and after the soil washing using Fourier transform infrared (FTIR), scanning electron microscopy (SEM), X-ray fluorescence (XRF), X-ray diffraction (XRD) and Atomic adsorption spectrometry (AAS). The optimization of washing parameters, using response surface methodology (RSM) based on Box-Behnken Design was performed on the response from the laboratory experimental results. This study also investigated the application of machine learning models [Artificial neural network (ANN), Adaptive neuro fuzzy inference system (ANFIS). ANN and ANFIS were evaluated using the coefficient of determination (R^2) and mean square error (MSE)]. Removal efficiency obtained from the Box-Behnken design experiment ranged from 29% to 98.9% for batch process remediation. Optimization of the experimental factors carried out using numerical optimization techniques by applying desirability function method of the response surface methodology (RSM) produce the highest removal efficiency of 98.9% at absorbent dosage of 34.53 grams, adsorbate concentration of 69.11 (g/ml), contact time of 25.96 (min), and pH value of 7.71, respectively. Removal efficiency obtained from the multilevel general factorial design experiment ranged from 56% to 92% for column process remediation. The coefficient of determination (R^2) for ANN was (0.9974) and (0.9852) for batch and column process, respectively, showing the agreement between experimental and predicted results. For batch and column precess, respectively, the coefficient of determination (R^2) for RSM was (0.9712) and (0.9614), which also demonstrates agreement between experimental and projected findings. For the batch and column processes, the ANFIS coefficient of determination was (0.7115) and (0.9978), respectively. It can be concluded that machine learning models can predict the removal of crude oil from polluted soil using vermicompost. Therefore, it is recommended to use machines learning models to predict the removal of crude oil from contaminated soil using vermicompost.

Keywords : ANFIS, ANN, crude-oil, contaminated soil, remediation and vermicompost
Conference Title : ICEBBGSM 2024 : International Conference on Environmental Biotechnology, Bioremediation and Green Sustainable Manufacturing
Conference Location : Toronto, Canada
Conference Dates : July 18-19, 2024