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Comparison of enhanced neural network and response surface models in predicting bio-dissolution of aluminum and vanadium from bauxite residue by isolated *Aspergillus niger* strains

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A R T I C L E I N F O

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Bioleaching
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A B S T R A C T

Background: Recovery of Al and V from red mud, a hazardous residue of the Bayer process, using bioleaching is a nature-based waste management solution that simultaneously improves environment protection and metallurgical recoveries.

Methods: For the first time, a novel hybrid multilayer Perceptron (MLP) network enhanced by an Imperialist Competitive Algorithm (ICA), and a response surface developed based on a factorial experiment design methodology (RSM) were employed and compared for, prediction optimization and optimization prediction of Al and V bioleaching by strains of A. Niger microorganisms isolated from pistachio shells and grape skins. The controlling variables were fungi source (A), adoption strategy (B), solid activation (C), solid percent (D), and bioleaching time. Considering the stochastic nature of ICA, a multi-criteria-ranking system based on accuracy and error indices was developed to select the best MLP. Probability value at 95% confidence interval, lack-of-fit, analysis of variance, R^2, Adj. R^2, and predicted R^2 were the judges for the determination of the developed model's statistical significance.

Significant Findings: Based on ANOVA, between A, B, C, and D, the effectiveness orders of $A > D >$ C>AC>AD on Al, and A>AD>C>AC>D on V bioleaching were obtained. The superiority of the developed hybrid ICA-MLP model over the developed RSM model in predicting Al and V dissolution was determined by NSE, RSME, MAE, and MEDAE. Parameters optimization and consequently evaluating optimum condition repeatability through three repeating experiments resulted in maximum dissolution recoveries of RSM: 96.5% for Al and 91.2% for V, and ICA-MLP: 97.1% for Al and 90.3% for V. Considering the lower relative errors of repeating validation tests, it can be concluded that, although both models provide reasonable results, but the ICA-MLP methodology is more reliable (relative error <1.8%).

1. Introduction

Nowadays, the implication of a microorganism-based, facile, and environmentally friendly technique to leach valuable metals from a vast type of industrial/urban waste has gained attention. Bioleaching facilitates the production of soluble entities mediated by a variety of microorganisms, from bacteria to fungi and archaea. Nowadays, bioleaching is highly encouraged, as it provides an eco-friendly, cost-effective, and competent solution to process wastes/wastewater, spent catalysts, low-grade ores, and mine tailings [1-6]. There are pros and cons once bioleaching is compared to chemical leaching in most cases requires accurate and detailed considerations for large-scale implementation as well as the economy of the process. Limitations in solution pH (pH above 0.5), longer operation time for similar dissolution yield, and higher infrastructure costs could be addressed as issues against bioleaching while, being a greener technology, feasibility of in-site acid production and therefore less acid transport costs and hazards, possibility of acid production from wastes, applicable to the low-grade ores or industrial/electrical wastes, and in general, less environmental pollutions could be addressed as advantages of bioleaching towards chemical leaching [6-8].

The mechanisms involved in metal solubilization through

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