Groundwater for Sustainable Development 9 (2019) 100232

Contents lists available at ScienceDirect

Groundwater for Sustainable Development

journal homepage: www.elsevier.com/locate/gsd

Research paper

Support vector regression (SVR)-based adsorption model for Ni (II) ions removal

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ARTICLE INFO

Keywords:
Adsorption
Low-cost adsorbent
Support vector regression
Structural risk minimization

ABSTRACT

Removal of heavy metals with adsorption using low-cost adsorbents has motivated many researchers across the world. In this work, support vector regression (SVR) model is developed for the prediction of the removal efficiency of Ni(II) ions using the waste from tea factory in terms of the independent parameters namely, particle size of adsorbent, pH of the solution, initial Ni (II) ion concentration, flow rate, effluent volume, bed depth and contact time. The SVR-based model is compared with the multiple linear regression (MLR) model using the statistical parameters. The correlation coefficient (R) and the average absolute relative error (AARE) values for the SVR-based has been obtained as 0.993 and 6.88% while those of MLR model they are 0.8393 and 74.54% respectively. The developed state-of-the-art SVR model, based on the structural risk minimization (SRM) principle, is found to predict the experimental values more accurately and is highly generalized.

1. Introduction

Pollution due to Ni(II) ions is of great concern across the globe because of its toxicity and harmful effects on human health like lung cancer, chronic bronchitis, dermatitis and asthma (Sud et al., 2008). Conventional methods which were used earlier for removal of metal ions like chemical precipitation, ion exchange, chemical oxidation/reduction, reverse osmosis etc. suffer from many disadvantages such as less efficiency, sensitive operating conditions, and production of non-biodegradable sludge leading to high disposal cost. Another more powerful technology as an alternative to these existing methods is the adsorption of heavy metals using low-cost adsorbent for treating the domestic and industrial wastewater (Ju and Ezuma, 2014).

In the recent past support vector machines have become very popular for classification and regression purposes as support vector classification (SVC) and support vector regression (SVR) (Gunn, 1997). SVR-based models do not suffer from over-fitting problems i.e. high accuracy for training dataset and low for test dataset (unseen) as they are based on structural risk minimization (SRM) principle which always guarantees a unique, global and optimal solution. SVR-based models do not rely on the amount of data. Even with a fewer amount of data they can give a good prediction. However, the only disadvantage of using SVR technique is that it requires an efficient parameter optimization to give prediction with higher accuracy i.e. SVR model parameters needs to be optimized via some optimization techniques (grid search methodology with 10-fold cross-validation, particle swarm optimization (PSO), genetic algorithm (GA), differential evolution (DE) etc.). The more robust the optimization of SVR model parameters, the better is the prediction accuracy and generalization of the SVR model.

Recently, SVR has found its application for prediction purposes such as time series prediction (Thissen et al., 2003), predicting thermal-hydraulic performances in compact heat exchangers (Peng and Ling, 2015), prediction of circulation rate and heat transfer coefficient in thermosiphon reboilers (Zaidi, 2015, 2012), predicting the auto-ignition temperatures of the organic compounds (Pan et al., 2009), atmospheric temperature prediction (Radhika and Shashi, 2009), prediction of sorption capacity of heavy metals (Parveen et al., 2017a, 2016) etc. Fawzy et al. (2016) studied the biosorption process of Ni(II) and Cd(II) ions from aqueous solution using *Typha domingensis* as a biosorbent. The effects of input parameters such as initial pH, biomass dosage, initial metal-ions concentration, contact time and particle size on the biosorption efficiency were also investigated. Furthermore, the experimental data was fitted to Langmuir and Freundlich isotherm models and biosorption kinetics (pseudo-first-order and pseudo-second order) were also determined. Another similar study was performed by Fawzy et al. (2018) for Ni(II) ion biosorption from aqueous solution using *Potamogeton pectinatus* as a biosorbent. A removal efficiency of 63.4% of Ni(II)-ions was achieved at the optimum pH value of 5, biosorbent dosage 10 g/L, particle-size: 0.125–0.25 mm within 180 min. Artificial neural network (ANN) structure of 5-6-1 predicted the adsorption

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https://doi.org/10.1016/j.gsd.2019.100232
Received 27 May 2018; Received in revised form 26 May 2019; Accepted 26 May 2019
Available online 28 May 2019
2352-801X/