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Support vector regression: A novel soft computing technique for predicting the removal of cadmium from wastewater

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The presence of toxic heavy metals in the wastewater coming from industries is of great concern across the world. In the present work, a novel soft computing technique support vector regression (SVR)technique has been used to predict the removal of cadmium ions from wastewater with agricultural waste 'rice polish' as a low-cost adsorbent, with contact time, initial adsorbate concentration, *p*H of the medium, and temperature as the independent parameters. The developed SVR-based model has been compared with the widely used multiple regression (MR) model based on the statistical parameters such as coefficient of determination (R^2), average relative error (AARE) etc. The prediction performance of SVR-based model has been found to be more accurate and generalized in comparison to MR model with low AARE values of 0.67% and high R^2 values of 0.9997 while MR model gives an AARE value of 29.27% and 0.2161 as coefficient of determination (R^2). Furthermore, it has also been observed that the SVR model effectively predicts the behavior of the complex interaction process of cadmium ions removal from waste water under various experimental conditions.

Keywords: Heavy metals, Low cost adsorbent, Support vector regression (SVR), Coefficient of determination (R^2), Average relative error (AARE)

Cadmium being the toxic heavy metal is of great concern across the world as its long-term exposer in the environment can cause kidney damage, high blood pressure, renal disorder, bone degradation, anemia and destruction of red blood cells. The major source of cadmium discharge in the environment include mining industries, metal plating, pigments, phosphate fertilizer, cadmium nickel batteries, stabilizers and alloys[1,2]. Various conventional technologies have been used in the past for the removal of heavy metals like membrane process, filtration, ion exchange, precipitation, solvent extraction etc[3-5]. Adsorption process has offered an ideal alternative to these technologies, being economical and efficient treatment method for wastewater treatment[6,7]. However, its performance is mostly affected by the type of adsorbent used. A lot of research is going on natural materials to be used as adsorbent such as saw dust, rice husk, fly ash, tea waste etc., since these are environmental friendly, low cost, biodegradable and having high metal recovery[8,9].

There are many factors that influence the heavy metal removal in an adsorption process such as initial concentration of adsorbate, operating temperature, pressure, initial *p*H, contact time, and other coexisting substances and adsorbent structure[10]. Several techniques like multiple regression (MR), artificial neural network (ANN), genetic algorithm (GA) etc. are being used to predict the heavy metal removal efficiency[11-13]. Recently, support vector machine (SVM), an artificial intelligence (AI) technique have been developed as a support vector classification (SVC) and support vector regression (SVR). The support vector machines (SVMs)based on the superior structural risk minimization (SRM) principle offer a lot of advantages over the traditional techniques ANN and MR such as unique, global and optimal solution[14,15]. The most commonly used multiple regression (MR) technique suffers from multiple local solutions, over-fit to data and often leads to poor generalizability. This means good performance for training dataset and poor performance for unseen test dataset. Thus, in the present work, the issue has been address to explore the use of SVR to predict and analyze the adsorption capacity of Cd (II) ions. The applicability of SVR-based models in the field of chemical engineering has been well demonstrated[16-21].