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Prediction of MEUF process performance using artificial neural networks and ANFIS approaches

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ABSTRACT

In the present study, a micellar-enhanced ultrafiltration (MEUF) procedure for the separation of lead ions from aqueous solution using response surface methodology (RSM) has been proposed. Due to the extreme complexity and nonlinearity of membrane separation processes, two models, including a feed forward artificial neural network (ANN) and an adaptive neuro-fuzzy inference system (ANFIS) have been utilized. These simulation methods have been given extreme accurate model that are more efficient than the second quadratic mathematical model for both response variables. The results of ANN and ANFIS models have been shown that the independent predicted rejection and permeate values were compared to measured target values and good correlations were found ($R^2 > 0.92$, $R^2 > 0.97$) for two above mentioned approaches, respectively.

1. Introduction

Pb (II) is a common heavy metal that contaminates water through various industrial activities such as mining, metal coating, television tube, and battery production. Even at low concentrations, these metals can be toxic to different organisms, *i.e.* human's organism [1,2]. In recent years various wastewater treatment methods to remove the heavy metal ions, such as chemical precipitation, ion exchange, coagulation–flocculation, flotation and adsorption have been developed as the result of high environmental risks of the wastewater discharge and rising water scarcity in the world [3–5]. Somerset *et al.* [6] utilized synthesized zeolites from fly ash (FA) and related co-disposal filtrates as low-cost adsorbent material to remove lead and mercury. Kaczala *et al.* [7] employed batch sorption with untreated Pinus sylvestris sawdust as low-cost adsorbents to remove vanadium and lead from a existent industrial wastewater. Bahadir *et al.* [8] used biosorption to remove Pb (II) ions from the storage battery industry wastewater using Rhizopus arrhizus that offers the advantages of low operating costs and the possibility of metal recovery. Sabry *et al.* [9] did an extensive study on the removal of Pb (II) from aqueous solutions using an emulsion liquid membrane (ELM) technique.

In recent years, a search for new non-classical separations has been observed. Membrane processes have provided a viable alternative for heavy metal recovery, as they can achieve high performance, have low energy costs and mild operating conditions [10]; these are some of the reasons that have made the membrane processes more and more widespread. Among them, hybrid processing such as micellar-enhanced ultrafiltration (MEUF) has been used for the removal of various organic and inorganic pollutants [11]. In order to obtain the highest retentions, surface active agents which have electric charge opposite to charge of the ions to be removed, have to be used [12]. Metal is removed through the adsorption onto surfactant micelles, as a result, the surfactant concentration become higher than its critical micellar concentration (CMC) [13]. The solutes can be retained after trapping by the micelles, whereas the untrapped species readily pass through the UF membranes [14]. The advantages of this method are the low-energy requirements and its high removal efficiency [15,16].

The main purpose of computer software that is based on artificial intelligence methods is to achieve a set of local input–output relationships describing a certain process. These models have excellent capabilities to describe a given system [17]. Such approaches are suitable for uncertain or approximate reasoning when the systems are complex to describe with a mathematical model. They allow problem solving and decision making with incomplete or uncertain information [18].

Furthermore, their ability to model non-linear processes, adaptive learning, real time operation and ease of insertion into

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