Description of Lead Removal from Aqueous Solution Onto Eggshell Using Artificial Neural Network

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Abstract:

A 130 batch experiments were conducted for prediction the uptake of Pb(II) from simulated aqueous solutions onto chicken eggshell using artificial neural network model. Many operational conditions are considered in this process such as contact time (10-240 min), initial pH of the solution (3-7), initial lead concentration (50-300 mg/l), eggshell dosage (0.1-4 g/100 ml), and agitation speed (0-300 rpm). The best values of these parameters that achieved the maximum uptake (=90 %) of Pb(II) were 60 min, 5, 50 mg/l, 2 g/100 ml, and 200 rpm respectively at room temperature (=25 ºC). The artificial neural network model was able to predict sorption efficiency with a tangent sigmoid transfer function at hidden layer and a linear transfer function at output layer based on10 neurons. The linear regression between the outputs of the model and the corresponding targets were acceptable with a correlation coefficient of 0.99738 for adopted variables.

Keywords: Sorption; Neural network; Eggshell; Batch; Pollution.

الخلاصة:

تم اجراء١٣٠ من تجارب الدفعة للتنبؤ بإمتصاص الرصاص (الثنائي) من المحاليل المائية المحاكاة على قشر بيض الدجاج باستخدام نموذج الشبكة العصبية الاصطناعية. العديد من الظروف التشغيلية أخذت بنظر الأعتبار في هذه العملية مثل زمن التماس (١٠-٢٤٠ دقيقة)، درجة الحموضة الأولية للمحلول (٣-٧)، التركيز الأولي الرصاص (٥٠-٣٠٠ ملغم / لتر)، الجرعة لقشر البيض (٠,١-٤ غم / ١٠٠ مل)، وسرعة الإهتزاز (٠-٣٠٠ دورة في الدقيقة). أفضل القيم من هذه المعايير التي حققت أقصى امتصاص (= ٩٠٪) من الرصاص كانت(٦٠ دقيقة و ٥ و ٥٠ ملغ / لتر، ٢ غرام / ١٠٠ مل، و ٢٠٠ دورة في الدقيقة) على التوالي في درجة حرارة الغرفة (= ٢٥ درجة مئوية) . كان نموذج الشبكة العصبية الاصطناعية قادرا على التنبؤ بكفاءة الامتصاص مع نقل وظيفة الظل السيني في طبقة مخفية ووظيفة نقل الخطية في طبقة الإنتاج على أساس ١٠ خلايا عصبية. كان الانحدار الخطي بين مخرجات النموذج وأهداف المقابلة مقبول مع معامل ارتباط ٠,٩٩٧٣٨ للمتغيرات المعتمدة.

الكلمات المفتاحية: الأمتصاص، الشبكة العصبية،قشر البيض، الدفعة، التلوث.

1. Introduction

One of the widely problems in the field of conservation and protection of water resources is water pollution with heavy metals. It is associated with several activities of human such as mining, the metal processing industry, petroleum industry, power industry and on a smaller scale by electroplating wastes, metal-based pigments and numerous other industrial wastes, besides the high exhaust emissions in urban regions from car engines, burning of hospital wastes and domestic solid waste, as well as wasteland-landfills (Hashim *et. al*., 2011). There are several methods to treat the metal contaminated effluent, but the choosing of the adequate method is based on the cost of treatment and the concentration of pollutant and (Hilal *et. al*., 2012). These methods are included chemical precipitation, electroplating, ion exchange, and reverses osmosis. Many studies (Volesky and Leusch, 1995; Dabrowski *et. al*., 2004; El-Ashtoukhy *et. al*., 2008) proved that these methods are expensive and inefficient especially when treating wastewater with low concentration of heavy metals.

Adsorption process was studied as one of the promising technique due to its low initial cost, simplicity of design, ease of operation and insensitivity to toxic substances. It is necessary to have a low-cost material to treatlarge quantities of wastewater. The use of low-cost sorbents has beenthoroughly investigated instead of other more expensive materials. For example, natural and waste materials coming from industrial agriculture and forestry activities such as date pits, olive pips …etc. acquired a great importance in the removingof metal ions (Samra *et. al*., 2014).

Modeling of adsorption process is a topic of interest for the prediction of the metal partitioning between the aqueous solution and the solid surface, and its subsequent application to the design of adsorption treatment units (Faisal,2015). Adsorption isotherm models such as Langmuir, Freundlich, Elovich, Temkin and others are used mostly for description the equilibrium relationship between the adsorbate concentration in the solution and its concentration in the adsorbent particles at a given temperature (Hamdaoui and Naffrechoux, 2007). Hence, there is a need to use a more representative model that can identify the equilibrium/ non-equilibrium biosorption process for different values of temperature. Consequently, ANN technique has drawn great attention as an alternative approach in the determination of complex relationship between operating parameters.

ANN based predictive models are powerful in terms of learning the nonlinear relationships to understand and solve and thereby achieving ability to predict accurately (Yetilmezsoy and Demirel, 2008). Accordingly, the significance of the present study is characterization the non-equilibrium/equilibrium non-isotherm cadmium removal from aqueous solutions using eggshell by ANN model in comparison with batch experimental results for different operational conditions.

2. Materials and Methods

2.1 Materials

The chicken eggshells were collected from kitchen waste and washed by deionized water for several times to remove the dirt particles. The eggshells were then air-dried and incubated in hot air oven at 40 ºC for 30 minutes (because protein component in eggshell can denature at high temperature; > 40 ºC) (Faisal,2015). Eggshells were ground to a powder in a grinder, and sieved to obtain between 75-100 µm size particles.The eggshell powder comprises of 94 % calcium carbonate, with small amounts of magnesium carbonate, calcium phosphate and other organic matter including protein (Animesh, 2013).

A solution of lead with concentration equal to 1000 mg/l was prepared at room temperature (25ºC) by dissolving $Pb(NO_3)_2$ (manufactured by BDH, England) in the distilled water. The pH of this solution was adjusted by adding 0.1 M NaOH or 0.1 M HNO_3 as required and it was used to prepare any required concentration.

2.2 Batch Experiments

Series of batch sorption tests were conducted to determine the effect of contact time, initial pH, initial concentration of Pb(II) ions, and sorbent dosage on sorption performance of eggshellused as sorbent materials. Therefore, various sorbent dosages ranged from 0.1to 4 gwere introduced into 250 ml flasks with 100 ml solution containing 50 mg/l of Pb(II) ions. The flasks were then placed in an orbital shaker and agitated up to a total contact time of 240 min at a fixed agitation speed of 200rpm. Samples were taken at predetermined time intervals (10, 30, 40, 60, 80, 100, 120, 150,180, 200 and 240 min) and then separated by filtration. Metalconcentration was analyzed by atomic absorption spectrophotometer(Norwalk, Connecticut (USA)).

Batch tests were carried out in a pH range of 3–7 to determine the effect of initial pH on sorption. Percentage of Pb(II) ions removal being the output parameter of the ANN model was considered as a measure of sorption efficiency of eggshell. The removal efficiency (R, %) was calculated as follows:

$$R = \frac{(C_o - C_e)}{C_o} \times 100 \quad (1)$$

WhereC_o and C_e are the initial and the equilibrium Pb(II) concentrations respectively.

3. Results and Discussion

3.1 The development and maximize included no refund of ANN mod

Levenberge–Marquardt back propagation (LMA) training algorithm for ANN model correlated the efficiency of removing metalthe ions of water solution by sorption, it has been the development of method. The algorithm was calculated using Matlab version of program 7.9 (R2009b). Thephysical layout artificial neural network determined by the number of layers, the Maximizing of ANN topology beingin developing the model and this could be achieved through the division of batchtrainingdata into, verification and testing subnet test with percentages of 60 and 20 and 20% respectively. The pilot loading data in each section of the workspace.

Training data is the largest of the group and used by a network of the work of the nervous system of data through the update network weights. Use the test data to assess the quality of the network.And making the final selection of the performance and the circulation of the ability of the network has been trained to use to verify the validity of the data. Shadow used the post-transfer (tansig) in the hidden layer and profession transfer pace (purelin) in a layer production in this study. The variables contribution to feed the nervous network Forward Contact Time (minutes), and pH, dosage of eggshell (g/100 ml), the first focus (one liter), and agitationspeed (rpm). It has been selected the efficiency of removing (%) variable production. The first focus (one liter engine), the speed of the excitement (RPM). It has been selected the efficiency of removing (%) variable production. The optimal model ANN parameter teams based on the value of the minimum means of square error (MSE) of a training package and forecasting. In maximizing the use of the network, use two of neurons in the hidden layer first Predictions. With the increase in the number of neurons, network gave many minimum values of local values and access to different series training MSE. With 10 cells Invisible nervous, MSE less valuable .of 0.000104.

Training stopped after it began 17 LMA epochs because of differences between training errors verifying to increase. Figure 1 illustrates this means errors square training, verify that the accessory Test. Finally, the optimal ANN structure for prediction the command of the ions removal the water solution by sorption method was 5:10:1 as shown in Figure2. The recruitment of the best steep for training, verification and testing Levenberg algorithm - marquardt in Figure3.

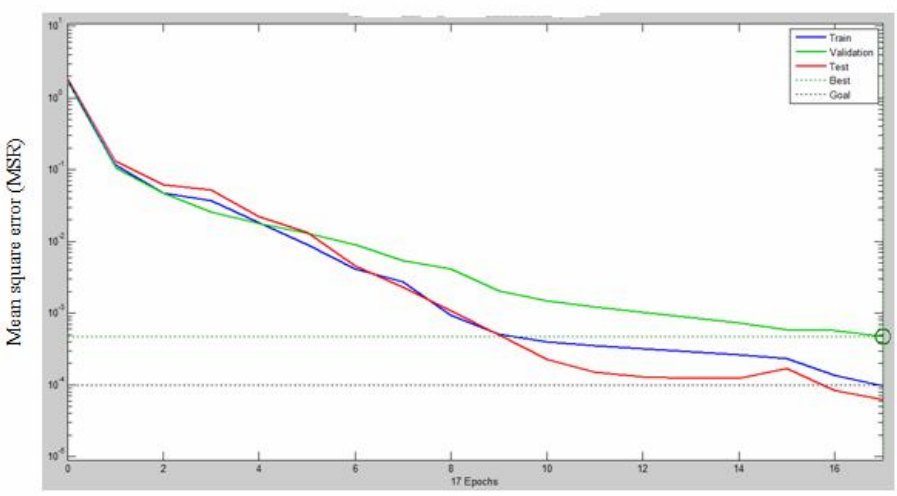

Figure1.Mean square errors For Training, verification and test subsets using The Algorithm Levenberg - Marquardt

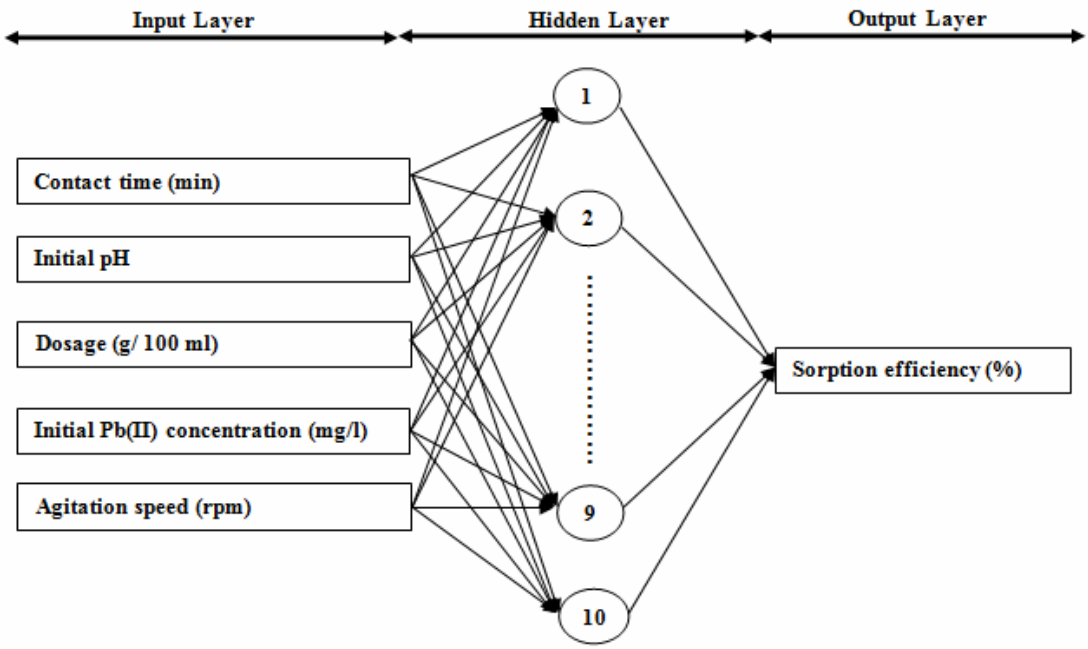

Figure 2.Architecture of ANN

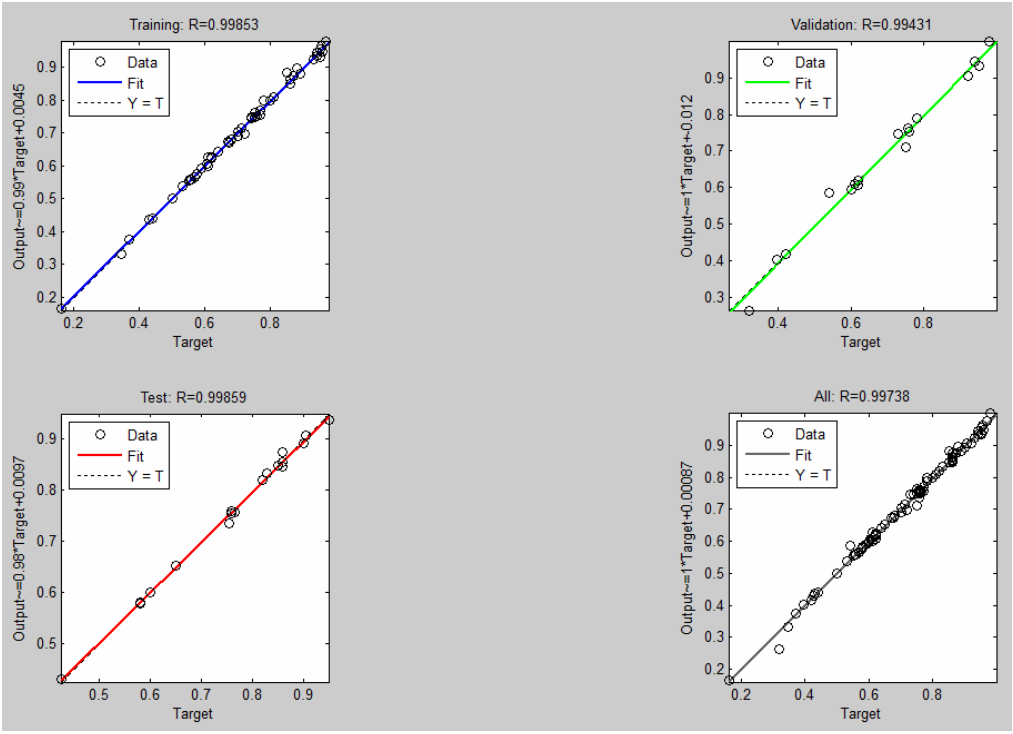

Figure 3.The gradient for training, verification and testing usingLevenberg-Marquardt algorithm

3.2 The impact of the time and the degree of initial acidity of the Solution

The figure indicates 4 different efficiency of eliminating lead to peel eggs as a function of the Contact Time different values of the initial Acidity. It is clear that the removal was increased rapidly in the beginning and, then, remained constant with time until it reached equilibrium timewhich equal to 60 min. It may be because of the presence of a large number of sites to absorb this. As the roofs of the remaining vacant posts decreasing, slowed the rate of the bottom of the heat sink energy because of the formation of a strong disharmony between hard surfaces mineral resources in the liquid phase (El-Sayed *et. al.*, 2010; Faisal and Hmood,2015). This figure illustrates that the Slowed Specific Absorption Rate down because of an increase in the Removal of minerals and increase the (3-5) may be interpreted on the basis of the drop in the competition between proton species sites and metal surface drop in charge of positive Surface, Leading to incompatibilities columbic less than metal sorbing (Alkan *et. al.*, 2008). There is a further increase in the values and the degree of acidity (> 5) would lead to a decline in the efficiency of removal. This can be attributed to the formation of the complexes hydroxybutyric soluble, which accelerated the process of the solution of preparing the studies real suction impossible (Raji *et. al.*,1997).However, the degree of acidity of 5 is already visited find such, PH initial best further test of a boost to investigate the consequences of female teachers and other running on the efficiency of bullets (II) Ions.

The Convention of empirical data and expectations ANN models as a function of the degree of initial acidity can be identified in the same number.

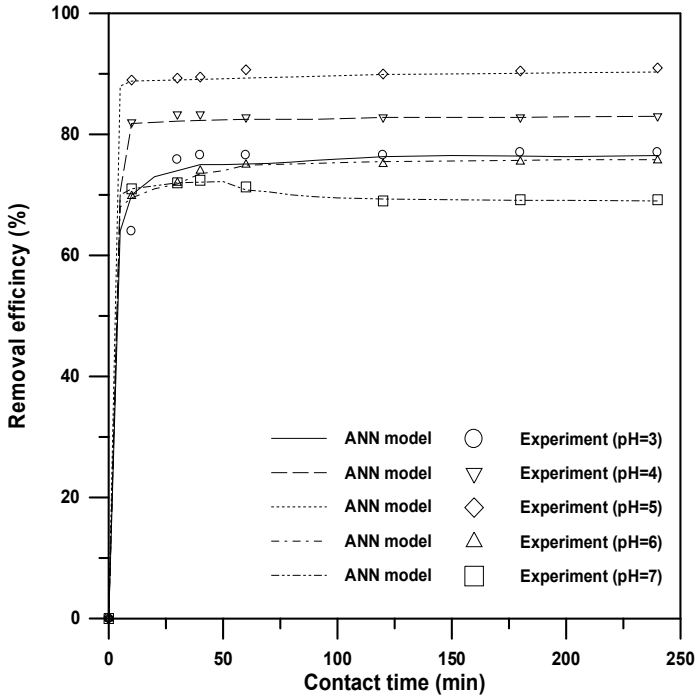

Figure 4. The output of the ANN and empirical data as a function of the time to contact, and the degree of initial acidity (initial concentration = 50 mg/liter, doses = 2 grams (100 ml, and speed of irritation = 200 rpm

3.3 Effect of Eggshell Dosage

Figure 5 shows that the removal efficiency was increased from 10 93% as sorbent mass increased from 0.1 to 2 g for the focus of the first metals fixed 50 mg/liter. This may be due to the increasing of sorption sites as a function of the weight of the sorbent, which led to the removal of the High Metal in percent in high-dose(Amarasinghe and Williams, 2007). This figure certifies that there is a good model output ANN and empirical data

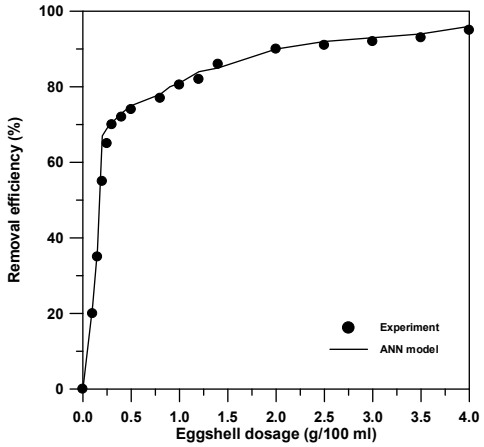

Figure 5.The output of the ANN and empirical data as a function of the doses sorbents (initial acidity = 5, C_0 = 50 mg/liter, Contact Time = 60 minutes, the speed of irritation = 200 rpm)

3.4 Effect of MetalConcentration

Decreased the efficiency of eliminating lead (ii) 90-06 % with increased focus first 50-300 mg/liter as shown in Figure 6.This can be attributed to the absence of sufficient space to accommodate more of metal available in the solution. Less than concentrations and (b) the ions in solution can interact with the locations of the link,it was therefore the highest compared to the efficiency of removing with high concentrations (Rao *et. al*., 2010). It is clear that the Model ANN explains the good performance in the predictability of empirical data.

3.5 Effect of Incitement Speed

Figure7illustrates that about 30 % of the Pb(II) Guest removing withoutvibration (stagnant solution). There was an increase in the heat sink pollutants and increase the speed of the excitement of 0 to 200 rpm which removal of about 90 % of pollutants. This can be attributed to the improved dissemination of ions toward the interactive media, thus sound communication between the ions and link sites can be achieved (Anwar *et. al*., 2010). It is clear that there is a good consensus between the data pilot and demonstration ANN.

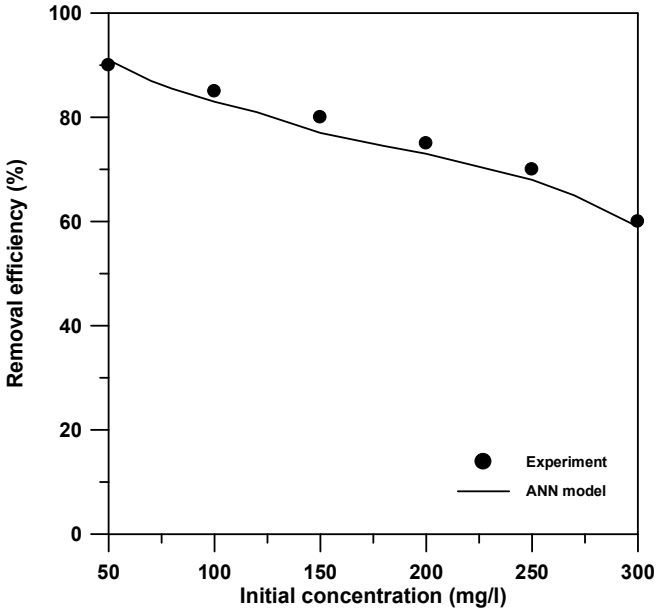

Figure6.The output of Ann and empirical data as a function of the focus of the first bullets (The degree of initial acidity = 5, contact time = 60 min, dosage= 2 g/ 100 ml, and incitement speed = 200 rpm)

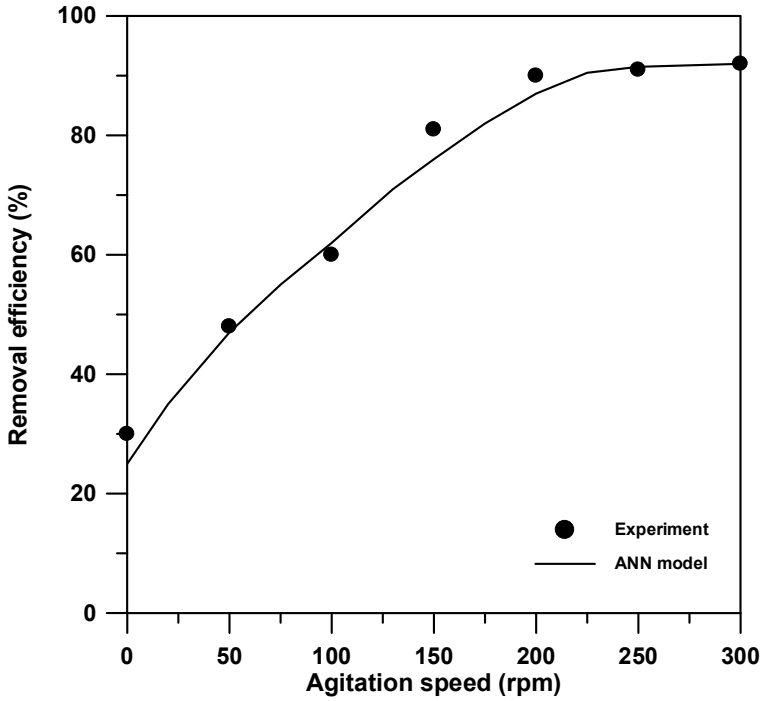

Figure 7.The output of the ANN and empirical data as a function of the speed of irritation (initial pH = 5, C_0 = *50 mg/liter, at the time of the communication* = 60 min and dosage = 2 g/ 100 ml)

4. Conclusions

Batch sorption experiments to remove the lead (II) showed the ions of water solutions that the best operating conditions were determined that the figure might be ph. Initial 5, a sorbent dose2 g/ 100 ml, in principle bullets (ii) Focus 50 mg/liter, and the speed of irritation 200 rpm at room temperature. Time of 80 minutes found to be sufficient to achieve the balance of the pilot phase of the results indicate the efficiency of elimination of lead (II) could ions improve the effectiveness of up to about 90% using peel eggs as absorbing low cost. Proposed a three layer ANN with the transfer of posts shadow in hidden layer and the transfer of the profession of layer written production to predict the efficiency of removing the ions. The number of neurons optimal utilization of the LMA is 10 nerve cells with MSE of 0.000104. The model showed ANN suggested minutes and predictability of effective for the experimental data with a high link of 0.99738 operating variables five.

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