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Application of Artificial Neural Network (ANN) for the Prediction of Perchlorate Wastewater Treatment

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Perchlorate,
Anaerobic - Aerobic reactor,
Artificial neural networks,
Simulation.

Abstract

The system was modeled, having employed Artificial Nerve Network (ANN) and the studies about simulating the assumed sewage treatment plant made through process with SPSS software and the experience gained over time. The results yielded for the noted treatment plant were analyzed by developed nerve network model. In the modeling of the assumed sewage treatment plant, the highest correlation coefficient of 0.980 was obtained. The most appropriate nerve network model for value R equaled 0.898.Bearing percentage of errors in the input data, it is indicative of an approximately high precision.

1. Introduction

Perchlorate (ClO4) is a strong electrochemical oxidant which is expensive when solid. It is very stable which is found in two forms natural and artificial [1]. Due to its high dissolving in water, The underground water pollution is more significant than the one in soil; therefore a methods such as ion transfer bioreactors [2]. Biological decomposition [3], grand filters, improvement through herbs, using nano particles and catalytic reactors, are used for treating drinking water and underground water [4]. Fluid Perchlorate prevents ion absorption via SIN2 when it comes to thyroid glands [5]. In case of high density the ability of thyroid glands is adjacent grands in some non-thyroid tissue [6]. The ingredients and building component of per Perchlorate, such as all salts like Perchlorate aluminum, Perchlorate sodium, Perchlorate potassium and Perchlorate acid are produced [7]. In January 2002, following a complete series of studies, US organization for environment conservation came to this fact that the Perchlorate density in drinking water should be at below 1 milligram per liter and all the water components must meet this limit. The first scientist, aslandr, made an observation of microbic decomposition decomposition of chlorate in soil. Microorganisms which are frequently used for

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Perchlorate treatment are of facultative anaerobes kids, using electron absorbents such as nitrate, surfate, Perchlorate to restone organic matetrials. Under ground water naturally contains some Perchlorate restoring bacteria [8].

The nerve network is commonly used aiming at modeling by researchers of different sciences and disciplines. [8, 9, 10, 11] In the present study the perchlorate Sewage Treatment was studied regarding the deletion of perchlorate for six of months. The studied variables were the heat temperature of both the environment and sewage, flow rate, pH, opacity, alkalinity, suspended solids (SS), COD, BOD5, the flow of sewage tiny particles and wastewater as well as the different units in treatment functions of education. The data were collected from the sewage control engineering unit.

2. Materials and Methods

2.1. Wastewater

In this study, reactor was established by a sewage which had average 5mg/lit Perchlorate as the indicator of sewage pollution included 24.8 MLSS and 16.9 MLVSS g/l. In order to set up the system, the use of a suitable sludge is required. In this study, due to the fact that sewage purification is implemented in the slaughterhouse, digester sludge of purification plant is used for anoxic parts, and aerated returned sludge is also used for aerobic parts.

2.2. The Bioreactor Experimental Setup

A reactor with total volume of 43.2 liters was produced for evaluation of wastewater. This reactor included 8 equal parts, and they were separated from each other using vertical baffles. The reactor and its equipments are shown in Figure 1. Each chamber is divided into two small chambers that have 45 degree bevel edge, which leads to low and high flow of Wastewater and provide s effective time of exposure and composition between wastewater and bio-mass in each chamber. The total pilot volume was 22 liter (length: 72 cm, width: 20 cm, height: 15 cm respectively). For sampling from all 8 parts of reactor, in sum 16 sampling valves were used. In each part of rector, two sampling valves were provided, in which one valve was used for sampling the sludge and another one was used for wastewater sampling. Reactor was used successively at 4 residence times including 12, 24 and 48 hours for 32 weeks. Electron irradiation was implemented using electron accelerator model TT 200 manufactured by IBM company in Belgium (Current: 10AM, radiation power: 100KW, and energy: 10Mev) and in a 200 ml Polystyrene foam. After sampling from input and output of the bioreactor and their analysis, samples were irradiated with electron beam in three doses including 10 KGy, 30 KGy, and 50 KGy.

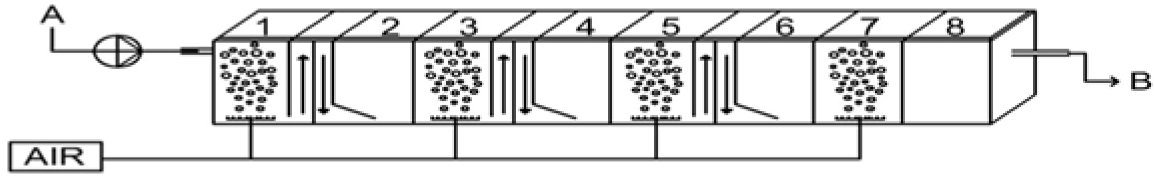

Figure 1. The schematic diagram of the bioreactor system: sampling sites; A: inlet reservoir; 1, 3, 5, 7: aerobic compartments; 2, 4, 6, 8: anaerobic compartments; B: outlet reservoir

2.3. Post-distribution Algorithm

In course of the forward process , and is sent to each of the hidden units Z1 ,Z2,....ZP f. Following that, each of the hidden units calculates the activation thereof and its signal (Zj) is sent to every output unit. Each of the output units (Yk) calculates its activation (Yk) as a pure response for the given input pattern.

2.4. Pre-processing

Preprocessing is required for the weights of Nerve Network. Choosing the weight effect results in the fact that the network gains the general or sectional status in error reduction as well coming across the reason behind the convergence. Representing the data (data normalization) in nerve networks is of great significance. In many equations the sectional input and output vectors are equal in terms of value when they are considered in a shared range. It can be noted that in many functional parts of the nerve network, the data could be provided through the variables with consistent values, a group or range.

2.5. Code Writing and Toolkits for MATLAB Nerve Networks

2.5.1. Introduction to Neural Network Toolbox and the Graphical User Interface

Developing the model was done, having used the closed version of MATLAB 2013 by Mathworks company . Matlab is a program that includes some toolkits aimed at engineering purposes. Nerve network toolkits in the present study were used to explore more precise data from a developed nerve network, using the codes that were written for creating an automatic model of artificial nerve network.

2.5.2. Code Writing Matlab

To develop the model, a MATLAB code was written. The said code was capable of creating an automatic nerve network for sewage plant. The code takes up the same function GUI toolkit of nerve network does. It is noteworthy that the code was used to notice the changes of precision, when the various parameters of nerve network change. This code mainly takes a set of data from the working space of MATLAB .Afterwards, using the written code"norm01.m" for (0,1) limit in which the transfer function ranges (_1,1), the information is normalized in (1,0) and (-1,1) thereby dividing the data in three categories: educating ,evaluating the validity and set of tests. The code enters the circle through which creates the nerve networks for13 MATLAB education functions.

2.6. Simulation of Treatment Processes

They usually perform the prediction through providing the data witch had not been encountered. It is known as powered square of error RMSE and R as the generalization of the network to this aim, the criteria of correlation coefficient were used to reach the assessment of psychometry in the designed network MAPE and Media Absolute Error (MAE).

Mean squared error, $$MSE = \frac{1}{n}\sum_{t=1}^{n} e_t^2 \quad (1)$$

Root mean squared error, $$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n} e_t^2} \quad (2)$$

Mean absolute error, $$MAE = \frac{1}{n}\sum_{t=1}^{n} |e_t| \quad (3)$$

Mean absolute percentage error, $$MAPE = \frac{100\%}{n}\sum_{t=1}^{n} \left|\frac{e_t}{y_t}\right| \quad (4)$$

3. Results and Discussions

3.1. Development of Neural Network Models with Simulation Data SSSP

The studies about the simulation of model of treatment process. The developed code was used for the automatic model in the levels after getting to know GUI toolkits of NN. Taken from the modeling studies regarding the user's manual the two education function were tested. The simple was as follow: The number of hidden ions for each education function (as to the algorithm) changed from 2 to 10. 13 function as such were provided, using the MATLAB toolkit of nerve network, in order to carry out the algorithm. For each algorithm 9 nerve network models were developed with, 2 to 10 hidden neurons, overall number 117 models for each full implementation.

3.2. The Development Manual for NN Using Graphics Toolkits

The manual implementation shoed that the model produced with 3 hidden neurons had the lowest error and the best relativity with the main data. Afterwards the model was chosen as optimal with one hidden layer 3 hidden neurons; the learning changed.

3.3. Data Preparation

In the modeling process 8 variables of system were used to produce a NN also, the component of the data were used in the development process. The variables used were the speed of particles flue pH particles , temperature of particles, density and waste water. Sewage of TSS, waste rate from the sediments of the tank. These variable are either alone or in combination, used to predict Perchlorate density of the wastewater. A number of substance were used. also hundreds of models to come across the effects of predicted developments were noticed. The pre-processing of the data from Perchlorate, after preparation for model development, processing in updating were applied in equal weight variables especially when it came to using non-liner transfer function. The data pre-processing was done, having allocated the input and output of the data in the range of [0 1] and [-1 1]. This translation or let us say change is done for all point as in the following.

These variable were used, predicted each data variable, using the normalization input data with non-liner function such logsin, tamsig, were fed with equal weight development of NN for Perchlorate treatment.

$$X_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \tag{5}$$

$$X_i = 2X \frac{X_i - X_{min}}{X_{max} - X_{min}} - 1 \tag{6}$$

3.4. The Development of Artificial Neural Network Model

MATLAB was used to create the model of NN automatically, having used the data collected from Perchlorate waste water. Implementing the script began with assigning a combination of variables, wed together. Reaching 25, it was the best processing of Perchlorate for waste water. The output stood at R=0.898. the combination of the variable, which is under study, is tabulated 1.

Table 1. The combination of variables tested

Set No	Variable(s) used
1	MLSS only,
2	TSS_{eff} only
3	MLSS and Q_{inf},
4	Q_{inf} and TSS_{eff},
5	Qinf, TSS_{eff} and MLSS,
6	MLSS and TSS_{eff}.

In order to come across the optimal structure for NNs, parameters such as number of hidden layers, number of neurons in the hidden layers and output as well as the number of 16-17education periods underwent changes. The repetitions base on the number of neurons in hidden layer and stimulant of hidden layers and output, aimed at stimulation changes of Perchlorate qualitative parameters, are shown in table 2. This table include values for correlation coefficient (R), powered square mean of errors (RMSE), mean absolute error (MAE) and mean absolute powered error (MAPE), each of which is under evaluation and education.

Table 2. different models of network performance during training and testing

Frequency Network	The number of Neuron	Stimulus function		MAE (mg/L)		R		MAPE (%)		RMSE (mg/L)	
		Output Layer	Hidden Layer	training	Evaluation	training	Evaluation	training	Evaluation	training	Evaluation
Trial 1	16	Logsig	Logsig	7.453	7.64	0.8737	0.8507	4.699	4.945	10.871	11.964
Trial 2	17	Logsig	Tansig	7.284	7.373	0.8947	0.8846	4.403	4.831	9.983	10.827
Trial 3	16	Tansig	Tansig	6.736	7.457	0.9035	0.8642	3.992	4.745	9.577	11.55
Trial 4	15	Tansig	Tansig	6.526	7.517	0.9234	0.8723	4.192	4.625	9.967	11.15
Trial 5	16	Tansig	Logsig	6.363	7.561	0.8781	0.863	4.256	4.515	10.691	11.709

As seen in table 2, in trial 2. In trial 1the lowest correlation and the highest RMSE, MAE and MAPE in education and evaluation are notified of. As a result, the lowest RMSE and MAPE is accounted for trial 3. Trial 2 had the highest (R) and lowest RMSE and MAE while education and evaluation. This is indicative of the fact that although trial 3 yielded. The best results while in educating process, trial 2 was better in evaluation and yielded more generalizability. Trial 3 gave out no stability while serving education and evaluation. As can be seen in table 2, trial 3 kept the educational data. Data estimation in trial 2 out did others.

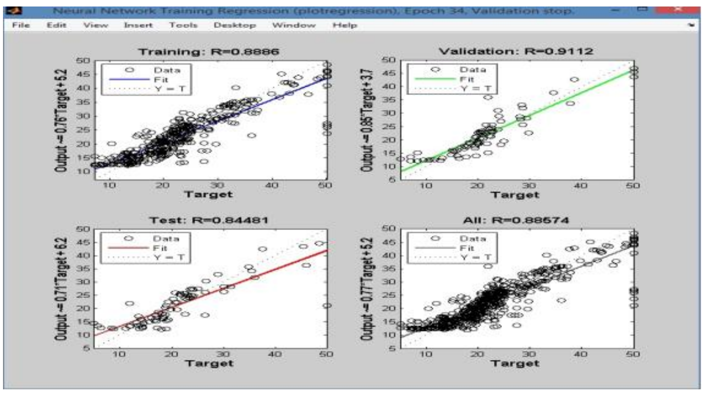

Figure 2. Output regression neural network model

MSE is indicate for the best implementation in table 4. The NN model is taken from implementing script 25. The system variables used in this script are speed flow, TSS and MLSS. 99 daily information was used in this model. The data were divided in 3 parts; education, validation and set of tests.

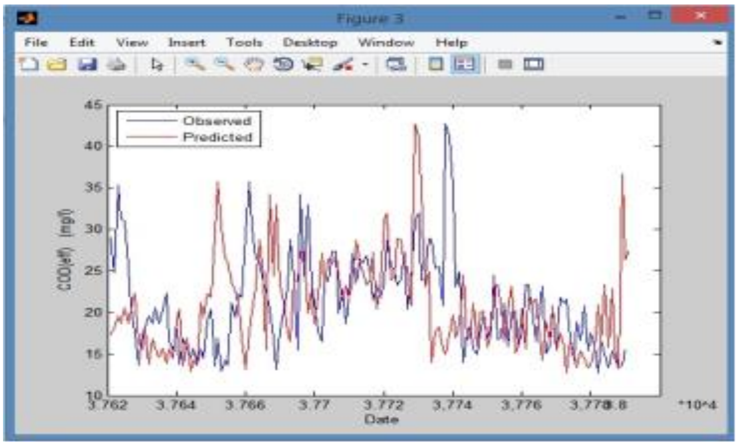

Figure 3. Predict the amount of perchlorate in the neural network model with R = 0.8978

It can be noticed, in the above graphs, that the result were rather good, with the highest correlation coefficient at 0.8978.

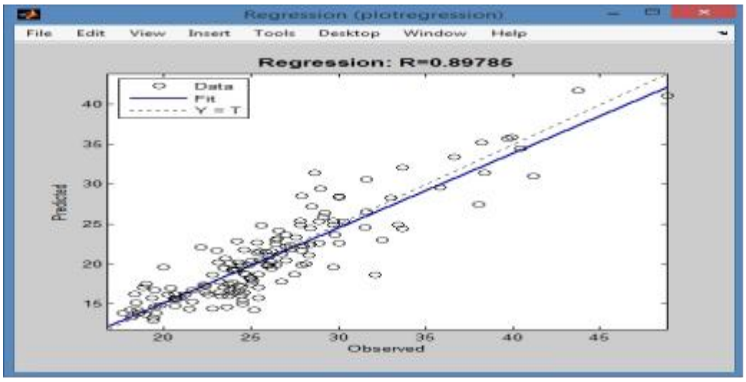

Figure 4. Regression analysis of the neural network

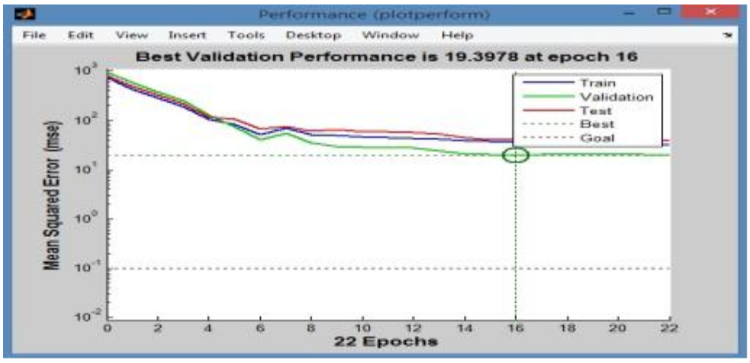

Figure 5. The average prediction error of perchlorate in neural network

Table3.best results in the 25 th running software code MTLAB

Training function	Set	HNs	R
Trainbfg	6	4	0.673
Traincgb	5	6	0.898
Traincgb	6	6	0.694
Trainlm	6	1	0.670
Trainscg	6	6	0.668

4. Conclusions

Due to huge amount of data collected in the recent years regarding the quantity and quantity of the necessity to reuse irregular waters has increase. Among the databased methods, NN have complicated and non-liner behavior thereby assuming importance. In this study the performance of Perchlorate treatment was studied through simulated NN over 6 months. Through the noted studies on the assume sewage treatment, single-sewage process was modeled through SSSP software and the experience gained. In modeling assumed plant the high correlation in NN with SSSP equaled 0.980 versing the real data from Perchlorate. The best nerve network hit an R of 0.898, which shows a high relative precisiom consider the existent error percentages. The results from this researched show that multi-layers nerve network designed with 8 intakes and 17 middle neurons, considering the high correlation coefficient and the lowest error in prediction of density Perchlorate, was chosen as the optimal option. The trial 2 model, as the most optimal one, hand the highest correlation coefficient (0.8846) and the lowest powered square median values for errors (10.827) and average absolute error in the evaluation level. The data yielded reveal that this model had. The most generalizability in comparison with others.

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