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Modeling and Optimization of Coagulant Dosage in Drinking Water Treatment Plant Using Artificial Intelligence. Case of the Ain Tin Station in Mila, Algeria

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ABSTRACT

This study presents the modeling and optimization of the coagulant dose of a drinking water treatment plant by the use of neuron networks based on the characteristics of raw water. The determination of the optimal dose of the coagulant is particularly important in the treatment plant and requires so-called Jar-Test laboratory tests. This type of approach (Jar Test) has the disadvantage of requiring a relatively long response time, in addition, it does not allow for detailed monitoring of the evolution of raw water quality. To this end, the objective is to provide a preliminary tool for the automated management of the said station by improving its quality of service accordingly. For this, neural models were used where modelling attempts were used to link the value of the optimal dose of the coagulant (aluminium sulphate) to the quality of the raw water at the inlet of the treatment plant (turbidity, temperature, pH, conductivity and dissolved oxygen) of the surface waters of Ain Tin. The results we arrived at are very satisfactory, where the correlation coefficient R=0.998, NSE=0.996, RMSE=0.187 and MAE=0.016.

Keywords: Treatment Station, Coagulant Dose, Coagulation-Flocculation, Jar-Test, Neural Network

1 Introduction

Drinking water treatment plants are among the infrastructures to which great importance has been given by Algeria. Among all the stages in the chain of these water treatment plants, the coagulation process flocculation. The objective of this thesis is therefore to develop a mathematical model for the optimization of the coagulant dose at the treatment plants of Ain Tinn, Oued El Athmania and Mahouane, according to the descriptive variables characterizing the raw water at the entrance of the drinking water treatment plant, namely temperature (Temp.), pH and turbidity (Turb.) based on neural network techniques. This mathematical model will be developed for the optimization of the coagulant dose at the treatment plant.

The Ain Tinn plant is supplied by gravity with raw water from the Beni Haroun dam located about 20 kilometres upstream of the station. The nominal capacity of the plant is 64,500 m3/d based on a raw water supply of 67,725 m3/d and a maximum recycled wash water flow rate of 5%. The treatment chain of the Ain Tinn plant consists of the following steps: aeration, pre-oxidation, clarification, biological filtration, post-Ozonation, granular activated carbon filtration (adsorption) and chlorine disinfection.

2. Experimental

We used 3 neural models in this study, multilayer perceptron (MLP), random forest (RF) and random tree (RT). The performance of the models is verified by R, NSE, RMSE and MAE.

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2.1. Random Tree

The scatter plots of the predicted and observed coagulant dose during the calibration and validation phase are shown in Figures 1 and 2, respectively.

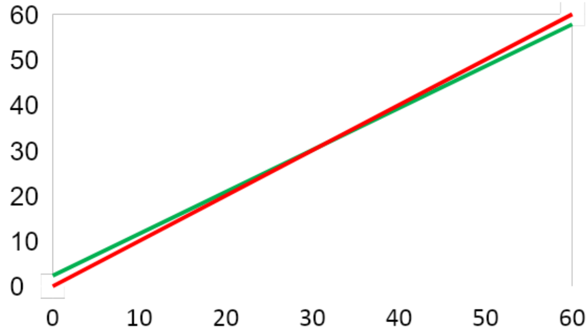

Figure 1 : Scatter plot of the coagulant dose predicted and observed during the calibration phase with RT.

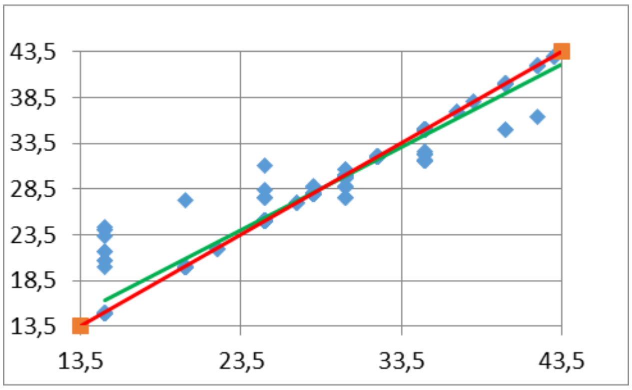

Figure 2: Scatter plot of the coagulant dose predicted and observed during the validation phase with RT

Note that all the points are aligned around the diagonal, which suggests that the model's predictions closely match the observations. The narrow concentration of these points around the diagonal meant a good accuracy of the model. The angle between the bisector and the regression line is very small, indicating the performance of the model. The results are summarized in Table 2.

Table 2: *Model performance settings.*

	Cushioning 70%			Validation 30%		
Performance Criteria	**R T**	**RF**	**MLPNN**	**R T**	**RF**	**MLPN N**
R	0.958	0.94	0.337	0.998	0.957	0.32
NSE	0.918	0.885	0.114	0.996	0.903	0.1
RMSE (mg/l)	1.56	1.849	4.615	0.187	0.936	5.17
MAE (mg/l)	0.317	0.872	3.315	0.016	0.593	3.53

Table 2 presents the coagulant dose performance values by the three neural network models. It is noticeable that the results obtained by MLPNN are very poor. During validation, the values of R, NSE, RMSE and MAE are 0.32, 0.1, 5.17 and 3.53 respectively, which means that the simulated values do not coincide with the observed values. For the results obtained by RF, the performance parameters are significantly improved and very significant. The values of R, NSE, RMSE and MAE for the calibration set are 0.957, 0.903, 0.936

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and 0.593 respectively. These values are very acceptable, it suggests that the simulated values are very close to the observed values. The RF model can predict a very good model when simulating previously unseen data. For the RT model, we can see that the results are significantly improved compared to the MLPNN and RF. This suggests that the predicted coagulant dose is extremely close to the observed values. The performance parameters shown in Table 2 show that the RT model is best represented in this study. The model could be used to predict coagulant dose accurately with a correlation coefficient R=0.998, NSE=0.996, RMSE=0.187 mg/l and MAE=0.016mg/l. These parameters are highly significant and indicate that the RT model is able to predict coagulant dose well.

3. Conclusions

This work was carried out in order to predict the optimal dose of coagulant from a maximum of parameters of the raw water of the Ain Tin drinking water treatment plant. This study allowed us to provide a preliminary tool for the automated management of the Ain Tin station, improving the quality of service of these stations.

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