



Artificial Neural Network Modelling of Shyamala Water Works, Bhopal MP, India: A Green Approach towards the Optimization of Water Treatment Process

Shrivastava Kriti and Joshi Smita

Trinity Institute of Technology and Research, Bhopal, MP, INDIA
Sarojini Naidu Govt. Girls P.G. College, Bhopal MP, INDIA

Available online at: www.isca.in

Received 1st October 2012, revised 31th December 2012, accepted 21th January 2013

Abstract

The water industry is striving hard to produce higher quality water at a lower cost due to increased regulatory standards. Municipal Water Treatment Plants can be considered as the industries producing potable water. They also produce huge amount of sludge after coagulation sedimentation in the clarri- flocculator unit which is a type of waste effluent containing large amount of aluminium and organic contaminants. Commonly it is discharged into surface water without proper treatment and hence causes water pollution. Aluminium salts extensively used for coagulation has been implicated in dialysis dementia, Parkinson and Alzheimer's disease in Humans and also known to cause structural and functional problems in fishes, birds and animals. The present research work emphasizes to develop a green eco-friendly, clean and cost effective water treatment process to avoid the water pollution by non- judicious use of coagulant. Artificial Neural Network (ANN) technique is applied to the prediction of optimum coagulant dosing in Shyamala Water Treatment Plant, Bhopal. The alum sludge generated can be recycled and reused for waste water treatment.

Keywords: Water treatment plant, coagulation, alum sludge, ANN model.

Introduction

Water treatment involves physical, chemical and biological processes that transform raw water into drinking water. However, contrary to most industrial processes, for which the quality of the input raw material is under control, the quality of the given raw water source may fluctuate due to natural perturbation or occasional pollution¹.

Purification of water is a daily need based task. In Bhopal the requirement of potable water supply is 90 MGD which is continuously increasing day by day. To fulfill this task large amount of alum is required which after water treatment in the form of alum sludge, directly discharged to the nearby water body. The present research work emphasizes to develop a greener eco-friendly, clean and cost effective water treatment process to avoid the water pollution by non- judicious use of coagulant.

The water industry is facing increased pressure to produce higher quality treated water at a lower cost. The main difficulty is to determine the optimum coagulant dosage related to the influent of raw water. Excessive coagulant overdosing leads to increased treatment costs and public health concerns, while under-dosing leads to a failure to meet the water quality targets and less efficient operation of the water treatment plant¹. All unit processes in the drinking water treatment industry are complex, involving many biological, physical, and chemical phenomena. While the numerous parameters that directly influence the performance of each process are known to plant operators and researchers, the interactions and relationships

between process inputs and outputs is often poorly understood and cannot be easily quantified².

To improve drinking water quality while reducing operating costs, many drinking water utilities are investing in advanced process control and automation technologies. The use of artificial intelligence technologies, specifically artificial neural networks, is increasing in the drinking water treatment industry as they allow for the development of robust nonlinear models of complex unit processes³.

Material and Methods

The artificial neural network (ANN) technique is an artificial intelligence technique that attempts to mimic the human brain's problem solving capabilities. ANNs are categorized as an Artificial Intelligence Modeling technique due to their ability to recognize patterns and relationships in historical data and subsequently make inferences concerning new data³.

Usually 3 distinct layers are present in an ANN model: the input layer where the data is introduced to the model and computations of the weighed sum of the input layer is performed; the hidden layer or layers where data are processed and the output layer where results of ANN model are produced. Each layer consists of two or more basic elements called a neuron or node. A neuron is a non-linear algebraic function parameterized with boundary values. The signal passing through the neuron is modified with weights and transfer functions. This process is repeated until the output layer is reached. The number of neurons in the input, hidden and output layers depends upon

the type of problem.

The main aim of present research work was to construct an artificial neural network (ANN) model for Shyamala Water Treatment Plant, Bhopal for the prediction of optimal coagulant dose. The steps outlined by Maier et.al. were used as a guide in the development of ANN model (Table-1). All the computations were performed using Microsoft Excel 2007 and MATLAB R2007b (Math Works, Inc., Natwick, MA) ⁴. In this study, three-layer feed forward neural network with back propagation learning algorithm was constructed for the prediction of optimum coagulant (alum) dose using seven input water quality parameters.

The data set used in this study was generated through the monitoring of water quality at the inlet and outlet of Shyamala Water Treatment Plant, Bhopal and amount of coagulant dose added after jar testing. All the water samples were collected during the different seasons of summer, rainy and winter season (table- 2). Total 250 data points were divided into three subsets: (i) a training set for adjusting the connection weights, (ii) a testing set for determining when to stop training and optimizing network architecture and internal model parameters and (iii) a validation set for testing the generalization ability of the model over the range of data used for calibration.

The ANN architecture consisted of a multilayer perceptron (MLP). MLPs have already been used successfully for the prediction of coagulant doses and other water resources and environmental variables. Fletcher and Goss (1993) suggested that the appropriate number of nodes in a hidden layer ranges from $(2n^{1/2} + m)$ or $(2n+1)$, where n is the number of input nodes and m is number of output nodes⁵. Number of hidden neuron taken was 15.

The selected ANN for Alum Dose Model is composed of one input layer with 7 input variables, one hidden layer with 15

nodes and one output layer with one output variable. The constructed ANN model was trained using the Levenberg-Marquardt algorithm (LMA). The LMA is much faster as compared to other algorithm used in back propagation⁶.

Results and Discussion

The R value and MSE error indicate how close one data series is to another. In the present case, data series were actual alum dose and predicted alum dose. R value ranges from -1.0 to 1.0. A larger R value indicates a higher correlation. The R values for the Model on training and test data sets were close to each other, which mean the model generalizes well and is likely to make actual predictions⁷. Value of R for the Actual Alum Dose and Predicted Alum Dose is 0.99 which shows a good correlation between them. Performance as calculated by MATLAB software for the ANN model of Sh.WTP was found 3.4027 (figure-1 and table-3).

Water Treatment Plant can be considered as an “industry” producing potable water and the sludge generated in the clarriflocculator unit is a type of waste effluent which cannot be discharged into surface water without proper treatment. Shyamala Water Treatment Plant was established in year 1961 at the bank of the Upper Lake on the Shyamala hills, for production of potable water from the raw water. Now days, a total of 7 water treatment plants are situated near the Upper Lake. From a very long time due to the lack of awareness and proper technology, the alum sludge of these Water Treatment Plants is being discharged to the lake water itself. Therefore the optimization of coagulant dose is required so as to decrease the pollution and cost of plant operation. Processes of water treatment in Sh.WTP consists of a sequence of complex physical and chemical processes and their dynamics are non linear. Still ANN gives very satisfactory results for the model. ANN learns from plant historical data so as the time passes on ANN will give more accurate results.

Table- 1
Ann Model inputs and outputs

S.No.	Variable	Input (I) /Output (O)	Symbol
1.	Raw Water pH	I	RWPH
2.	Raw Water turbidity	I	RWT
3.	Raw Water Suspended Solids	I	RWSS
4.	Raw Water DO	I	RWDO
5.	Raw Water Conductivity	I	RWC
6.	Clarified Water Conductivity	I	CWC
7.	Clarified Water Turbidity	I	CWT
8.	Alum Dose	O	AD

Table-2
Performance of Ann Model

S.No.	Type of Sample	Samples	MSE	R	Performance
1.	Training Data	150	1.85475e-7	0.999999	1.3839e-018
2.	Validation Data	50	2.31633e-0	0.992578	3.1557
3.	Testing Data	50	1.61976e-7	0.999999	3.4027

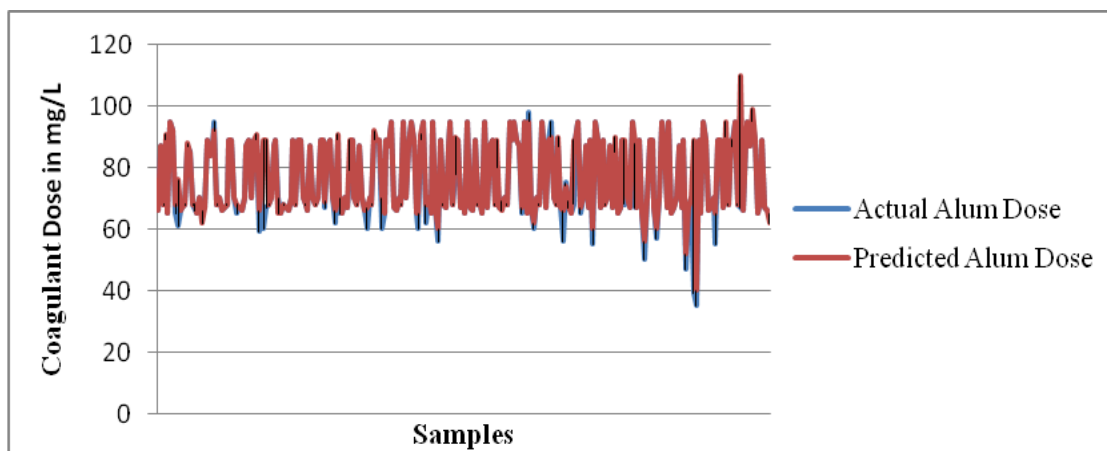


Figure-1

Comparison of the Model Computed and Measured Alum Doses for the Shyamala Water Treatment Plant

References

1. Valentin N., Fotoohi F. and Denoeux T., Modeling of coagulant dosing in a water treatment plant, *Proc. of EANN'99, Warsaw*, 165-170 (1999)
2. Baxter C.W., Stanley S.J., Zhang Q. and Smith D.W., Developing artificial neural network models of water treatment processes: a guide for drinking water utilities, *J. Environ. Eng. Sci.*, **1**, 201-211(2002)
3. Baxter C.W., Zhang Q., Stanley S.J., Shariff R., Tupas R.R.T. and Stark H.L., Drinking water quality and treatment, the use of artificial neural networks, *Can. J. Civil Engg.*, **28** (1), 26-35 (2001)
4. Maier H.R., Morgan N. and Chow W.K.C., Use of artificial neural networks for predicting optimal alum doses and treated water quality parameters, *Envir. Mod. & Soft.*, **19**, 485-494 (2004)
5. Fletcher D. and Goss E., Forecasting with Neural Networks: an application using bankruptcy data, *Inform. Manage*, **24**, 159-167 (1993)
6. Ying Z., Jun N., Fuyi C., Liang G., Water Quality forecasting through application of BP neural network at Yuquiao Reservoir, *J. Zhejiang Univ. Sci.*, **A** (8), 1482-1487 (2007)
7. Vyas M., Modhera B., Vyas V. and Sharma A.K., Performance forecasting of common effluent treatment plant parameters by artificial neural network, *ARNP Jour. Engg. Applied Sci.*, **6**(1), 38-42, (2011).
8. Parihar S.S., Kumar Ajit, Kumar Ajay, Gupta R.N., Pathak Manoj, Shrivastav Archana and Pandey A.C., Physico-Chemical and Microbiological Analysis of Underground Water in and Around Gwalior City, MP, India, *Res. J. Recent Sci.*, **1**(6), 62-65(2012)
9. Kushwah Ram Kumar, Malik Suman and Singh Archana, Water Quality Assessment of Raw Sewage and Final Treated Water with Special Reference to Waste Water Treatment Plant Bhopal, MP, India, *Res. J. Recent Sci.*, **1**(ISC-2011), 185-190 (2012)
10. Safari D., Mulongo G., Byarugaba D. and Tumwesigye W., Impact of Human Activities on the Quality of Water in Nyaruzinga Wetland of Bushenyi District Uganda, *I. Res. J. Environment Sci.*, **1**(4), 1-6(2012)