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Artificial Neural Network: An Effective Tool for Predicting Water Quality for Kalyan-Dombivali Municipal Corporation

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Abstract: ***Municipal Corporations often do not prioritize environmental impacts caused in the areas due to pollution. Due to this many cities are facing severe pollution problems which are affecting health of citizens and disturbing overall ecological balance of the cities. Most often the people are not aware of the quality of air and water in the city. Hence there is need to study, analyze and predict the water quality for Kalyan Dombivali Municipal Corporation (KDMC). The present work aims at development of an artificial neural network (ANN) model for predicting water quality in KDMC area. The raw water quality at the intake of treatment plant has been consistently deteriorating and an advanced knowledge of the pollutant load expected at the treatment plant is beneficial to the operator at the treatment plant. This information helps to budget for the chemicals and extend of treatment to be provided. Results of Physico-chemical analysis performed on raw water from the river Ulhas has been tabulated for the following parameters: pH, TDS, Turbidity, Hardness and Chloride on a daily basis for the past three years. Predictions about water quality for the next few days and suggestions about minimizing threats will be made by using Artificial Neural Network. The first model has been run and has shown output values of Coefficient of co-relation (R) as high as 0.9992 by using Modular Neural Network.***

Keywords: Artificial Neural Network (ANN), KDMC, Prediction, Water Quality, Generalized Feed Forward Network, Multilayer Perceptron Network, Modular Neural Network.

1. Introduction

Every municipal corporation/municipal council has to supply pure and potable water to the citizens of the corporation/council as per the Maharashtra Municipal Corporation Act for public and private purposes. The Kalyan Dombivli Municipal Corporation is supplying water to the citizens of Kalyan and Dombivli, having a total population of approx.12.5Lacs (as per census of 2011).

Water treatment involves physical, chemical and biological processes that transforms raw water into potable water. In most of industrial processes the quality of the input raw material is controllable, but the quality of the given raw water source may fluctuate due to natural perturbation or occasional pollution. Purification Of water is a daily need based task. In Kalyan-Dombivali cities and surrounding areas the requirement of potable water supply is 238 MLD which is continuously increasing day by day.

To improve drinking water quality while reducing the costs of operation, almost all potable water providers are adopting advance process control and automation technologies. Hence now a day's use of techniques such as artificial neural networks (ANNs), is increasing in the drinking water treatment industry as they allow for the development of robust nonlinear models of complex unit processes.

In recent years the trend has been to use statistical methods instead of traditional deterministic methods to predict water quality. Many researchers have successfully used ANN models for prediction of various parameters of water such as PH, Hardness, TDS, Chlorides, and Turbidity and found the ANN model suitable for predicting water quality.[4] In this study, four ANN models with back propagation algorithm are used to predict PH, Hardness, TDS, Chlorides, and Turbidity of raw water for few days for KDMC at Barave WTP using daily data of above parameters for the period between Jan 2012 to March 2015.

2. The Network and Training Algorithms

2.1 Generalized Feed forward network

One of the networks used in the present study is of feed forward type, which has the ability to approximate any continuous function. As shown in Fig.1, the input nodes receive the data values and pass them on to the first hidden layer nodes. Each hidden node collects the input from all input nodes after multiplying each input value by a weight, attaches a bias to this sum and transforms it through a non-linearity like the sigmoid function. Thus it creates the input for the subsequent hidden layer or to the output layer that operates identically to the first hidden layer. The resulting nonlinearly transformed output from each output node constitutes the network output. [2]

A typical artificial neural network consists of an interconnection of computational elements commonly known as neurons. Function of neurons is combining the input, determining its strength by using mathematical formulas.

$$O = 1/ (1 + e\text{-}S) \quad (1)$$

$$\text{where, } S = (x1\ w1 + x2\ w2 + x3\ w3 + \ldots\ldots) + \quad (2)$$

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In which,
O = output from a neuron; x1, x2,….. = input values;
w1, w2,…….= weights along the linkages connecting two neurons that indicate strength of the connections.

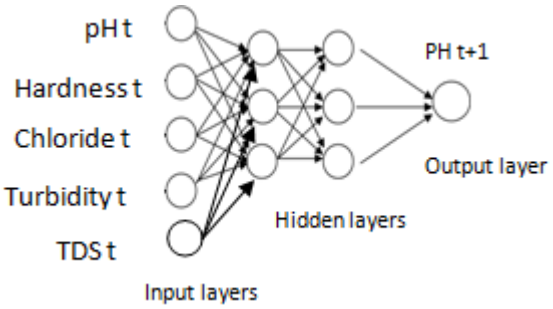


Figure 1: Generalized Feed Forward Network

2.2 Multilayer Perceptron Network

A multilayer perceptron (MLP) is a feed forward artificial neural network model that maps input data sets onto a set of appropriate outputs. A MLP consists of multiple layers of models in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network[5].

3. Study Area

In the present study, input is given in the form of parameters like pH, Hardness, TDS, Turbidity and Chlorides while the output from it belongs to forecasted above parameters for next few days at one day lead time. The daily data set consisting of water quality of above parameters for 3 years used in this study is collected from Barave water treatment plant situated at Kalyan (West). Various combinations of data are used for training and testing. The Barave water treatment plant is as shown below:

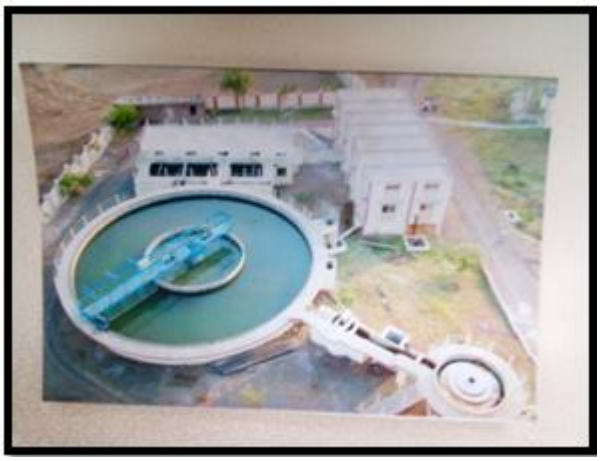
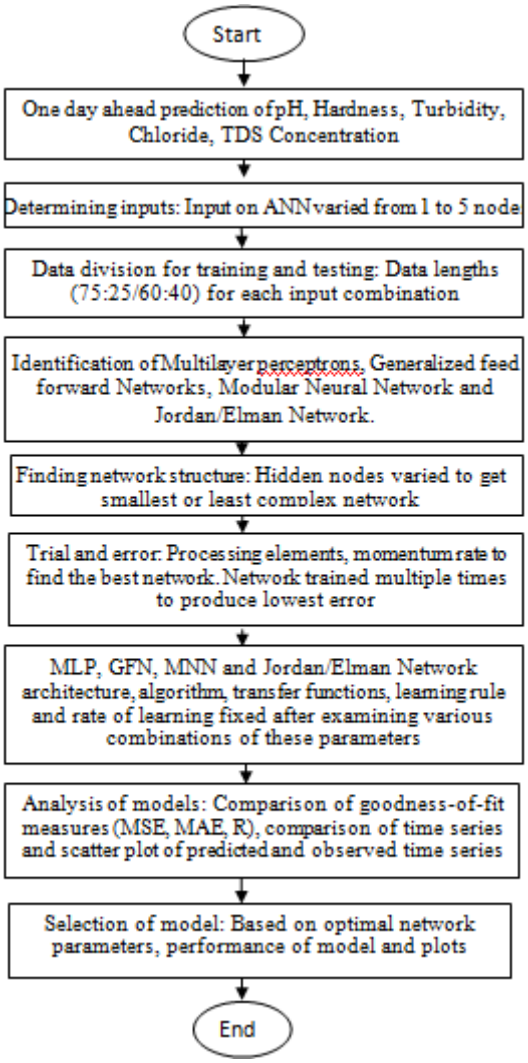


Figure 2: Arial view of Barave Water Treatment Plant



Flow Chart of Methodology

4. Artificial Neural Network Model

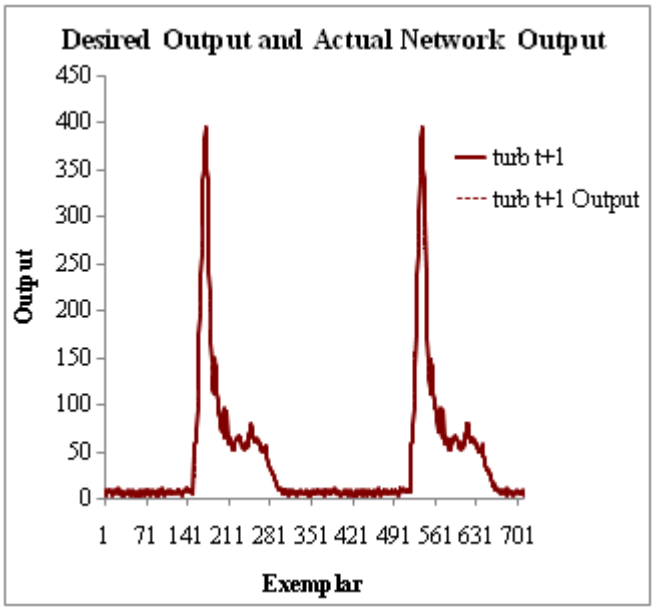
The detailed coverage of ANN can be found in many books [8]. ANN is a powerful machine learning method widely used in the problems of numerical prediction and classification. The network is made up of number of interconnected nodes, arranged into three layers: input, hidden, and output. (Figure 1) The links represent weighted connections between the nodes. A processing element multiplies input by a set of weights, and linearly or non-linearly transforms the result into an output value. By adapting its weight, the neural network works towards generating an output that would be close to the measured target output.

Trial and error procedure would be adopted with respect to input determination; pre-processing, percentage training and testing data sets; network architecture; algorithms; learning rules; learning rates; and training cycles.

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Table 1: Summary of ANN models

Model	Parameter	Training Data%	Testing Data %	Epochs	R
MLP (5-1(3)-1)	pH	60	40	500	0.9441
	Hardness	60	40	500	0.9890
	Turbidity	60	40	500	0.9975
	Chloride	60	40	500	0.9875
	TDS	60	40	500	0.9992
GFFNN (5-1(3)-1)	pH	60	40	500	0.9625
	Hardness	60	40	500	0.9941
	Turbidity	60	40	500	0.9996
	Chloride	60	40	500	0.9970
	TDS	60	40	500	0.9995
MNN (5-1(3)-1)	pH	60	40	500	0.9557
	Hardness	60	40	500	0.9920
	Turbidity	60	40	500	0.9989
	Chloride	60	40	500	0.9959
	TDS	60	40	500	0.9993
Jordan/Elman Network (5-1(3)-1)	pH	60	40	500	0.9237
	Hardness	60	40	500	0.9815
	Turbidity	60	40	500	0.9018
	Chloride	60	40	500	0.9928
	TDS	60	40	500	0.9958



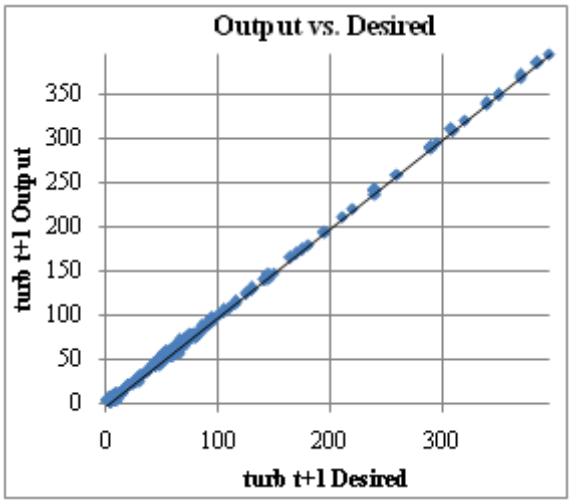


Figure 3: Graph of Output Turbidity vs. Desired Turbidity at Barave WTP for R=0.9996 using Generalized Feed Forward Network.

5. Results and Discussion

As seen from above Table No.1accurate efficiency is obtained at Barave water treatment plant by using GFFN and maximum accurate efficiency is obtained for Turbidity having value of R to be 0.9996. The most efficient network is Generalized Feed Forward Network. Number of epochs provided are 500 and the network architecture provided is (5-3-1).

6. Software Used

The forecasting software used is Neurosolutions 6 by Neurodimensions. It is efficient software used for forecasting and analyzing. It analyses input data in Excel format and creates various networks. These networks are formed by various training-testing patterns (75:25, 60:40 etc.) and various learning algorithms. The networks are in turn saved in the form of breadboards. Hence, Prediction results are saved in the form of breadboards. It has various applications in predicting population, predicting weather etc. Hence, it is an effective software for predicting water quality.

7. Conclusion

The use of MLP, GFFN, MNN and Jordon/Elman Network methods of ANN for short term prediction of pH, Hardness, Chloride, Turbidity and TDS values provided reliable results. Comparing results of various networks shows that the accuracy of GFFN network for pH, Hardness, Chloride, Turbidity and TDS is maximum. Predicting the values of above parameters of water quality will thus help the KDMC while making budget provision for various type of coagulants which are used in the treatment process of raw water in Barave WTP and operating the water treatment plant more efficiently.

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