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Modeling of Ambient Air Pollutants through Artificial Neural Network in Residential Area of Ujjain City

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Abstract: ***The quality of air has become a major priority for worldwide health. The rise of human illness, because of pollution, leads to the gathering of new strategies for the levels of integrated systems of environmental management. The present paper subscribes to this concern and proposes a model for concentration prediction of airborne pollutants: SOx, NOx, RSPM and SPM from a risk area (Sensitive area) in Ujjain City. The model uses the ANN system which analyze all these data's and find the error coming during the experiment. Actually the ANN can simulate this phenomenon, and in the present paper, values of the pollutants concentration from will be provisioned. The present ANN uses for training a number of variables and a large number of data (measured values). For the development and validation of the model it is necessary to have an adequate and continuous monitoring system for data. Airborne pollutants concentrations were measured with different instruments between December 2013 and December 2015. The comparison between the results from real measured data from sensitive area and the result of coming values provided a small maximum absolute error of 0.55 .***

Keywords: Artificial Neural Network, Mean Square Error, Suspended Particulate Matter, Respirable Suspended Particulate Matter

1. Introduction

The growth of both an industrial and residential area is unplanned in many developing cities of India, thus, contributing to the air pollution problems. About 60 percent of air pollution in Indian cities is due to automobile exhaust emission. Automobiles produces volatile organic compounds (VOC), suspended particulate matter (SPM), oxides of sulfur (Sox), oxides of nitrogen (Nox) and carbon monoxide (CO), which have adverse effects on surrounding ecosystem. Air pollutants exert a wide range of impacts on biological, physical, and economic systems. The decrease in respiratory efficiency and impaired capability to transport oxygen through the blood caused by a high concentration of air pollutants may be hazardous to those having pre-existing respiratory and coronary artery disease (Rao et.al. 2000).

Air pollution in urban centers are associated with sudden occurrence of high concentration of vehicular exhaust emissions (VEEs), which are generally governed by the local meteorology and dispersion mechanism (Nagendra and Khare 2002a). Since the relationship of VEE with the meteorology and traffic characteristic data is highly nonlinear, both deterministic and statistical models under perform in predicting the air quality (Nagendra and Khare 2002a). Monitoring of air pollutants is a prerequisite to air quality control. Their impact on the chemical composition of plants is often used as an indicator of and a tool for monitoring environmental pollution (Rao, 1977; Posthumus, 1984, 1985; Agrawal and Agrawal, 1989; Kulump et al., 1994; Dmuchowski and Bytnerowicz, 1995). The modeling and forecasting of environmental parameters involves a variety of approaches. Artificial neural networks (ANN), developed in recent years, can handle nonlinear systems and have been used to model pollutant concentrations with promising results (Gardner and Dorling, 1996, 1998 ;). This is regarded as an intelligent, cost-effective approach and has received much attention in environmental engineering.

In recent years, feed - forward ANN trained with the back - propagation have become a popular and useful tool for modeling various environmental systems, including its application in the area of air pollution and vehicular exhaust emissions modeling under the complex urban conditions.

2. Materials and Method

Artificial Neural Network (ANN)

As network architecture, a 3-layer perceptron model as shown in **Figure 2.1** was used. The first input layer contains the input variables of the network. Here, there were eight neurons in the input layer including four pollutants which is SOx, NOx, RSPM and SPM; and four comfort variables which is Temperature, Pressure, Relative Humidity and rainfall. The number of hidden layers and values of neurons in each hidden layer are the parameters to be chosen in the model. Therefore, one or two hidden layers and different value of neurons were chosen to optimize the ANN performance. The last layer is the output layer, which consists of the target of the prediction model. Here, SOx, NOx, RSPM and SPM were used as the output variables. Hyperbolic tangent sigmoid function was used as the transfer function. The database was divided into three sections for early stopping. 70% of the data were used in training the networks, 15% were designated as the validation set, and the remaining 15% were employed in testing the networks. The mean square error (MSE) was chosen as the statistical criteria for measuring of the network performance.

3. Results and Discussion

Feed-forward neural network have been applied in this study. The tansig and purelin functions were used for the neurons in the hidden layer and output layer respectively. The input and target values were normalized into the range of [-1,1] in the pre-processing phase. The weights and biases were adjusted based on gradient-descent back-propagation in the training phase. The mean square error was chosen as the statistical criteria for measuring of the network performance. The overview of the parameters and their values was shown in

Table 1: Network Structure in Year 2013-2014

Model No.	Net Structure	Training function	Learning	Learning Rate	Momentum constant	MSE
1.	4-7-4	Transig - purelin	Traingdm	0.2	0.7	0.5620
2.	4-9-4	Transig - purelin	Traingdm	0.2	0.7	0.5692
3.	4-11-4	Transig - purelin	Traingdm	0.2	0.7	0.5523
4.	4-13-4	Transig - purelin	Traingdm	0.2	0.7	0.5622

Table 2: Network Structure in year 2014-2015

Model No.	Net Structure	Training function	Learning	Learning Rate	Momentum constant	MSE
1.	4-7-4	Transig - purelin	Traingdm	0.2	0.7	0.5520
2.	4-9-4	Transig - purelin	Traingdm	0.2	0.7	0.5492
3.	4-11-4	Transig - purelin	Traingdm	0.2	0.7	0.5513
4.	4-13-4	Transig - purelin	Traingdm	0.2	0.7	0.5622

During the training, the following figure appears. It represents the difference between the actual value and predicted value of pollutant concentrations. The performance function of the network is shown in **Fig. 1.2**

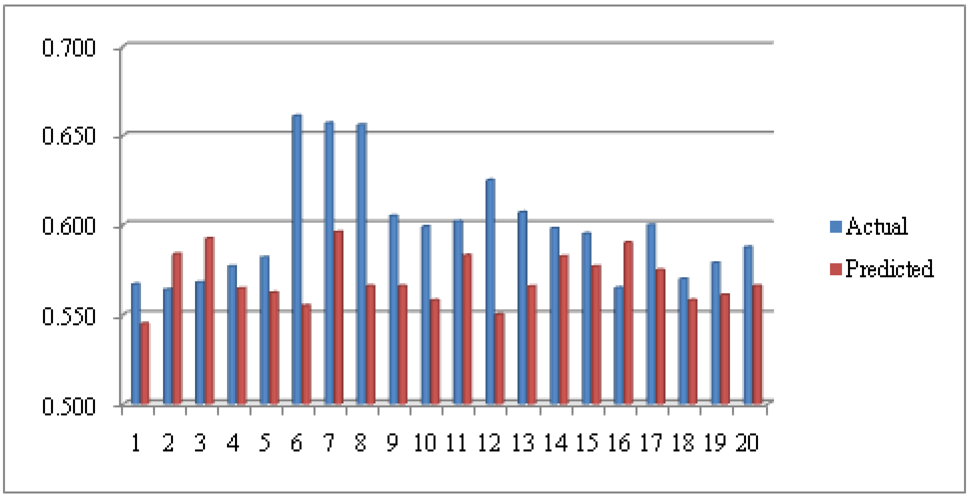

Figure 1: Actual and predicted values of Pollutants concentration in year 2013-2014

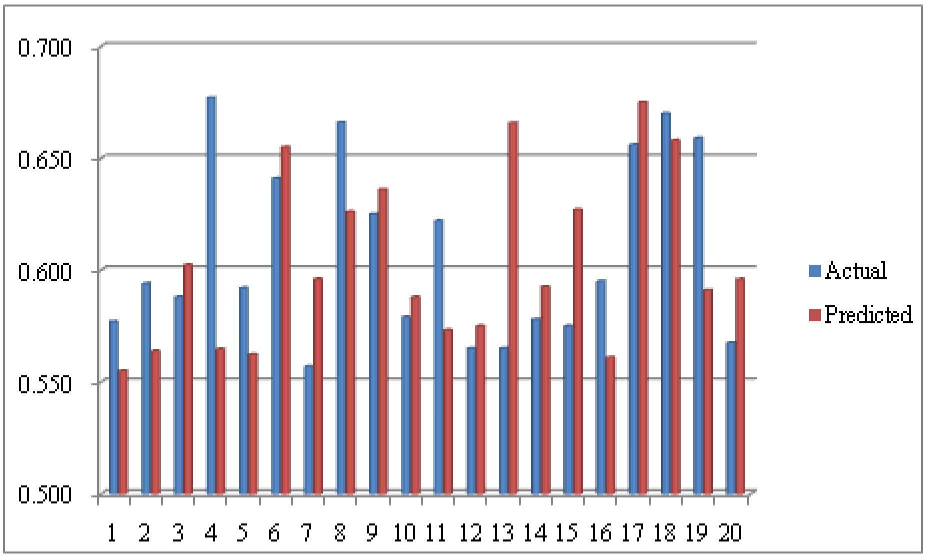

Figure 2: Actual and predicted values of Pollutants concentration in year 2014-2015

4. Conclusions

In this paper, the study was carried out on modeling of air pollutants like Sox, Nox, SPM and RSPM using Artificial Neural Network. The study was focused at the estimation of the Mean Square Error (MSE) from the inputs and outputs which were given to ANN in the industrial area of Ujjain City in India. The investigation was carried out by giving inputs of meteorological data's like Temperature, Humidity, wind pressure and rainfall and giving outputs of collected data's of the various concentration of Pollutants from State Pollution Control Board and accordingly the mean square error was found in all cases was in the range of 0.55.

The result shown here indicates that the neural network techniques can be useful tool in the hands of practitioners of air quality management and prediction. The models studied in this study are easily implemented, and they can deliver prediction in real time, unlike other modeling techniques.

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