Abstract

The aim of this study was modeling of ambient air pollutants through ANN, in industrial area of Ujjain city in India and the study was carried out on modeling of air pollutants like Sox, Nox, SPM and RSPM using Artificial Neural Network. The ANN system was run by giving the inputs of meteorological data’s and giving the outputs of concentration of various pollutants and accordingly the estimation of Errors was done by this study. The monthly data’s in year from 2006 -2012 of meteorological data like Temperature, Humidity, wind pressure and rainfall and the pollutants concentration were collected from the State Pollution Control Board. The ANN system used as shown in figure 1 analyses all these data’s and find the error coming during the experiment. The study estimated the Mean Square Error (MSE) from the inputs and outputs which were given to ANN in the industrial area of Ujjain City in India was found satisfactory being in the range of 0.01-0.03. The results shown here indicate 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.

Keywords: Artificial Neural Network, Mean Square Error, Volatile organic Compounds, Suspended Particulate Matter, Residual Suspended Particulate Matter.

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.

Materials and Method

Artificial neural network (ann):  
An artificial neural network is a mathematical model inspired by biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes the information using a connectionist approach to computation. Neural networks are used to model complex relationships between inputs and outputs or to find patterns in data.

![Figure 1. The Artificial Neural Network system](image)

Air pollution monitoring instruments:  
The monitoring instrument is usually composed of three components, air remover, transducer and recorder. The air remover measures the flow rate of air and the pressure under which gas pollutants exist. The transducer measure a physical property, while the recorder notes change in physical property of gaseous pollutant. The instrument should be checked for response time, specificity, sensitivity, noise level, maintenance and downtime and overall accuracy.

Measurement of Spm:  
High volume air sampler was used for the monitoring for suspended particulates matter. Before sampling, the watt man filter GFA (20.3cm x25.4cm) of the high volume sampler was kept at 15-34 °C, 50% relative humidity for 24-hour and then weighed. The filter paper was placed into the filter holder of the high volume sampler and air was drawn through a 410 cm² portion of the filter at the flow rate of 1.70 m3/min. The filter was removed after sampling. The concentration of suspended particulates in ambient air can be calculated by measuring the mass of particulates collected and the volume of air sampled.

MEASUREMENT OF SO₂:  
Sulphur dioxide from the air stream is absorbed in a sodium tetrachloromercurate solution. It forms a stable di chlorosulphitomercurate. The amount of sulphur dioxide was then estimated by the color produced when prosaniline hydrochloride is added to the solution. The color was estimated by a reading from an absorption meter or spectrophotometer for which a calibration curve has already been prepared.

Measurement of NOₓ:  
Jacob’s and Hochheiser method is used to determine the oxides of nitrogen. Nitrogen dioxidexides are collected by bubbling air through a sodium hydroxide solution to form a stable solution of sodium nitrate. The nitrite ion produced during sampling was determined calorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide, and N (i-naphthyl) ethylenediamine dihydrochloride.

Experimental Data:  
Monthly data SOₓ, NOₓ, RSPM, SPM concentration data have been collected from State Pollution Control Board for the period of 4 years from Jan 2010 to 2012. The meteorological data including wind pressure, temperature, humidity, rainfall have been collected from meteorological department. ANN has been used to develop the model for given data’s. The inputs to model are directly connected to the quantity of information given to the neural network and was generally constituted from meteorological and air quality data. Four inputs are given as meteorological data. The output corresponding to these inputs was monthly average SOₓ, NOₓ, RSPM, SPM concentration. The number of hidden layers and its neuron, learning rate (g), momentum term (l), learning algorithm and activation function, depend on the problem complexity viz. the number of training patterns and the amount of noise in the data.

An ANN is typically defined by three types of parameters:  
1. The interconnection pattern between different layers of neurons  
2. The learning process for updating the weights of the interconnections  
3. The activation function that converts a neuron's weighted input to its output

Results and Discussion  
In this survey and after the experimentation it was found that the air pollutants were greatly affected the selected areas in years 2009, 2010, 2011 and 2012 as shown in figure .

In 2006, As shown in figure 2, the concentration of SOx was 22.4 µg/m³ and NOx was 23.2 µg/m³ found as maximum in the month of May and the concentration of RSPM was 74 µg/m³ and SPM was 158 µg/m³ found as maximum in the month of December and these pollutants were found minimum i.e. SOx was 10.5 µg/m³, NOx was 10.8 µg/m³ in the month of January RSPM was 42 µg/m³ and SPM was 100 µg/m³ in month of August and accordingly due to this the pollution load was high in this area.

In 2007, As shown in figure 3, the concentration of SOx was 23.2 µg/m³ and NOx was 25.6 µg/m³ found as maximum in the month of February and the concentration of RSPM was 188 µg/m³ and SPM was 388 µg/m³ found as maximum in the month of December.
and these pollutants were found minimum i.e. SOx was 9 µg/m³, NOx was 10.7 µg/m³, RSPM was 48 µg/m³ and SPM was 106 µg/m³ in month of September.

In 2008, As shown in figure 4, the concentration of SOx was 33.8 µg/m³ and NOx was 33.1 µg/m³ found as maximum in the month of August and the concentration of RSPM was 255 µg/m³ and SPM was 454 µg/m³ found as maximum in the month of March and all these pollutants were found minimum i.e. SOx was 10.4 µg/m³, NOx was 11.1 µg/m³, RSPM was 61 µg/m³ and SPM was 132 µg/m³ in month of August.

In 2009, As shown in figure 5, the concentration of SOx was 13.4 µg/m³ and NOx was 14.5 µg/m³ found as maximum in the month of October and the concentration of RSPM was 91.4 µg/m³ and SPM was 178 µg/m³ found as maximum in the month of January and all these pollutants were found minimum i.e. SOx was 5.6 µg/m³, NOx was 7.2 µg/m³, RSPM was 33 µg/m³ and SPM was 58 µg/m³ in month of August and accordingly due to this the pollution load was high in this area.

In 2010, As shown in figure 6, the concentration of SOx was 19.9 µg/m³, NOx was 21.1 µg/m³, RSPM was 154 µg/m³ and SPM was 319 µg/m³ were found maximum in the month of May and these pollutants were found to be minimum i.e. of SOx was 13 µg/m³, NOx was 13.6 µg/m³ in the month of July, RSPM was 82 µg/m³ and SPM was 168 µg/m³ in the month of November.

In year 2011, As shown in figure 7, the concentration of SOx was 22.4 µg/m³ and NOx was 23.4 µg/m³ found as maximum in the month of May whereas RSPM was 153 µg/m³ and SPM was 313 µg/m³ found as maximum in December and all these pollutants were found minimum i.e. SOx was 12.2 µg/m³, NOx was 12.7 µg/m³ in August RSPM was 88 µg/m³ and SPM was 180 µg/m³ in the month of July.

In 2012, As shown in figure 8, the concentration of Sox was 19.6 µg/m³ and NOx was 20.6 µg/m³ found as maximum in the month of May whereas the concentration of RSPM was 145 µg/m³ and SPM was 294 µg/m³ found as maximum in the month of April and all these pollutants were found minimum i.e. SOx was 13.5 µg/m³, NOx was 14.2 µg/m³, RSPM was 97 µg/m³ and SPM was 196 µg/m³ in the month of August.

**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 0.01-0.03. 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.
Figure 5. The concentration of Sox, NOx, RSPM and SPM in year 2009

Figure 6. The concentration of Sox, NOx, RSPM and SPM in year 2010

Figure 7. The concentration of Sox, NOx, RSPM and SPM in year 2011

Figure 8. The concentration of SOx, NOx, RSPM and SPM in year 2012

References


