Forecasting Air Quality Parameters of Kozhikode Using Artificial Neural Network

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***Abstract*-Each day marks a proliferation in the development of a place, which definitely suggest a rich country, even with an acute mess of increasing air pollution, which is a serious threat for both environment and human beings. Unquestionably, this case need to have a breakthrough which itself is the aim of this project. Tracking two locations of Kozhikode district, the project destines at finding the best model for the prediction of air quality parameters in both the invigilated stations. Artificial Neural Network (ANN) is used along with Nonlinear Autoregressive Exogenous Input (NARX) network for predicting the best model having a minimum Mean Square Error (MSE) and Coefficient of Regression (R^2) having a value nearer to 1. NARX network consist of two series of input and output representing the meteorological parameters and past values of pollutant concentrations respectively, where output is feedback to input for preparing the model. The model is prepared using pollutant like Sulphur dioxide(SO_2), Nitrogen dioxide(NO_2), Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter(SPM) using Levengerg Marquardt(L-M) algorithm. The best model for two stations Kozhikode city and Nallalam have 8 hidden layers and 4 hidden layers respectively, which is used for predicting the air pollutant concentration of future years by providing the input of the same using forecast sheet in Excel. The resulting values of both stations seems to have the concentration of SO_2 and NO_2 with in the limit of National Ambient Air Quality Standards (NAAQS) where as both SPM and RSPM have values greater than the NAAQS, which thus proves that there is a need for taking necessary safe measures.**

***Keywords*-Air pollution, Artificial Neural Network, NARX, L-M algorithm, SO_2, NO_2, RSPM, SPM, MSE, R^2**

I. INTRODUCTION

Clean air is gradually becoming a thing of past in Kozhikode. According to the latest statistics by the World Health Organization (WHO) database, on ambient air pollution monitoring the concentration of Suspended Particulate Matter (SPM) is 57µg/m^3 and of Respirable Suspended Particulate Matter(RSPM) is 25 µg/m^3, and in this study Kozhikode stands second to the most polluted district Kochi, which has a pollutant concentration of SPM is 64µg/m^3 and RSPM is 28 µg/m^3. The 2013-2016 trend analysis data from two monitoring stations, Nallalam and Kozhikode city in Kozhikode district under Pollution control board, Govt.of Kerala and under Meteorological Department under Govt.of India indicates that Daily average pollutant concentration of Nitrogen Dioxide (NO_2) increased drastically, 2013-14 data shows that the Respirable Suspended Particulate Matter (RSPM) concentration increased from 113 µg/m^3 to 127 µg/m^3. Though the Respirable Suspended Particulate Matter (RSPM) showed an increasing trend during the past two years it showed a decreasing trend in the two respective stations in 2015-16 despite the round the clock construction activity works in the city. However, RSPM was alarmingly high in 2013-14 at both the stations. The 2013-16 trend analysis data shows that Suspended Particulate Matter (SPM) concentration was increased from 133 µg/m^3 to153 µg/m^3. Daily average concentration of SO_2 is a constant value of 2ppm in both stations. If this trend continuous the pollutant concentration in atmosphere will impose risk to human health and environment. So, it is necessary to predict the future values of concentration of pollutant for the safeguard of society.

The dispersion of pollutant is controlled by meteorological conditions prevailing in the atmosphere. In this thesis paper the combined effect of meteorological data such as Temperature, Wind speed and Relative humidity on pollutant concentration is established through Artificial Neural Network (ANN) model for the forecasting of air pollutant. Artificial Neural Network (ANN) is the technique for the forecasting of air pollutants. To determine the input -output relationship of a complex process such as prediction of air pollutants in the atmosphere, processing elements called neurons can be used.

II. METHODOLOGY

A.Study area

Being the third most urbanized district of Kerala, Kozhikode Corporation is opted as the study area for prediction of air quality parameter. Kozhikode Corporation as a greatest as well as the most crowded area having a population of 4,31,560 in which Kozhikode city is selected as one of the study areas for the prediction because of the possibility of having highest air pollutant concentration. Nallalam, located as the biggest industrial hub in Kozhikode corporation is selected as the second study area

B. Data collection

As far as the subject for the thesis is concerned, SO_2, NO_2, SPM, and RSPM are the preferred pollutants. Being the most influencing factors of air pollutant concentration, meteorological factors like Wind speed, Temperature and Relative humidity are also considered. India Meteorological Department and Kerala State Pollution Control Board are the

two sources selected for acquiring the necessary data. For a duration of 4 years, from 2013-2016, the values of daily ambient air temperature, Wind speed, Relative humidity are gained from India Meteorological Department, and State Pollution Control Board has provided the necessary data regarding the daily concentration of SO_2, NO_2, SPM, and RSPM over the same period.

C.Air quality prediction model using ANN

Development of air quality prediction model is processed using Nonlinear Autoregressive Network with Exogeneous Input (NARX network). MATLAB software becomes the ground for preparing the model. SO_2, NO_2, SPM, and RSPM are the output of network. NARX network uses meteorological condition and 4 past values of output as the exogenous input. 'nts' tool is used for the development of model.TheNARX network is shown in Fig.1

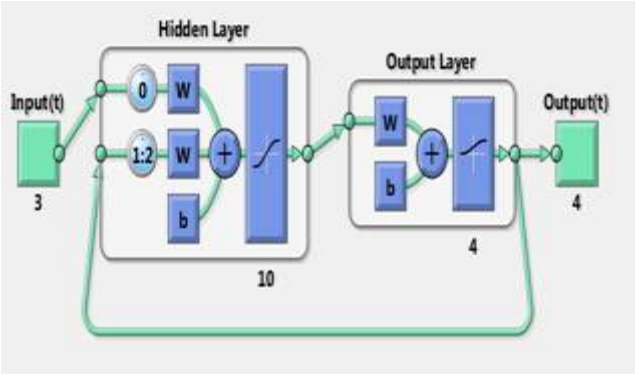

Fig.1 NARX network

D. Sensitivity analysis

In ANN, sensitivity analysis detects the influence of inputs like wind speed, Temperature and Relative Humidity on the concentration of pollutant. Leave one out method satisfies the same by avoiding each of the inputs and thus finding the performance evaluation on each case. Each error thus obtained is referred for the highest error which will solve the demand for the search for the factor that has greater influence on pollutant concentration.

E. Forecasting the concentration of air pollutant with the help of best model

The best model acquired is forecasted using nntool. The input data for the future years is gained from Microsoft Excel 2016 using forecast sheet. Using this input in the best model clears the task of forecasting the concentration of air pollutant for next three years

III. RESULT AND DISCUSSION

A. Artificial neural network model

ANN model is developed using three input parameters and four output parameters using NARX network with the help of nts tool. This model is structured with a sigmoid transfer function as the hidden layer and linear transfer function as the output layer. Levenberg-Marquardt (L-M) algorithm is used for training the developed model. The total data for the development is used in a such a manner that 70% is used for training, 15% is for testing and 15% for validation. The best ANN model is developed using minimum MSE and with Regression coefficient R^2 having a value approximately equal to 1. The performance of network based on MSE and R^2 value at both stations are given in the table I.

TABLE I

TESTING RESULTS FOR THE NEURAL NETWORK MODEL

Monitoring station	No of Hidden layers	R	R^2	MSE
Kozhikode	8	0.9434	0.890	0.0078
Nallalm	4	0.93184	0.868	0.0101

For Kozhikode, the best model is developed with 8 hidden layers having MSE 0.0078 and R^2 0.890, nearer to 1. This model thus acquired is proved to be the best and the most reliable one for this monitoring station. The best model for Nallalam is created using 4 hidden layers with MSE 0.0101 and R^2 0.868, which is the best and most reliable model.

B. Sensitivity Analysis

Sensitivity analysis is carried out in both the station for recognizing the relative importance of input parameters. Result for sensitivity analysis at both stations are shown in the table below.

TABLE II

RESULT OF SENSITIVITY ANALYSIS

Monitoring Station	Parameter Excluded	MSE	Ranking
Kozhikode	Ambient Air Temperature	0.0071	3
	Relative Humidity	0.0102	1
	Wind Speed	0.0082	2
Nallalm	Ambient Air Temperature	0.0103	3
	Relative Humidity	0.0106	1
	Wind Speed	0.0105	2

For Kozhikode and Nallalm removal of Relative humidity gives the highest error of 0.0102 and 0.0106 which indicates that Relative humidity is the factor that have the highest influence than the other factors, on air pollutant concentration.

C. Forecasting the concentration of air pollutant with the help of best model

Forecasting the input data of Wind speed, Temperature and Relative humidity using Excel forecasting method. The result of the forecasted concentration of the air pollutant using the best model for Kozhikode and Nallalm are shown in the Fig 2 and 3 respectively.

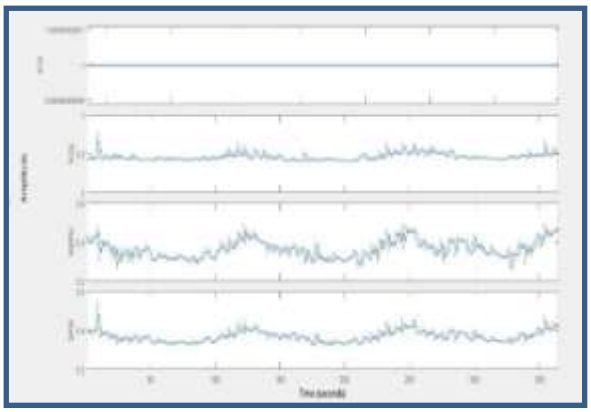

Fig.2 Forecasted values of pollutant concentration at Kozhikode

The result of Kozhikode indicates that the concentration of all the pollutant shows an increasing trend. Both SPM and RSPM shows an excessive increase of which RSPM is having the highest extension. The maximum value of SO_2 is 2 ppm and NO_2 is 36ppm, which is within the prescribed limit of NAAQS, whereas SPM shows its peak value of 127µg/m^3 above the normal value of 100µg/m^3 and RSPM also suggests a greater value of 63µg/m^3 than the NAAQS value of 60 µg/m^3.

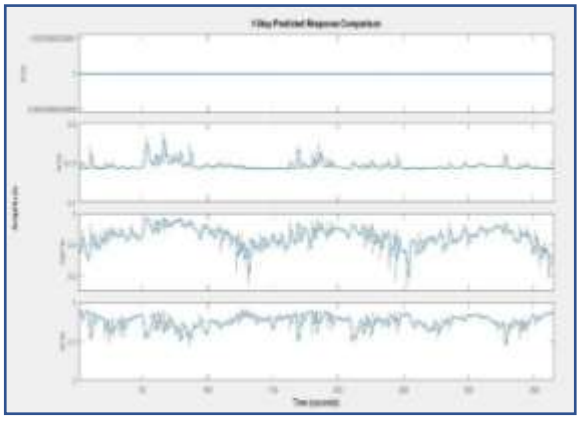

Fig.3 Forecasted values of pollutant concentration at Nallalm

The result of Nallalm shows that Both NO_2 and SO_2 shows gradually increasing trend while both SPM and RSPM shows a huge increase for the years 2017-2019.Both SO_2 and NO_2 have value with in the NAAQS limit of 2ppm and 22.73ppm respectively. The highest value of SPM is 162µg/m^3, which is beyond the safe limit of 100 µg/m^3.RSPM also shows a value of 132µg/m^3, higher than the normal value of 60 µg/m^3.

IV. CONCLUSION

Concentration of air pollutants in the atmosphere is increasing day by day due to human activities. These pollutants are very threat to human health and environment. The primary pollutants include SO_2, NO_2, Particulate matter.

ANN was developed for the prediction of pollutant concentrations like SO_2, NO_2, RSPM and SPM at two locations of Kozhikode. Meteorological parameters like Wind speed, Temperature, Relative humidity are considered as the input parameters. The best model for Kozhikode city is developed having a MSE of 0.0078 and R^2 0.890 with 8 hidden layers whereas Nallalm have its best model with 4 hidden layers having MSE of 0.0101 and R^2 value of0.868. Both the best model has minimum MSE and R^2 having a value nearer to 1. Sensitivity analysis shows that in both stations, Kozhikode city and Nallalm, Relative humidity having considerable effect on pollutant concentration. With the help of this best model pollutant concentration for upcoming three years were predicted. From this predicted value it is clear that concentration of SO_2 and NO_2 are within NAAQS, whereas the concentration of SPM and RSPM cross the limit. On analysing the concentration of particulate matter at both stations, Nallalm an industrial area having higher emission compared to Kozhikode city. The main sources of particulate matter include burning, vehicular emissions, road dust, smoking, industries etc. This particulate matter is very dangerous to human health as it causes death when a certain limit crosses. So, we should provide some safe measures like Reduce diesel emissions by replacing older engines with newer and cleaner ones, take action to reduce wildfires, Limit the use of fireplaces and wood stoves, stop smoking, Mulch garden waste instead of burning it.

A. Scope for future study

Scarcity of time and data availability have an impact on the development of ANN model. The model is developed using only 3 input parameters, which can be further advanced, providing more input parameters like solar radiation etc. This project is also specifically around 2 stations which is having yet another limitation that this model has that can be increased. The third limitation of this model is that data used in this study is only for four years data. This can be increased as per availability. This model is site specific so it cannot be used for a third location as the input parameters are meteorological data, which changes from place to place according to latitude. A hybrid model can overcome this limitation of the developed model using ANN.

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