

International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452

Maths 2025; SP-10(2): 16-20

© 2025 Stats & Maths

www.mathsjournal.com

Received: 08-11-2024

Accepted: 13-12-2024

Lokesh KumarResearch Scholar, Department of
Mathematics, NAS College,
Meerut, Uttar Pradesh, India**Gaurav Kumar**Professor, Department of
Mathematics, NAS College,
Meerut, Uttar Pradesh, India

An Artificial Neural Network (ANN): Based air quality index forecast for the city of Meerut

Lokesh Kumar and Gaurav KumarDOI: <https://www.doi.org/10.22271/math.2025.v10.i2Sa.1995>

Abstract

PM10 is one of the primary air pollutants responsible for air pollution. This research employed ANNs, a widely used learning method, to assess the effects of this contaminant on human health and the environment, utilizing data collected between 2019 and 2023. The Pollution Control Board of Uttar Pradesh (UPPCB)'s air observation center gathered data on the center of industry in Meerut and completed the simulation and optimization procedures using SPSS programming. Before being compared with the actual air quality data, the estimated air quality results were subjected to a multilayer perceptron analysis. Additionally, there have been cases where the air quality index (AQI) values in the Meerut province have surpassed the permissible limit, particularly during periods of high output.

Keywords: ANN, air pollution, AQI

1. Introduction

As industrialization advances, air pollutants such as particulate matter (PM10), carbon dioxide (CO₂), and sulfur dioxide (SO₂) are on the rise. This surge in population has a detrimental effect on the environment and human well-being, which adversely affects public economies. By implementing these measures, these air pollutants are effectively regulated, and state-run administrations, both local and general, respond appropriately. These toxins are the ones that are deemed significant when evaluating their impact on the environment and human well-being.

One of the most harmful atmospheric pollutants to human health is SO₂, as it primarily affects the respiratory system (Boznar *et al.*, 1993 & 2002) [3, 4]. It could potentially pose a risk to human health as it can be converted into sulfate and sulfuric acid. Both natural and artificial sources contribute to the production of SO₂. The foundation of the essential natural resource is composed of volcanoes. One of the major causes that humans contribute to is the combustion of fuel, particularly diesel and coal. The majority of SO₂ is generated by power plants, companies involved in metal processing and handling, and vehicles that rely on these fuels.

These indicators are regularly evaluated and carefully scrutinized both within the country and on a global scale. The UPPCB's air observation facilities in Meerut keep track of the pollutants present in the air. These stations keep track of substances and gases that can impact the air's quality. The results are frequently updated on the website of the center.

The purpose of this review is to assess the air quality in Meerut, the industrial hub of Uttar Pradesh, and to predict and visualize the situation using a multilayer perceptron (MLP) approach. The data collected by the UPPCB from 2019 to 2023 was analyzed in this context. Following that, the projections were obtained, and SPSS software was utilized to present the data between 2019 and 2023. In this process, the MLP approach was employed.

2. Methods

An artificial Neural Network (ANN) is a quantitative and computational model that draws inspiration from the structure and operations of real brain networks. They are mainly distinguished by their neural activation technique, preparation approach, network architecture, relationship example, and data handling capabilities. The NN model that is most frequently used is the MLP. This kind of neural network is referred to as a controlled network as it requires an ideal output in order to train. The goal of this kind of network design is to use

Corresponding Author:**Lokesh Kumar**Research Scholar, Department of
Mathematics, NAS College,
Meerut, Uttar Pradesh, India

verifiable data to build a model that accurately connects input and output. Therefore, the model can provide the intended outcome even if it is not immediately apparent.

When data is moved from the input layer to the hidden one, the connection weights cause the number of data sources to rise. They are handled by a nonlinear function in the hidden layer once they have been summarized. The next hidden layer adds, enlarges, and controls the data that is handled by the connection weights after it exits the previous hidden layer if there are many hidden layers.

The data is then copied with accessible weights and processed once again using the output layer to supply the neural network's output. Before the neural network can be applied to any specific task, it must be trained on several input-output mapping tests. For every trained neural network to produce reliable results, these are the necessary details. The sample utilized for training information must thus be rather large and comprise a large amount of data from various process variables and experimental conditions to contain all the pertinent information.

2.1 Time series interpretation

Multi-layer perceptron (MLP) is applied to finish the analysis of time series, and it is defined by:

$$T_{q+1} = f(T_q, T_{q-1}, \dots, T_1)$$

Where $T_1, T_2, T_3, \dots, T_q$ are inputs and T_{q+1} is output.

MLP is applied to form f .

The output is defined as the fifth information point, following the use of the first four as input.

3. Data analysis

The SO₂, PM₁₀, and NO₂ air pollution components are the three categories on which the UPPCB screens information for its webpage to compile information about the state's numerous metropolitan districts. The AQI levels are measured at Meerut City's Kesharganj Street. The stage has proven crucial during the preceding years. The quality of the air in Meerut would deteriorate in tandem with an increase in the AQI. In this work, AQI data for Meerut's Kesharganj Road has been gathered between January 2019 and June 2023. An overview of the data is shown in Figure 1:

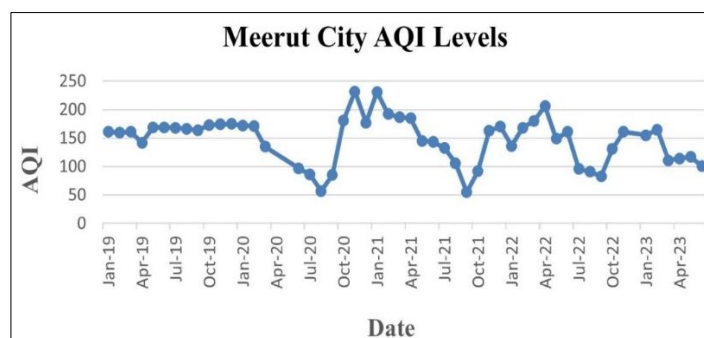


Fig 1: Actual data of AQI

4. Examination of ANN

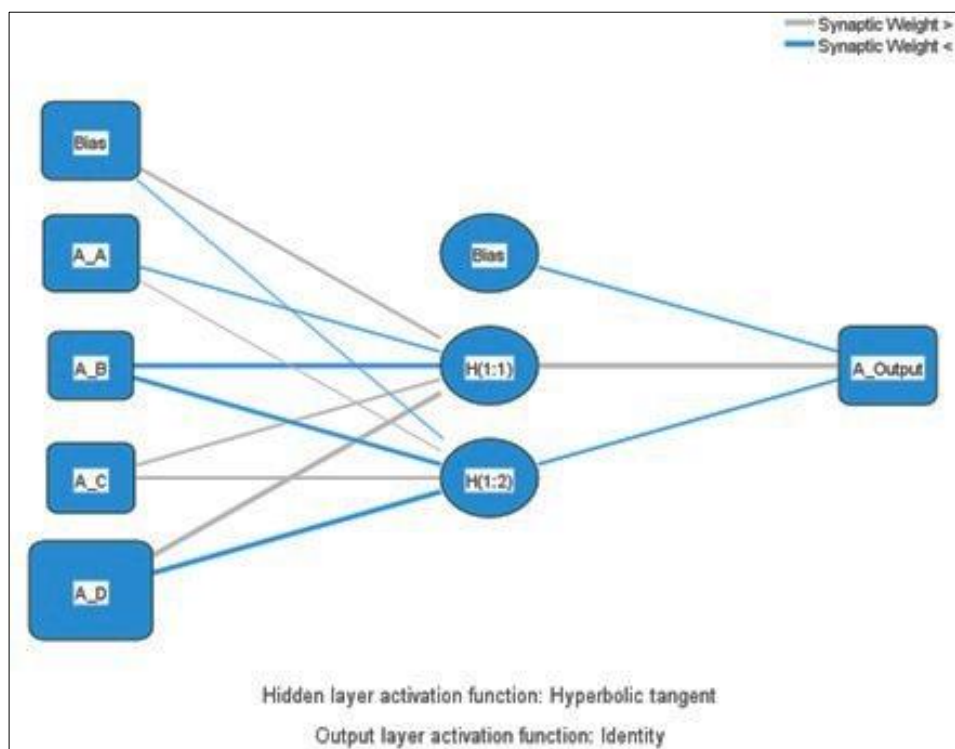
Using SPSS programming, we have developed an MLP system for the town of Meerut. This inquiry uses 51 points of information in total. These noteworthy data points are categorized into 47 groups. For every group, there are five points of information. The result was considered to be the fifth AQI information point, with the starting four points serving just as input. Again, when the first information point is eliminated, the following four points of information are inputs, and the subsequent information point within the order will be output, and so on. The four underlying data inputs are A_A, A_B, A_C, and A_D, whereas the label assigned for the

output data point is a Output. Below is a time series structure that has been developed. Network information, comprising input, hidden, and output layers, is displayed in Table 1.

Relative error during testing is 0.425 and during training is 0.455, based on the model summary displayed in Table 2. Table 3 displays parameter estimation, while Table 4 discusses the significance of the independent variables. The specifics of the network's configuration are illustrated in Figure 2. In Figure 3, predicted values are displayed versus output. Figure 4 displays information about expected values in comparison to residuals. The normalized importance of the network's independent variables is displayed in Figure 5.

Table 1: Overview of the neural network architecture

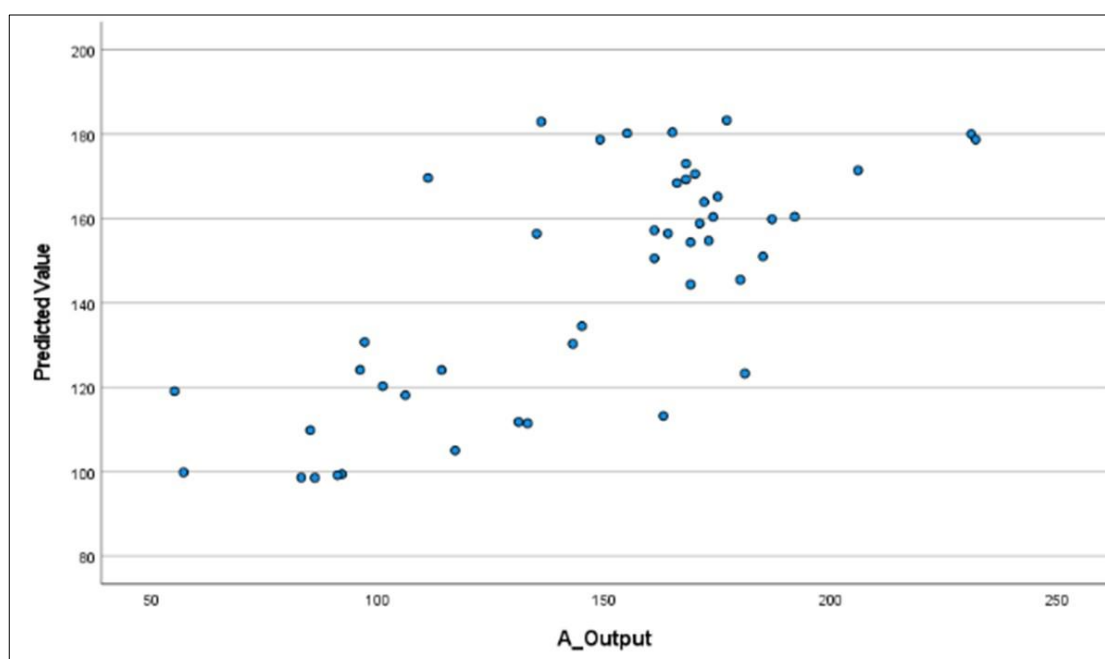
Network Information			
Input Layer	Covariates	1	A_A
		2	A_B
		3	A_C
		4	A_D
	Total Units ^a		4
Rescaling Method		Regularized	
Hidden Layer(s)	Hidden Layers		1
	Hidden Layer Units 1 ^a		2
	Function of Activation		Hyperbolic tangency
Output Layer	Dependent Component	1	A_Output
	Total Units		1
	Rescaling Method		Regularized
	Function of Activation		Identity
	Function of Errors		Addition of Squares
a. Not including the biased unit			

**Fig 2:** Neural Network Configuration**Table 2:** Model's error metrics during training and testing phases

Model brief		
Instruction	Error in Addition to Squares (EAS)	6.820
	Relative Error (RE)	0.455
	Stopping Rule	One consecutive step having no decrease in error ^a
	Training Time	0:00:00.01
Testing	EAS	2.366
	RE	0.425
Predicted Variable: A_Output		
a. Using the assessment sample, error calculations are made.		

Table 3: Estimated parameters for the input layer and hidden layers of the neural network

Parameter estimation				
Predictor		Predicted		
		Hidden Layer 1		Output Layer
		H (1:1)	H (1:2)	A_Output
Input Layer	(Bias)	-.200	-.186	
	A_A	.357	.664	
	A_B	.651	.090	
	A_C	-.169	-.815	
	A_D	-.469	-.790	
Hidden Layer 1	(Bias)			-.322
	H (1:1)			-.459
	H (1:2)			-.719

**Fig 3:** Predicted AQI values generated by the ANN model with the actual recorded values

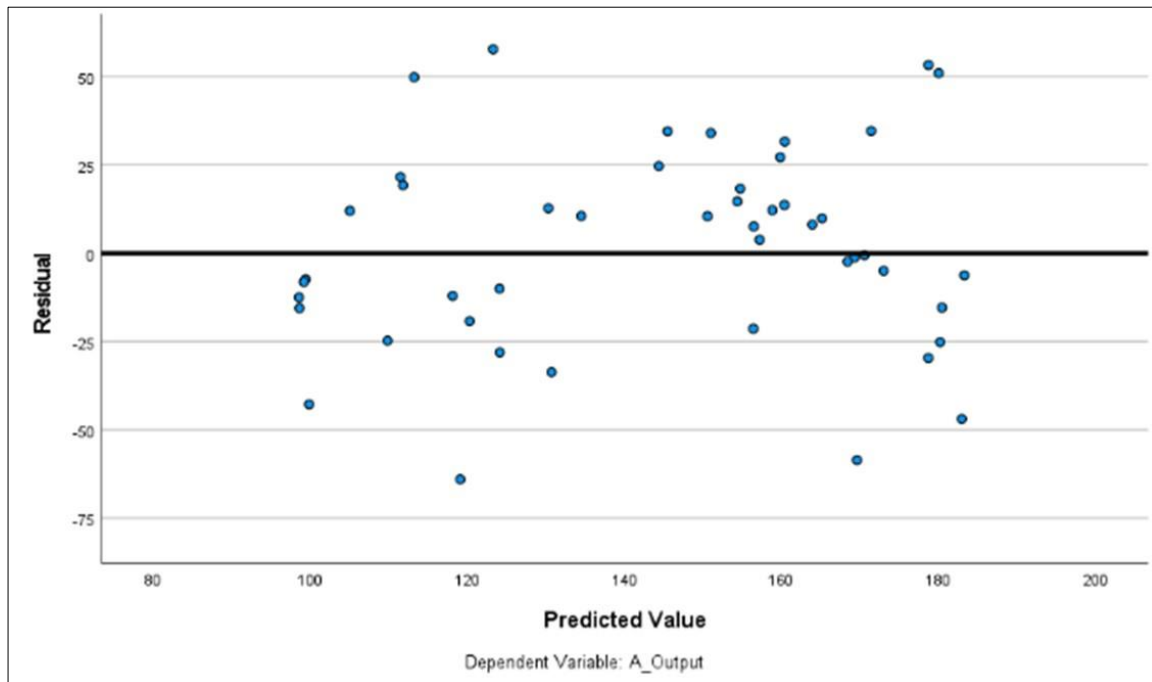


Fig 4: Residuals (differences between actual and predicted values) plotted against the predicted AQI values

Table 4: Significance and normalized significance of the independent variables in the model

Independent Component Significance		
	Significance	Normalized significance
A_A	.257	82.0%
A_B	.170	54.1%
A_C	.260	82.9%
A_D	.314	100.0%

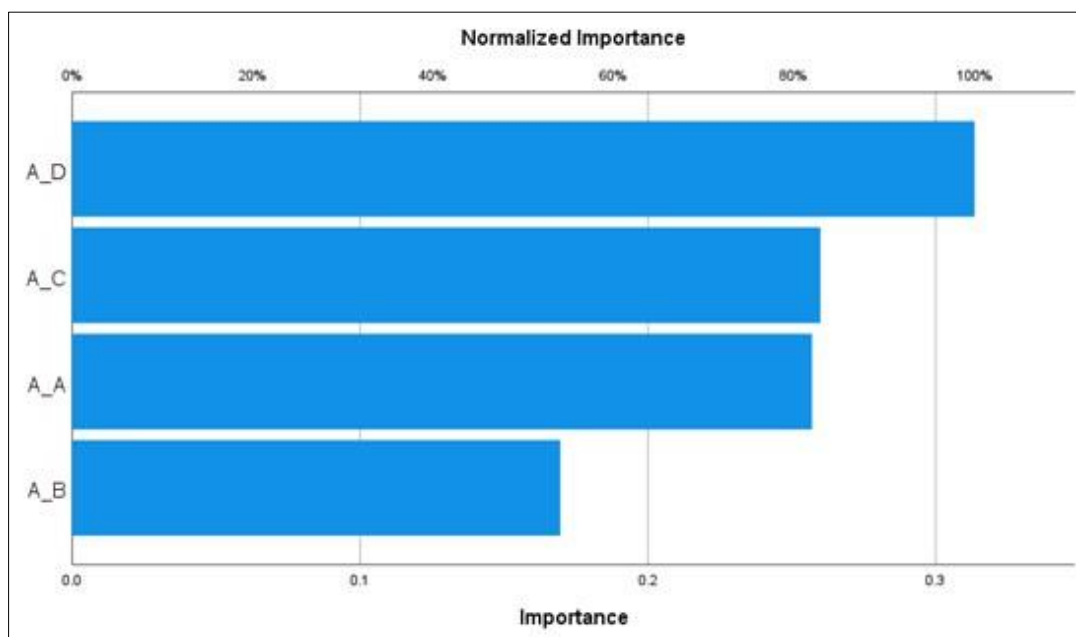


Fig 5: Normalized Importance of Independent Variables

5. Conclusion

In this paper, time series analysis is used to determine the AQI levels. There is non-linearity in the model. To manage non-linearity, an ANN-based model is built. The MLP is employed when building the model using time series. According to the model, the relative error was 0.425 during the testing phase and 0.455 during the instruction period. This implies that future AQI values may be predicted using historical data.

6. References

1. Asadollahfardi G, Zangoeei H, Aria SH. Predicting PM_{2.5} concentrations using artificial neural networks and Markov chain: A case study Keraj City. Asian J Atmos Environ. 2016;10(2):67-79.
2. Bhavsar R. Air pollution monitoring using artificial neural network. Int J Sci Eng Res. 2019;10(12):515-519.
3. Boznar M, Lesjak M, Mlakar P. A neural network-based method for short-term predictions of ambient SO₂

- concentrations in highly polluted industrial areas of complex terrain. *Atmos Environ.* 1993;27B:221-230.
4. Boznar MZ, Mlakar P. Use of neural networks in the field of air pollution modelling. *Air Pollut Model Appl* XV. 2002;375-383.
 5. Coglian E. Air pollution forecast in cities by an air pollution index highly correlated with meteorological variables. *Atmos Environ.* 2001;35:2871-2877.
 6. Comrie AC. Comparing neural networks and regression models for ozone forecasting. *Air Waste Manag Assoc.* 1997;47:653-663.
 7. Freeman AM III. Air pollution and property values: A further comment. *Rev Econ Stat.* 1974;56:554-556.
 8. Kumar G, Sharma RK. Air pollution evaluation methods. *Int J Eng Res Dev.* 2017;13(9):12-17.
 9. Kumar G. Time series analysis of PM10 for Bulandshahr industrial area in NCR using multiple linear regression. *Int J Eng Res Dev.* 2018;14(3):56-62.
 10. Kumar G. Time series analysis of PM10 for Noida Sector 1 industrial area in NCR using multiple linear regression. *Bull Pure Appl Sci Sect E Math Stat.* 2018;37(2):273-277.