Prediction and Estimation of Pm10 and SO_2 Concentrations in the Ambient Air At Vijayawada Station using Artificial Neural Networks Computing

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Abstract: ***The point of this paper is to use Artificial Neural Networks and Fuzzy Logic for measuring and foreseeing of vital contamination parameters that is SO_2 and PM10 fixations. Structure and advancement of soft computing specialized methodologies like Feed-forward Back Propagation arrange (BPN) model and Mamdani Fuzzy Inference show which are prepared and tried utilizing five years past information (meteorological information). For improving the precision of estimation, assessing the base determining mistake (minimum forecast error) and the outcomes are done by utilizing MATLAB software. To contemplate the connection between meteorological parameters and PM10 by utilizing the previous authentic information to such an extent that they can be utilized for prediction of pollutant. To set up a model for the forecast of PM10 dependent on meteorological parameters at every single station by utilizing Artificial Neural Networks. To set up a model for the prediction of SO_2 dependent on meteorological parameters including PM10 as one of the information parameters at every single station by utilizing Artificial Neural Networks. To set up a model for the forecast of PM10 and SO_2 dependent on meteorological parameters at every single station by utilizing Artificial Neural Networks as a Computing techniques.***

Index Terms: ***Air pollution, Artificial Neural-networks, Expectation, Forecast, PM10, Sulfur Dioxide.***

I. INTRODUCTION

From the beginning of time, the Human mind has taken up the tendency to predict unknown aspects of different phenomena. In the early years, the concept of forecast was used a superstitious concept to strengthen beliefs or for personal benefits. In the modern world, it is no longer a superstition but a tool to predict the uncertain future based on the past, present and analysis of trends. It is concerned with a broad range of applications and purposes as a scientific capability.

The entire life existing on earth depends upon the ambient air present in the atmosphere. The average person consumes about 7-8 liters of air per minute. Therefore, an average person uses about 550 liters of pure oxygen per day.

The substances that are present in the air which can cause potential harm to Humans, animals, vegetation and/or materials present in the form of liquid droplets, gases or solid particles. These are formed in the air either by interaction between other pollutants or from emissions from identifiable sources. Particulate matter (PM10) and Sulfur dioxide (SO_2) are the two major pollutants, which are formed as a result of coal combustion processes and they co-exist in coal-smoke air pollution. Effects of PM10: Exposure to high PM10 can range in various conditions like coughing, wheezing and asthma attacks and all the way to more severe diseases like bronchitis, high blood pressure, heart attack and premature death. PM10 is one of the key components in depleting the soil nutrition values which will degrade the plantation levels.

Effects of SO_2: Very toxic, it can cause death on inhalation on large concentrations. At high concentrations it can lead to lung fluid accumulation (pulmonary edema). It can also cause coughing, respiratory shortage, difficulty breathing, and chest tenderness. A single high-concentration exposure may cause a lasting condition such as asthma.

II. ARTIFICIAL NEURAL NETWORK COMPUTING MODEL

Artificial Neural Network Computing (ANNC) models are the subset of the arena Machine Learning which is a subset of Artificial Intelligence. The main agenda of the ANNC is to provide computer with abilities of taking decisions accurately under hypothetical circumstances and also the ability to recognize the objects and others. Ability of Learning Spontaneously from the data is one of the key factors that make neural networks a key problem solver. The concept of learning from past experiences is one the main protagonist feature which is implemented in these neural networks.

Revised Manuscript Received on April 09, 2019.

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The main composition of any neural network is Neuron. This neuron is the processing element in the neural network. Based on the position of the neuron we decide the layers of the neural networks. On general instances of solving problem through neural networks we broadly have three layers. Layer-1: Input layer which receives from external environment. Layer-2: Hidden layer process the inputs received and provide the solution of the inputs. Layer-3: Output layer collects the results of the hidden layer and portray to the User. Stanley (1990) showed the neuron arrangement in neural network with network topology and the operation along with efficiency of the network.

III. COLLECTION OF DATA

The data for meteorological parameters like Atmospheric Pressure (AP), Atmospheric Temperature (AT), Relative Humidity (RH), Wind Speed (WS), Wind Direction (WD), Solar Radiation (SR) (calculated hourly) and the hourly concentrations of PM10 & SO_2 were acquired concurrently from the Andhra Pradesh Pollution Control Board's Ambient Air Quality Station's located at Vijayawada (from 2009 – 2013).

IV. METHODOLOGY AND DEVELOPMENT OF MODEL

A. Methodology

To contemplate the connection between meteorological parameters and PM10 by utilizing the previous chronicled information with the end goal that they can be utilized for forecast of pollutant on scale.

Development of a unique model which predicts the existence of PM10 based on meteorological parameters at each and every station by utilizing Artificial Neural Networks.

Development of a unique model which predicts the existence of SO_2 relied on meteorological parameters including PM10 as one of the input parameter at each and every station by using Artificial Neural Networks.

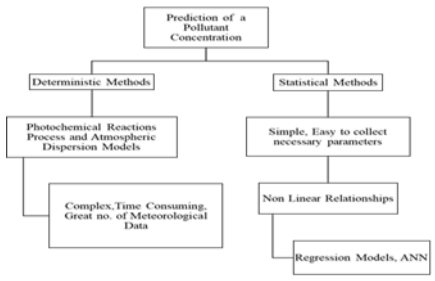

Fig. 1: Overall Block diagram of Analysis of Measured Values Vs Predicted Values by ANN

Table I: Different Approaches for Deciding no. of Hidden Layers

Author	Hidden layer
Maren et al (1990);Masters (1993);Rojas (1996)	Trial and error method
Salchenberger et al., (1992)	75% of Input
Berke and Hajela (1991)	(Input + Output)/2
Hecht-Nielsen (1990); Caudill (1989)	(2I*+1)
Rogers and Dowla (1994)	No. layers < No. training samples
Yu (1992)	Error in 1 layer=Error in (I-1)
Masters (1993)	(No. of training samples)/No. of layers = 2
	(Max value of tr sample) /No. of layers = 4
Hush and Horne (1993)	(Max value of tr sample) /No. of layers = 10
Amari et al (1997)	(Max value of tr sample) /No. of layers = 30

B. Development of ANN model with Feed- Forward Back propagation

Normalize the inputs and outputs with respect to their maximum values.

Normalization can be done by using the Eqn (1):

$$X = 0.1 + 0.8\left(\frac{x_i}{x_{max}}\right) \qquad (1)$$

Selecting a neural network, where its neural structure is re-designed and the inputs are given to the neural network. The neural system will self-assertively pick the preparation information from one of its design determined. The neural framework itself overviews its execution by utilizing the endorsement set data. Loop the methods 2 and 3 with various neural framework structures and its planning (training) parameters. Choose the best network by distinguishing the smallest error found with validation set.

For everything about very nearly 42 frameworks has been set up for Vijayawada station by contemplating 5 to 10 neurons and the no. of covered layers given by various makers as sorted out underneath in Table I. The accuracy of the neural framework is communicated with respect to authentic examination. As indicated by plan, the most significant co-related regard is to be > 0.9.

V. RESULTS AND DISCUSSION

The proposed model of Neural Networks considers Solar Radiation, Atmospheric Temperature, Atmospheric Pressure, Wind Speed, Wind Direction and Relative Humidity as the specifications for the input layer of the Neural Network.

The relation between the measured values and the predicted values are depicted as regression graphs that are plotted in the Fig. 1 - 3. From the regression graphs, It is

clearly observed that all the measured and the predicted values are approximately same and those points are distributed around the fitting line by utilizing R^2 (Regression Scheme).

From the Fig. 1 based on the reliability of the neural network the surmising value for pm10 on the basis of meteorological constraints is producing $R^2 = 0.9362$.

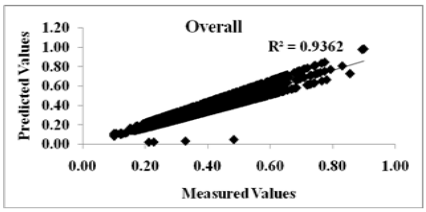

Fig 2. Overall Regression Analysis of Measured Values Vs Predicted Values for Architecture – 1 (Prediction of Pm10)

Table II: The best network Models Proposed for Prediction of PM10 and SO_2

S.No	Station Name	Network ANNC-Architecture	CORELATION				
			Network	Training	Validation	Testing	Overall
1	Vijayawada	Architecture-1	6-10-4-1	0.955	0.969	0.963	0.967
2		Architecture-2	7-10-15-1	0.965	0.968	0.957	0.970
3		Architecture-3	6-9-13-2	0.935	0.965	0.953	0.952

From the Fig. 2, based on the reliability of the neural network the surmising value for SO2 on the basis of meteorological constraints is producing R2 = 0.9425.

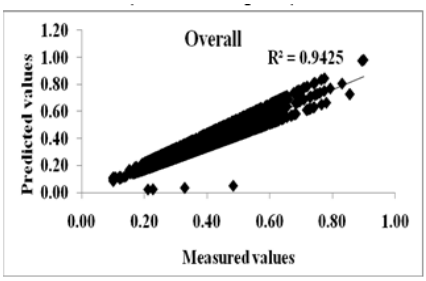

Fig. 3: Overall Regression Analysis of Measured Values Vs Predicted Values for Architecture – 2 (Prediction of Pm10 and SO_2)

From the Fig. 3, based on the reliability of the neural network the surmising value for pm10 and SO_2 on the basis of meteorological constraints is producing $R^2 = 0.9063$.

Fig. 4 shows Overall Regression Analysis of Measured Values Vs Predicted Values for Architecture -3 (Prediction of Pm10 and SO_2).

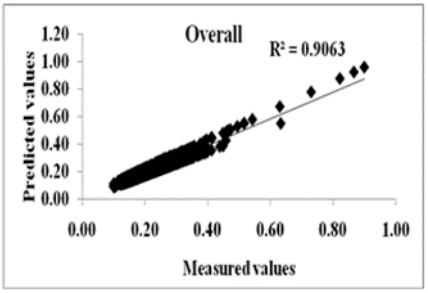

Fig. 4: Overall Regression Analysis of Measured Values Vs Predicted Values for Architecture -3 (Prediction of Pm10 and SO_2)

CONCLUSION

As observed from the graphs the concentrations are highest in winter season followed by summer and rainy season. The meteorological parameters like Wind Speed, Relative Humidity, Solar Radiation and Temperature establishes an indirect dependency with respect to pollutant concentration. There is a reduction in the concentration of PM10 and SO_2 in the ambient air with an increase in Relative Humidity and Wind Speed and there is a reduction in the concentration of PM10 and SO_2 with a decrement in the Atmospheric pressure and Solar radiation. The use of Artificial Neural Network modeling for the prediction of SO_2 and PM10 concentrations in the ambient air is proved to be a successful model as the correlation coefficients between predicted and measured concentration of the three neural networks are > 0.90.

FUTURE SCOPE

The same study can be extended by considering more number of meteorological parameters including pollutant parameters for the prediction of other pollutant including PM10 and SO_2. As this is only statistical analysis in order to know the behavior of pollutant under different meteorological parameters deterministic analysis has been carried out

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