A Review on Prediction of Ambient Air Quality

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Abstract- *Industrialization is the major parameter for urban development which poses an added burden on resources such as water and environment. In recent years, greatest environmental threats in developing countries are Air Pollution which causes adverse effects to humans, plants and animals. Air Quality Prediction is important as it helps to mitigate the effect of air pollution on human health. In recent years, many methods have been used for the treatment of environmental problems such as artificial intelligence methods, statistical methods, Physical methods, Photochemical Methods and Machine Learning methods. In recent investigation various methods has been reviewed for the prediction of Air Quality*.

Keywords- Air Quality Monitoring, Prediction, Adaptive Neuro Fuzzy Interference System

I. INTRODUCTION

Air quality largely influences the ecology, environmental and public health in a region. The relationship between the air pollution and the mortality is well known since early days. Numerous epidemiological studies have established the associations between the air pollutants (particulate matter, nitrogen oxides) and daily excess in mortality and morbidity. Repairable suspended particulate matter refers to those SPM with nominal aerodynamic diameter of 10 μm or less. High RSPM level in air may cause chronic and acute effects on human health, particularly the pulmonary function, as they can penetrate deep into the lungs and cause respiratory problems. Association with high levels of NO_2 etc. may further exaggerate such effect. High concentration of RSPM, sulfate and SO_2 would cause respiratory mortality in several situations. Besides the effect of the SPM, there is also a strong relationship between higher concentration of SO_2 and NO_x and several adverse health effects, including the cardiovascular diseases, respiratory effects such as asthma and bronchitis, and reproductive and developmental effects. To ensure the safety of the humans and the archaeological monuments, particularly in the urban environment, it is very much desired to monitor the ambient air quality on a regular basis and develop appropriate strategies for the control of the emission sources. [5] In major metropolitan cities of India, air pollution has become a serious problem as a result of industrialisation and urbanisation. Control of air pollutants is necessary to provide a better and safe environment for future generation. Few studies have been conducted for this purpose in India. Major steel and allied industries and many other small industries are located in the region. As a result, the regions are affected by increasing air pollution levels over the years [6]. Forecasting ambient air pollutants is an integral task in the process of evaluating regulatory control measures for air pollution in an urban city marred by increasingly heavy traffic and everyday mounting air pollution. Control measures will be more effective if forecasting is reliable. So far, various tools have been adapted by different researchers in order to have the reliable forecasts of air pollutants. When purpose is to forecast, it has been observed that highly sophisticated multi-parameter meteorological models grossly under predict or over predict the air pollutants concentration. In fact, the complexity of the physical and chemical processes that gaseous pollutants undergo in the atmosphere, the complexity of meteorological conditions in urban areas and the uncertainty in the measurements of all the parameters involved, make the fast and accurate modelling of these pollutants by computing detailed meteorological and physical/photochemical models very difficult. Indian Meteorological Department (IMD 2009) has classified seasons in India into four categories:

(i) Winter: Dec to Feb,
(ii) Pre-Monsoon: March to May,
(iii) Monsoon: June to August,
(iv) Post-Monsoon: Sep to Nov.

Depending upon varying meteorological conditions in different seasons, air pollutants behaviour will also vary [7].

II. LITERATURE REVIEW

Amit P. Kesarkara, Mohit Dalvia, Akshara Kaginalkara, Ajay Ojha, Coupling of the Weather Research and Forecasting Model with AERMOD for pollutant dispersion modeling. A case study for PM10 dispersion over Pune, India (2007) has studied the data from the emissions inventory development and field-monitoring campaign (13–17 April 2005) conducted under the Pune Air Quality Management Program of the Ministry of Environment and Forests (MoEF), India and USEPA, has been used to drive and validate AERMOD. Comparison between the simulated

and observed temperature and wind fields shows that WRF is capable of generating reliable meteorological inputs for AERMOD. The comparison of observed and simulated concentrations of PM10 shows that the model usually underestimates the concentrations over the city. However, data from this single case study would not be sufficient to conclude on suitability of regionally averaged meteorological parameters of driving Gaussian models like AERMOD and additional simulations with different WRF parameterizations along with an improved pollutant source data that will be required for enhancing the reliability of the WRF–AERMOD modelling system.

J.B. Ordieres, E.P. Vergara, R.S. Capuz, R.E. Salazar, Neural network prediction model for fine particulate matter (PM2.5) on the US – Mexico border in El Paso (Texas) and Ciudad Jua´rez (Chihuahua) (2005) has studied the short time PM2.5 prediction model that has built taking into account a large number of samples from a non-linear data set with high degree of internal noise. The model can be used as a tool for short time control and planning in difficult areas like the U.S. – Mexican border in El PasoeCiudad Jua´ rez. The comparative analysis neural network architectures has provided very interesting results, comparing Radial Basis Function networks with Multilayer Perceptron and Square Multilayer Perceptron networks, which are the most commonly used. The MLP network provides acceptable predictions, in spite of the drastic environmental conditions of the location. The RBF network shows the best behavior, with the shortest training times and best stability. These results suggest that the widely used MLP should be replaced by the more convenient RBF network.

José Juan Carbajal-Hernández, Luis P. Sánchez-Fernández, Jesús A. Carrasco-Ochoa, José Fco. Martínez-Trinidad, Assessment and prediction of air quality using fuzzy logic and autoregressive models (2012) has studied the new model based on fuzzy inference systems has been introduced to assess air quality status. The proposed AQI works two steps: first, the toxicity of set for measured concentrations is classified by levels (Sigma operator); second, the effects in the ecosystem are evaluated in order to determine air quality status (FIS). A comparison between models shows that a fuzzy environment directly affects the results providing a more accurate index dealing with real data. Experimental results shows that proposed algorithm is an efficient way to monitor air pollution in urban areas. A comparison of the assessment and the predicted air quality showed good system performance. Therefore the proposed model in this research is powerful tool in decision support for monitoring future air pollution environmental problems.

Kunwar P. Singh, Shikha Gupta, Atulesh Kumar, Sheo Prasad Shukla, Linear and nonlinear modeling approaches for urban air quality prediction (2012) has studied the dataset considered represent the air quality of Lucknow city. The data was partitioned into 3 subsets; training, validation, and test, using the Kennard–Stone (K–S) approach. The K–S algorithm designs model set in such a way that objects are scattered uniformly around the training domain. Thus, all sources of the data variance are included into the training model. The air temperature, relative humidity, wind speed, SPM, SO2, and NO2 were used as the predictor variables. Sensitivity analysis for the importance of the input variables in optimal GRNN models revealed that SO2 was the most influencing parameter in RSPM model, whereas, SPM was most important input variable in other two (NO2, SO2) models. Both these variables (SPM, SO2) exhibited positive correlation with Wind Speed.

R. Sivacoumar, A.D. Bhanarkar, S.K. Goyal , S.K. Gadkari, A.L. Aggarwal, Air pollution modeling for an industrial complex and model performance evaluation (2001) has studied Mathematical modelling that is applied in Jamshedpur region indicated that industries contribute about 53% of NOx pollution in the region, whereas domestic sources contribute about only 7% while nearly 40% was contributed by automobiles. Model performance are evaluated using statistical analysis by comparing measured and predicted concentrations shows good agreement between the two with accuracy of 68%.

Ujjwal Kumar, V.K.Jain ARIMA forecasting of ambient air pollutants (O3, NO, NO2 and CO) (2010) has studied modelling procedure in the present study has worked well for forecasting ambient air pollutants and can be effectively utilized for the air quality forward warning purposes. Moreover, the deterministic air quality models that are currently in vogue and provides useful spatial scenario of air quality status but performs not so well as compared to statistical models when comes to future prediction, may incorporate proposed statistical models as part of their data-assimilation process. It is expected that such incorporation may improve prediction ability of these air quality models. Time series models can't reproduce spatial scenario although very useful in future prediction and hence it is expected that their incorporation in deterministic air quality models may produce a much better spatio–temporal scenario be used by policy makers for air pollution regulatory purposes.

Wenjian Wang, Changqian Men, Weizhen Lu, Online prediction model based on support vector machine (2008) has studied development of an online SVM model to predict air quality parameter concentration levels, and it can provide

promising prediction results. Compared with the conventional SVM model, it can not only receive data in sequence and determine dynamically the optimal prediction model, possess a good prediction performance as well. Another outstanding advantage of the presented method is that the optimal prediction model can be determined before SVM learning unlike in general prediction models.

Yu-Chun Lin, Shie-Jue Lee, Chen-Sen Ouyang, Chih-Hung Wu, Air quality prediction by neuro-fuzzy modeling approach (2019) This paper proposes an air quality prediction system based on the neuro-fuzzy network approach. The proposed approach has the following advantages: Adding fuzzy elements can more appropriately deal with the uncertainty of the impact factors involved; The distribution of training data can be described properly by fuzzy clusters with statistical means and variances; Fuzzy rules are extracted automatically from the training data, instead of being supplied manually by human experts; The obtained fuzzy rules are of high quality, and their parameters can be optimized effectively.

III. AIR QUALITY PREDICTION MODELLING

1) Deterministic Models: Deterministic models are the traditional models for air quality prediction. They calculate the concentration of pollutants based on the solution of equation consisting of various emission and meteorological variables that represent the physical process.
    - Gaussian model is widely used deterministic air quality prediction model.
    - Numerical modelling is a deterministic model where the relationship between the variables is represented by partial differential equations.
2) Statistical Models: Statistical models find the pollutant concentration by associating a statistical relationship between the emission and meteorological variables.
    - Regression models describes the relationship between independent (meteorological and emission parameters) variables and dependent variable (pollutant concentrations).
    - Time series models are the statistical method applied to non repeatable experiments.
3) Physical Models: Physical models have high potential to predict air quality. These models use scaling methods to convert the measured concentrations to atmospheric concentrations of pollutants.
4) Photochemical model: Photochemical models calculate the pollutant concentrations by using a set of mathematical equations characterized by chemical and physical processes. Grid Models are most powerful model which solves a problem by dividing the region into horizontal and vertical cells.
5) Machine Learning: Machine Learning has been defined as a field of study that gives the computers the ability to think. A model with some parameters is defined and machine learning is the process of executing a program to optimize performance based on either training data or using some past experiences [3].

IV. CONCLUDING REMARKS

In this paper, the review was carried out on air quality forecasting using various models such as Deterministic Models, Statistical Models, Physical Models, Photochemical model and Machine Learning. All of them are used for forecasting of air quality but some are non - consistent as well as under or over accurate in this review it is shown that the statistical models used for the prediction is accurate as well as consistent compared to other models for forecasting of Air Quality.

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