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# Autoregression model for the prediction of ambient air pollutant concentration in Delhi

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## ABSTRACT

**Urban air pollution has been a serious environmental problem for several decades in most of the developing countries including India. It is due to the increase of anthropogenic sources of pollution from vehicular emissions and rampant industrialization. The objective of this study was to develop different models to quantify the air pollutants and to examine its forecasting ability. For this purpose autoregression model one and autoregression model two has been used to determine the concentrations of typical pollutants such as suspended particulate matter, sulphur oxides, nitrogen oxides, carbon monoxide, ammonia, ozone, benzene, toluene, xylene present in the R.K Puram area of Delhi. The results show that the autoregression model two is a better model for predicting the pollutant's concentration. Also diurnal variation show that typical air pollutant's concentration is highest in the morning and in the evening traffic hour, except ozone which shows the seasonal variation.**

***Keywords- Auto regression model; ambient air quality; diurnal variation***

## 1. INTRODUCTION

Urban air pollution is major cause environmental damage including agriculture (Agrawal et al, 2003) and ecosystem (Marenco et al, 1994) invariably affecting human lives. There are numerous pollutants concerned with environmental problem viz. suspended particulate matter, sulphur oxides, nitrogen oxides, carbon monoxide, ozone and VOCs(Volatile organic carbon) (Sharma et al, 2009). All the pollutants mentioned above are major constituents in smog and other secondary pollutant formations like PAN(Peroxy acetyl nitrate) which damage vegetation, building, reduces visibility and also causes several respiratory diseases like asthama in humans (Desqueyroux et al, 2000).

## 2. METHODOLGY

R.K.Puram was selected for the study as it is one of the oldest and also a residential area in South west Delhi. Auto- Regressive model has been used to forecast the pollutants concentration at R. K. Puram site of Delhi. An AR model expresses a time series analysis as a linear function of its past values. The order of the AR model depends upon the number of included past value. The simplest AR model is the first-order

$$y_t + a_1 y_{t-1} = e_t \qquad (1)$$

While, the second-order autoregressive model, AR (2), is given by

$$y_t = a_1 y_{t-1} + a_2 y_{t-2} = e_t \qquad (2)$$

Some important statistical measures has been also carried out for model accuracy, they are Mean absolute error (MAPE), Normalized mean square error (NMSE), Root mean square error (RMSE) and Index of Agreement (IOA).MAPE used to know the trend in fitted data, RMSE used to measure differences between the predicted and observed value therefore should be low, NMSE used to isolate statistical error in repeated measure data and IOA to model performance.

## 3. RESULTS AND DISCUSSION

The hourly data obtained from the November 2011 to April 2012 from Envirotech monitoring stations at R K Puram, were evaluated for monthly variations in the concentrations of different pollutants CO, NOx, $PM_{2.5}$ & $PM_{10}$ in the figure 2.1 and $SO_2$, $NH_3$, benzene, xylene, toluene and ozone are shown in the figures2.2 .

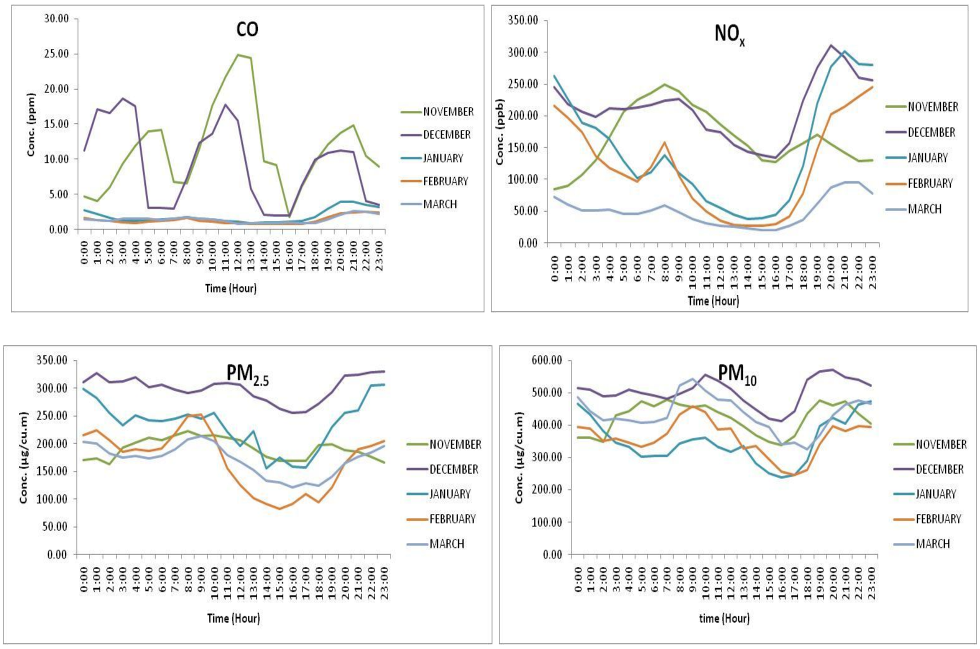


**Fig 2.1**: *Average diurnal plot of CO, NOx, $PM_{2.5}$ and $PM_{10}$at R K Puram.*

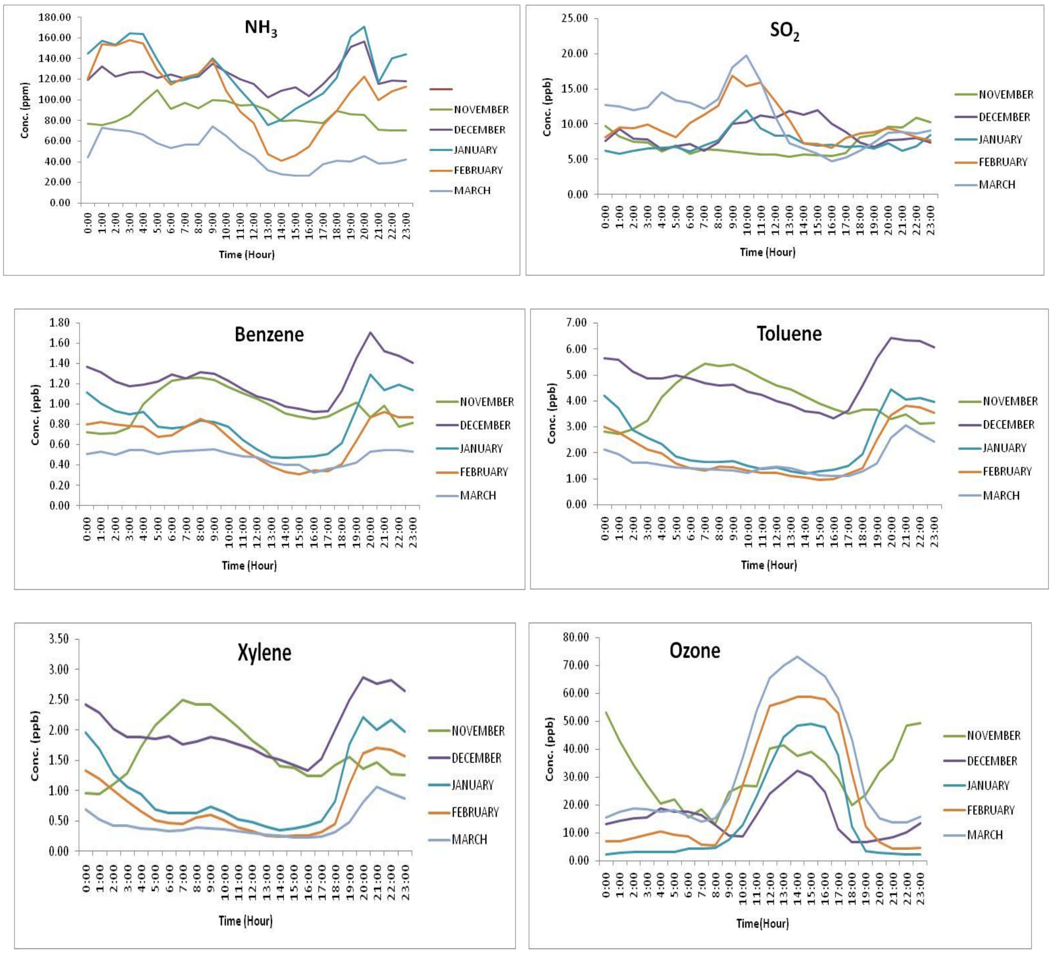


**Fig 2.2**: *Average diurnal plot of $NH_3$, SO2, benzene, toluene, xylene and ozone at R K Puram.*

From the diurnal variation diagram it is clearly observed that all the pollutants follow the typical diurnal variation except ozone are found to be higher during the months of November and December and least concentrations are observed during the months of February and March. The reason may be attributed to the high wind speed and low pressure zone over Delhi during February and March, resulted in fast dispersal of pollutants from urban canopy. Whereas, during November and December, due to high pressure conditions and low wind speed resulted in the formation of inversion condition which in turn traps the pollutants in the lower environment and creating high pollution events(Satsangi et al, 2004)

**Table 1** – *AR (1) and AR (2) for different pollutants at R K Puram site*

| | CO | | NOx | | $PM_{2.5}$ | | $PM_{10}$ | | $NH_3$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) |
| MAPE | 79.25 | 97.98 | 107.1 | 49.9 | 44.4 | 43.6 | 43.8 | 16.7 | 42 | 42 |
| RMSE | 0.92 | 1.1 | 72.68 | 64 | 49.9 | 50.4 | 37.2 | 80.3 | 52.4 | 52.5 |
| NMSE | 0.22 | 0.29 | 0.27 | 0.25 | 0.1 | 0.1 | 0.04 | 0.04 | 0.37 | 0.37 |
| IOA | 0.81 | 0.76 | 0.94 | 0.95 | 0.89 | 0.89 | 0.95 | 0.95 | 0.76 | 0.76 |

**Table 2** – *AR (1) and AR (2) for different pollutants at R K Puram site*

| | $SO_2$ | | Benzene | | Xylene | | Toluene | | Ozone | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) | AR (1) | AR(2) |
| MAPE | 124.4 | 123.9 | 22.1 | 21.7 | 66.6 | 73.01 | 35.35 | 24.44 | 80.07 | 0.22 |
| RMSE | 5.3 | 5.32 | 0.0008 | 0.12 | 0.42 | 0.44 | 1.08 | 0.46 | 6.2 | 6.67 |
| NMSE | 0.58 | 0.58 | 0.09 | 0.04 | 0.54 | 0.45 | 0.73 | 0.07 | 0.2 | 0.22 |
| IOA | 0.77 | 0.77 | 0.94 | 0.94 | 0.91 | 0.9 | 0.76 | 0.97 | 0.93 | 0.91 |

From the table 1 and 2, AR (1) and AR (2) show almost the similar result only the performance indicator improves for most of the pollutants like $NH_3$, $PM_{10}$, benzene and toluene.

## 4. CONCLUSION

The study describes the average diurnal variations in the observed data of different pollutants at R K Puram area in New Delhi. The variations in the data show typical high concentrations during the morning traffic and the evening traffic hours except Ozone show high concentration during the months of November and December and low concentrations during the months of February and March due to meteorological conditions over Delhi during these seasons. The AR (1) and AR (2) model has been applied to predict the concentration of pollutants for which AR (2) model shows better result than the AR (1) model.

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