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Time Series Analysis of Atmospheric Particulate Matter of Bengaluru City

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Abstract— Particulate matter (PM) is composed of inert carbonaceous cores with multiple layers of various absorbed molecules, including metals, organic pollutants, acid salts and biological elements, such as endotoxins, allergens and pollen fragments. PM is classified in the following types -"Total suspended particulates" (TSP) is a name given to particles of sizes up to about 50μm. The larger particles in this class are too big to pass through our noses or throats and so, they cannot enter our lungs. They are often from wind-blown dust and may cause soiling of buildings and clothes. However, TSP samples may also contain the small PM10 and PM2.5 particles that may enter into our lungs. Total suspended particulates (TSP) with additional subcategories of particles smaller than 10μm (PM10) and particles smaller than 2.5μm (PM2.5) are discussed. Size and chemical composition are among the most important parameters influencing the way in which airborne particles interact with the environment. This paper presents a time series analysis of particulate matter (PM10) in Bengaluru city, Karnataka, India from April 2018 to November 2018. An ARIMA(Auto-Regressive Integrated Moving Average) model of time series analysis is used for analysis and forecasting of the future concentration of the air pollutant. The data set of daily average PM10 concentration collected from Karnataka State Pollution Control Board was good fitted with an ARIMA model as per Ljung – Box test. The cross validation of model is done using residual analysis.

Keywords— Air pollution, Forecasting, Particulate matter, stationary, non-stationary, Time series analysis, ARIMA, ARMA, PM10.

I. INTRODUCTION

Air is the mixture of gases that fills the atmosphere, giving life to the human, plants and animals that make Earth as a living planet. Air is almost entirely made up of two gases (78.09% nitrogen and 20.85% oxygen), with a few other gases such as carbon dioxide (0.04%) and argon (0.93%). Air pollution is the condition when the chemical composition of air changes due to certain substance. In general air naturally maintains its chemical composition by dispersing the pollutant when they mixed with it. With insanely use of natural resources in the name of development to make human society affluent cause series of problem like deforestation, release of toxic materials and solid waste which results in scarcity of pure and clean environment. These problems become severe in all metro cities of the world. In last decade the air quality of most of metro cities in world is poorest [1]. Globally every year, 7 million people die because of exposure to high level of air pollutants. Urbanization is unavoidable process in developing nation which gives accelerating growth in the transport sector, a booming construction industry, and a growing industrial sector. In India most of metro cities are unplanned one which leads to higher population density towards the city centre. The high population density result in more transportation activities and improper maintenance of vehicles worsen air quality and human health. This increased level of air pollutants result in adverse effect on health of human being as well as animals.

There have been many studies published for assessment and forecast/prediction of air pollution for various cities in the world using different statistical concept like spatial, time series analysis etc.

II. RELATED WORK

Pan et al. (2008) analysis the air quality data of Taiwan using autoregressive fractionally integrated moving-average (ARFIMA) model and fount it is better than ARIMA models to predict the air quality data. Seetharam & Simha (2009) attempted to assess trend of ambient air quality status of Bangalore city for PM2.5, NOx and SO2 using time series analysis. Naveen & Anu (2017) studied ambient air quality data of Thiruvanantpuram District, Kerala, India using ARIMA and SARIMA method and found that ARIMA model gave better forecasting than the SARIMA model . Xile et al. (2012) analysed the concentrations of SO2,NO2 and PM10 during 1996 to 2008, in Zhengzhou city of China using nonparametric Mann-Kendall test . Sharma et al. (2012) used the extreme value theory to predict level of different pollutant in Delhi [26]. Kumar & Jain (2010) used ARIMA model to forecast the value of different pollutant for the ITO Delhi location. Ahmad & Bano (2015) using spatial temporal method found that value of that PM2.5 and PM10 remain higher than NAAQS standard in Firozabad city. Panday (2016) also showed that value of PM10 in Indore city was higher thanNAAQS, 2009.

III. METHODOLOGY

The ARIMA model is used for analysis of day-wise air pollutant data for the period of April 2018 to November 2018. Consider the model, for which the difference is a stationary ARMA process, these models are called Auto Regressive Integrated Moving Average Process. Consider ARIMA model, which is defined by

$$\eta(B)\tilde{z}_t = \theta(B)a_t$$, where

$$\eta(B) = 1-\eta_1 B^1 - \eta_2 B^2 -,...,-\eta_p B^p - \eta_{p+1} B^{p+1} -,...,-\eta_{p+d}^{p+d}$$

is a non-stationary Autoregressive operator such that the d of the roots of $\eta(B)=0$ lies on the boundary of the unit circle. And the reminder outside the unit circle.

One shorthand notation for the model is ARIMA (*p, d, q*), Where *p* = AR(Autoregressive) order, *d* = order of differencing, *q* = MA (Moving Average) order. The lack of fit and forecast performance of proposed time series model is done by L-jung Box test. The December 2018 data is used for the validation of proposed model.

IV. RESULTS AND DISCUSSION

The ARIMA(1,1,1) model was found to be the best fit for forecasting of mean PM10 concentration. The Ljung-Box test significance value is 0.9659 which is greater than p = 0.05(significance level for comparison). So the proposed model does not exhibit lack of fit.
Moreover, AIC is small as compared with other potential models, which is desirable. So the proposed model is good fitted and acceptable.
The above the model was used to forecast PM10 concentration of December 2018 and the corresponding observed concentration is compared in the below table.

Table1: Observed values and the corresponding forecasted values of the fitted model

Date	Observed value	Forecast value
04/12/2018	96	125.3432
06/12/2018	126	123.8784
09/12/2018	130	124.0097
13/12/2018	160	123.9979

It can be observed from Table1 that the forecasted values are close to the observed values and hence the model is a good fit.

V. CONCLUSION

1. Several potential models were fitted and compared based on the AIC values. We found that the ARIMA (1, 1, 1) model has the least AIC value. Thus we conclude that ARIMA(1,1,1) model is a good fit to the PM10 data.
2. Further the Ljung-Box test has resulted in the conclusion that the model fits adequately to PM10.
3. The forecast values can be used to keep a check on high pollution levels.

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