Time Series Analysis of Air Quality in Chennai city

M. Nirmala¹, M. Mallika², M. Gomathi³
¹Faculty, Department of Mathematics, Sathyabama Institute of Science and Technology, Chennai
²Faculty, Department of Mathematics, Sathyabama Institute of Science and Technology, Chennai
³PG Student, Department of Mathematics, Sathyabama Institute of Science and Technology, Chennai
¹mnirmalamaths@gmail.com

Abstract. A prime issue faced in India is the quality of air. As per World Health Organization (WHO) report, 2.4 million people die each year as a result of Air Pollution globally. In this study, the Air Quality Index (AQI) is analyzed based on the database monitored at different monitoring centres in Chennai in India. For this purpose, a data set consisting of monthly Ambient Air Quality data of Chennai city with various air pollutants for commercial, residential and industrial area were collected from Central Pollution Board, Chennai. This research article aims to understand air pollution aspects in the Chennai city by identifying an appropriate time series model and the result were analyzed.

1. Introduction

Different types of pollution exist in the universe. One among them is the Air pollution. It affects the health conditions of the human beings, plants, animals and also affects the entire ecosystem. Air quality can be defined as the state of air around us. The release of gases from the vehicles, wastes released from the industries pose a great threat for the health factors and also contributes much for the pollution of air. As a result, the quality of air deteriorates much in the cities than in the rural areas. Planting of trees and plants can be considered as one of the solution to overcome air pollution. Because of the adverse effects of air pollution throughout the world this topic is of prime concern for most of the researchers. Increasing and higher concentrations of air pollution can be life intimidating and thereby air pollution became one of the major issue in the world (Kurt and Oktay, 2010).

Gautham.sarella has analyzed the ambient air in the vapi city. The AQI of 4 major pollutants like PM₁₀, PM₂.₅, SO₂, and NO₂ is found in 3 different locations such as Industrial, Residential and Commercial Area has been taken. The AQI falls on moderately polluted. T.Senthilnathan has assessed about the pollutant in the Chennai city at residential and traffic intersection sampling stations using high volume sampler. Thilagaraj has assessed the AQI in 4 places of Chennai. He has done a survey based on questionnaire from various people. Biju B has analyzed the air quality in Thiruvananthapuram. The principle components of pollution are suspended particulate matter and it falls under the range Moderately Polluted. Devendra dohare has done a literature review relating to the monitoring of Ambient Air Pollution in India. R.Saravana Kumar has assessed the condition and quality of air in the city of Coimbatore by measuring Air Quality Index. The work was carried out based on measuring four major air pollutants such as PM₁₀, PM₂.₅, SO₂ and NO₂ at different climate conditions.
2. Study Area and Materials

Chennai, formerly known as Madras is one of the metro cities in India and is called the Gateway of South India. Chennai has the third-largest expatriate population in India at 35,000 in 2009, 82,790 in 2011 and estimated at over 100,000 Chennai Population 2017 – 9.88 Million (estimated). Tamil Nadu Pollution Control Board is operating eight ambient air quality monitoring stations in Chennai under National Air Quality Monitoring Programme (NAMP) funded by Central Pollution Control Board. All the stations are functioning on 24 hours basis, twice a week. The samples collected from NAMP stations are analysed for the Respirable Suspended Particulate Matter (RSPM) (RSPM is particulate matter less than 10 microns) and gaseous pollutants such as Sulphur di oxide (SO2) and Nitrogen di Oxides (NO2).

![Map of Chennai, India](image)

The Air Quality Index is a number which is used to measures the quality of air on any specified day. It differs from place to place and country to country. It tells us whether the air at a particular place is polluted or not. Thus, Air Quality Index mainly deals with health issues after few hours as a result of breathing polluted air. Environmental Protection Agency (EPA) calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulphur dioxide, and nitrogen dioxide. For each of them, air quality standards are established so as to protect human health. The major threat in our country to human health are the pollutants Ground-level ozone and airborne particles.

For this study, the data set consisting of Ambient Air Quality data of Chennai city with various parameters such as Sulphur oxide (SO2), nitrogen oxide (NOX), Respiratory suspended particulate matter (RSPM), Transpiratory suspended particulate matter (TSPM) are collected weekly from the year Jan 2018 to Aug 2019 for the areas Adyar (Residential area), Thiyagaraya Nagar (Commercial Area), Annanagar (Commercial Area) from Tamil Nadu Pollution Control Board, Chennai.
Table 1: Air Quality Index in India

| AQI (24 HOURS)     | PM10 / RSPM | TSPM | SO\textsubscript{2} | NO\textsubscript{X} |
|-------------------|-------------|------|---------------------|---------------------|
| Good (0-50)       | 0-50        | 0-30 | 0-40                | 0-40                |
| Satisfactory (51-100) | 51-100     | 31-60 | 41-80               | 41-80               |
| Moderately Polluted (101–200) | 101-250   | 61-90 | 81-380              | 81-180              |
| Poor (201-300)    | 251-350     | 91-120 | 381-800            | 181-280            |
| Very Poor (301-400) | 351-430    | 121-250 | 801-1600           | 281-400            |
| Severe (401-500)  | >430        | >250 | >1600               | >400                |

3. Trend Analysis

A time series plot or graph is a plot that shows observations against time. One of the components of a time series is Trend. A trend can be defined as a long term change in the mean level. It tells whether the given time series data increases or decreases over a long period of time. It is not always necessary that either there is an increase or there is a decrease throughout some given period of time. On the other hand, it may increase, decrease or remain stable at different points of time. But ultimately the trend must be either upward trend, downward trend or stable. Population of a country, agricultural production, number of births and deaths happened at a place, number of industries or factories located at a place, number of schools or colleges established are some of the examples depicting trend. Trend analysis aims at spotting a pattern or trend with the help of time series plot. Statistical methods for trend analysis of environmental data can be classified into two categories

1. Parametric test (e.g., linear regression) and
2. Nonparametric test.

Parametric tests are simple and straightforward tests for performing trend analysis. However, they require some assumptions about normality of data and homogeneity of variance of data whereas non-parametric tests are used as alternatives to parametric tests when the assumptions for parametric tests cannot be met. Environmental data, such as air quality data, are time series data that have sequential correlating relationships (autocorrelation) and are non-normally distributed. Despite this, several explanations support use of parametric testing methods for trend detection of air quality datasets used in this study: The methods (e.g., simple linear regression) are simple and straightforward to use.
4. Results and Discussion

The secondary data collected from Tamilnadu Pollution Control Board is calculated for monthly from the year Jan 2018 to Aug 2019 for the three areas, T.Nagar, Annanagar which are commercial areas and Adyar, the residential areas. For the monthly data, the linear trend model and quadratic trend model were fitted and the error measures were calculated to identify the best model for each area. The following figure 2 shows the actual versus fitted values for the various areas. The table 2 gives the error measure values for these areas. The results show that the data of commercial areas fits well when compared to the residential area, Adyar.
TREND ANALYSIS FOR ADYAR

Linear Trend Model

\[ Y_t = 50.43 + 1.349 \times t \]

Accuracy Measures

- MAPE: 31.087
- MAD: 17.444
- MSE: 375.880

TREND ANALYSIS FOR ADYAR

Quadratic Trend Model

\[ Y_t = 20.7 + 9.47 \times t - 0.387 \times t^2 \]

Accuracy Measures

- MAPE: 26.580
- MAD: 12.383
- MSE: 244.720
**TREND ANALYSIS FOR ANNANAGAR**

**Linear Trend Model**

\[ Y_t = 109.88 - 0.325t \]

![Graph of Observed and Fitted values of the three areas](image)

**Accuracy Measures**

- MAE: 10.890
- MAD: 14.892
- MSD: 297.454

**TREND ANALYSIS FOR ANNANAGAR**

**Quadratic Trend Model**

\[ Y_t = 87.8 + 5.71t - 0.287t^2 \]

![Graph of Observed and Fitted values of the three areas](image)

**Accuracy Measures**

- MAE: 12.417
- MAD: 12.416
- MSD: 325.043
Table 2: MAPE values of various areas

| Area   | Linear Trend | Quadratic Trend |
|--------|--------------|-----------------|
| T.Nagar| 17.900       | 17.772          |
| Annanagar| 14.590       | 12.417          |
| Adyar  | 31.087       | 23.550          |

5 Conclusion

Present study concludes that the time series analysis can be great use in trending monthly air pollution in Chennai. In future, trend can be analyzed for industrial area in chennai so that using forecasting models the AQI can be identified and steps can be taken for reducing the AQI.

References

[1] Naveen v “Time series analysis to forecast air quality indices in Thiruvanantha puram by using ARIMA and SARIMA methods” International journal of engineering research ,vol.7 Issue 6 (part-3) pp.66-84, 2017.
[2] Xinz RAO “Appliation of air quality statistical forecasting model in city A by using stepwise regression methods.” IOP Conference Series: Earth and Environmental Science 208 (2018).
[3] Biju B. Estimation of Health Impact Due to Air Pollution in Thiruvananthapuram City. ISSN: 2319-8753. .International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization). Vol. 3, Issue 7, July 2014 .
[4] Prakash Mamta, Bassin, J.K, 2010, Analysis Of Ambient Air Quality Using Air Quality Index – A Case Study, International Journal of Advanced Engineering Technology, Vol 1,106-114
[5] CPCB,National Air Quality Index, 2014, (http://cpcb.nic.in/AQI-FINAL-BOOK.pdf)