



**STATISTICAL TREND ANALYSIS AND FORECAST MODELING OF AIR POLLUTION  
IN CITY AGRA**

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Received 10<sup>th</sup> June 2021; Revised 11<sup>th</sup> July 2021; Accepted 20<sup>th</sup> Aug, 2021; Available online 15<sup>th</sup> Jan. 2022

<https://doi.org/10.31032/IJBPA/2022/11.1.1015>

**ABSTRACT**

The study provides a statistical trends analysis of air pollutant sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), and SPM using Air Pollution Index (API) and Moving average method. Data from 1996 to 2000 and 2001 to 2005 was calculated to find the effect of Supreme Court ruling, 1996 and public awareness about air pollution control. The Moving average method forecast was applied to check out the environmental air quality forecast in city Agra India. The API Trend indicated a decrease in pollutant level.

**Keywords:** Air quality, Statistical forecasting model. Mathematical modeling, Moving Average, SPM, SO<sub>2</sub>

**INTRODUCTION**

Industrial growth of a city has increased the problem of pollution. There is an urgent requirement of an effective measurement of Urban environmental forecast to control the air quality of cities (Urban) and to protect people's health. It is a public welfare work to improve people's quality of life and reflect the image of the people's government<sup>1</sup>. The scientific basis

is required for environmental management and decision-making departments which can be possible by releasing timely and accurate environmental air quality forecast to provide strong grip on observing the future change trend of urban environmental air quality<sup>2</sup>.

**METHODOLOGY AND OBSERVATIONS**

An 'air pollution index' can be defined as a scheme that transforms (weighted) values

of individual air pollution related parameters, e.g.. NO<sub>2</sub>, SO<sub>2</sub> & Suspended particulate matter (SPM) into single number or set of numbers. Air pollution index is calculated by the following formula

$$\text{Air pollution index (API)} = \frac{1}{n} \sum_{i=1}^n (A_i)$$

$$\text{Here } A_i = \frac{C_i}{S_i} \times 100$$

Where  $C_i$  = concentration of pollutant  $i$

$S_i$  = Air quality standard for pollutant  $i$

API = air pollution Index

The concentration of SO<sub>2</sub>, NO<sub>2</sub> and SPM (**Table 1**) was recorded at Tajganj, Dayalbagh, St. John's Crossing, Manas Nagar, Sadar Bazar and Foundry Nagar parts of Agra, India.

**Table 2** shown the National air quality standard presented by Central Pollution Control Board (CPCB, Government of India) New Delhi, India (CPCB report 2000)<sup>3</sup>.

On putting the values from **Table 1** and **Table 2** in calculating Air Pollution Index (API) was obtained (**Table 3**).

As per the obtained data, it can be concluded that the minimum air pollution is in the Foundry Nagar. The air pollution index of Taj Ganj St. John's, Manas Nagar and Sadat Bazar is Hazardous. Air Pollution in Dayal Bagh is also unhealthy.

Further, to check the trends of pollution level and Forecasting after effect of Supreme Court's ruling 1996, the Moving average model was implemented to analyzed SO<sub>2</sub>, NO<sub>2</sub> and SPM level in the city between year 1996 - 2000 and 2001-2005.

The chain index and API were calculated for SO<sub>2</sub>, NO<sub>2</sub> and SPM using formula-

$$\text{Index No.} = \frac{P_1^i}{P_0^i} \times 100 \quad ; \quad i =$$

1,2,3.....10

Where  $P_1^i$  is value of  $i^{\text{th}}$  commodity in the base year and  $P_0^i$  is  $i^{\text{th}}$  commodity in current year.

$$\text{Chain index} = \text{index no.} \times \frac{P_1^i}{P_0^i}$$

Normalization of given value was also done using formula

$$\text{Norm Y} = \sqrt{x_1^2 + x_2^2 + x_3^2}$$

$$\text{Where normalized values} = \frac{x_1}{y}, \frac{x_2}{y}, \frac{x_3}{y}$$

here  $x_1$ ,  $x_2$  and  $x_3$  are mean values of SO<sub>2</sub>, NO<sub>2</sub> and SPM respectively.

Average of SO<sub>2</sub>, NO<sub>2</sub> and SPM was

$$\left[ \frac{\frac{x_1}{y} + \frac{x_2}{y} + \frac{x_3}{y}}{3} \right]$$

**Table 4** has demonstrated the API and chain Index of SO<sub>2</sub>, NO<sub>2</sub> and SPM between 1996 - 2000 and thereafter a forecast was calculated by Moving average method.

The moving average model is a part of Box-Jenkins method of forecasting in Period  $t$  on the basis on its past values. There is a simple, rather a naive, yet a useful method of using average to forecast. This simple method assumes that forecast in future year equals the average of forecast in the past years. The formula of simple moving average method is expressed as

$$f_t = \frac{1}{N} (X_{t-1} + X_{t-2} + X_{t-3} + \dots + X_{t-n})$$

where  $f_t$  = forecast in period  $t$ ;  $X_{t-1}$ ,  $t-2$ ,  $t-3$ , ...  $t-n$  is forecast in previous years,  $N$  = number of preceding years (**Table 5**).

**Table 1: Concentration of SO<sub>2</sub>, NO<sub>2</sub> and SPM**

| Site | Location            | SO <sub>2</sub> | NO <sub>2</sub> | SPM |
|------|---------------------|-----------------|-----------------|-----|
| 1    | Tajganj             | 18              | 15              | 519 |
| 2    | Dayalbagh           | 14              | 12              | 516 |
| 3    | St. John's Crossing | 21              | 19              | 751 |
| 4    | Manas Nagar         | 15              | 14              | 653 |
| 5    | Sadar Bazar         | 16              | 14              | 656 |
| 6    | Foundry Nagar       | 22              | 20              | 742 |

**Table 2: Ambient air quality standard for SO<sub>2</sub>, NO<sub>2</sub> and SPM**

| Pollutant       | Time weighted average | Industrial | Residential or Rural | Sensitive |
|-----------------|-----------------------|------------|----------------------|-----------|
| SO <sub>2</sub> | Annual Average        | 80         | 60                   | 15        |
|                 | 24Hrs                 | 120        | 80                   | 30        |
| NO <sub>2</sub> | Annual Average        | 80         | 60                   | 15        |
|                 | 24Hrs                 | 120        | 80                   | 30        |
| SPM             | Annual Averag         | 360        | 140                  | 70        |
|                 | 24Hrs                 | 500        | 200                  | 100       |

**Table 3: API of Agra at various selected sites**

| S. No. | Location/Sites      | API    |
|--------|---------------------|--------|
| 1      | Tajganj             | 320.48 |
| 2      | Dayalbagh           | 161.11 |
| 3      | St. John's Crossing | 446.51 |
| 4      | Manas Nagar         | 498.09 |
| 5      | Sadar Bazar         | 378.82 |
| 6      | Foundry Nagar       | 86.203 |

**Table 4: Average mean API and chain index number of SO<sub>2</sub>, NO<sub>2</sub> and SPM during 1996-2000**

| Year | NO <sub>2</sub> |           |                 | SO <sub>2</sub> |           |                 | SPM     |           |                 |
|------|-----------------|-----------|-----------------|-----------------|-----------|-----------------|---------|-----------|-----------------|
|      | Average         | Index No. | Chain Index No. | Average         | Index No. | Chain Index No. | Average | Index No. | Chain Index No. |
| 1996 | 13.0            | 102.36    | 83.02           | 17.0            | 76.58     | 62.09           | 480     | 109.84    | 106.32          |
| 1997 | 12.3            | 94.49     | 96.72           | 13.7            | 61.71     | 47.26           | 380     | 86.96     | 95.52           |
| 1998 | 108             | 85.04     | 80.35           | 12.1            | 54.50     | 33.63           | 507     | 116.02    | 134.60          |
| 1999 | 9.7             | 76.38     | 64.95           | 10.7            | 48.20     | 26.27           | 418     | 95.65     | 91.49           |
| 2000 | 9.2             | 72.44     | 55.23           | 10.3            | 46.20     | 22.36           | 330     | 76.20     | 58.07           |

Table 5: Forecast calculated by moving average method for SO<sub>2</sub>, NO<sub>2</sub> and SPM

| Year | SO <sub>2</sub> | NO <sub>2</sub> | SPM    | $\frac{[SO_2 + NO_2 + SPM]}{3}$ |
|------|-----------------|-----------------|--------|---------------------------------|
| 2001 | 11.43           | 17.83           | 431.45 | 150.59                          |
| 2002 | 11.13           | 17.32           | 430.86 | 149.86                          |
| 2003 | 9.95            | 15.26           | 391.08 | 135.48                          |
| 2004 | 8.77            | 12.71           | 340.28 | 117.46                          |
| 2005 | 7.63            | 10.51           | 295.39 | 92.12                           |

Based on these calculations the moving average model of air represents a decreasing trends after 1996 which may be due to Supreme Court's ruling.

#### CONCLUSION:

The present study concluded that a legal and social awareness should be imposed on industrial units, transportation means and other activities, which are responsible for creating air pollution problems. The steps should be taken to educate persons to each other regarding pollution control. The Moving Average Model is a potential method to find the trend of a public awareness and legal ruling in any situation like air pollution.

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