A Comparative Study for Assessing the Air Quality Status for Industrial Areas [Gida, Gorakhpur and Talkatora, Lucknow]

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Abstract

With an increased pace of industrialization especially in developing countries, environmental problems have also increased. At the same time, with growing population and economic development, there has been a rapid rise in air pollution sources. Due to this, a number of pollutants are released in the ambient air deteriorating its quality. The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. The project investigates the concentration of the pollutants sulphur dioxide (SO2), nitrogen Dioxides (NO2), particulate matter (PM10) generated from various sources of industries over the ambient air quality of the GIDA (Gorakhpur) and Talkatora (Lucknow). The major pollutants as suggested by the Central pollution control board (CPCB) in an industrial area are sulphur dioxide (SO2), oxides of nitrogen (NOX) and particulate matter (PM10).The concentration of Air Quality Index (AQI) of these gases in the ambient air is studied by the methods – (a) Oak Ridge National Air Quality Index (ORNAQI) (b) Arithmetic Mean Method (c) Geometric Mean Method (d) Break Point Concentration. The results will show the concentration of AQI of the above cited gaseous and suspended solid pollutants and will be compared with the permissible concentrations as per the standards given by CPCB for an industrial area and major precautions can be taken to reduce the concentration level of these pollutants.

Keywords: Ambient Air Quality, Air Pollution, Air Quality Index, AQI Methods, SO2, NO2, RSPM

I. INTRODUCTION

Air pollution due to anthropogenic sources, is a matter of concern in whole world. The urban areas may be viewed as dense sources of enormous anthropogenic emissions of pollutants, which can alter the atmospheric composition, chemistry and life cycles in it’s down wind regimes, extending over several hundred kilometers (Gupta et al., 2008).

Air Pollution is one of the serious problems faced by the people globally, especially in urban areas of developing countries, which is not only rapid growth of population but also industrialization (Nagdene, 2004).

Sulphur dioxide (SO2), Nitrogen dioxide (NO2) and RSPM are regarded as major air pollutants in India (Agarwal and Singh, 2000)

India, a developing country, is one of the first ten industrial countries of the world (Sharma, 2007). Because of the enhanced anthropogenic activities (Goyal and Sidhartha, 2003) in India, air pollution problems have become a topic of intense debate at all platforms. According to a study released by World Economic Forum in Davos, India has the worst air pollution in the entire world, beating China, Pakistan, Nepal and Bangladesh. Of the total 132 countries whose environmental assets were surveyed, India ranked dead last in the ‘Air (effects on human health)’ ranking.

Table – 1
Contribution of air pollution from various sources in India

<table>
<thead>
<tr>
<th>Source</th>
<th>1980-81</th>
<th>1990-91</th>
<th>2000-01</th>
<th>2010-11 (Projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>44%</td>
<td>35%</td>
<td>32%</td>
<td>28%</td>
</tr>
<tr>
<td>Vehicular</td>
<td>40%</td>
<td>56%</td>
<td>62%</td>
<td>69%</td>
</tr>
<tr>
<td>Domestic</td>
<td>16%</td>
<td>9%</td>
<td>6%</td>
<td>3%</td>
</tr>
</tbody>
</table>

(Source MoEF, 2001)
II. STUDY AREA DESCRIPTION

Air quality impact assessment has been concern out at two different locations and their respective names are:

1) Gorakhpur Industrial Development Area (GIDA), Gorakhpur
2) Talkatora, Lucknow

GIDA is an Industrial Area in Gorakhpur district in the Indian state of Uttar Pradesh. It is fast developing an industrial area abbreviated as GIDA with many factories, including IGL, Parle and ARP, as well as power looms, plywood and the only jute mill in Uttar Pradesh. It is not only an industrial hub but also an educational hub for engineering students, skill development training and industrial training. This area is located on National Highway-28. This is spread over an area of 470 sq m and accommodates a population of 32886 as per 2011 census. It lies between north latitude 26°45’N and east longitude 83°13’E. It is bounded by Maharajganj district to the north, Kushinagar and Deoria districts in the east, Ambedkar Nagar, Azamgarh, and Mau districts to the south, and SantKabir Nagar district to the west.

Talkatora is an Industrial Area in Lucknow in the Indian state of Uttar Pradesh. It is fast developing an industrial area abbreviated as Talkatora with many factories, Minerals, Metals & Alloys, Sports Facilities, Clubs & Gymkhana, Water & Water Systems, Cable Laying & Maintenance, Fabricated Products & Fabrication, Furniture’s & Fixtures, Industrial Grinding & Cutting, Industrial Heaters, Elements & Thermostats, Medicines & Medical Supplies, Photo Studios Equipments, Accessories & Services, Power Generation, Transmission & Control etc. This area is located on National Highway-24(B). This is spread over an area of 200 sq m and accommodates a population of 52686 as per 2011 census. It lies between north latitude 26°8’N and east longitude 80°9’E. It is bounded on the east by the Barabanki District, on the west by Unnao District, on the south by Raebareli and in the north by Sitapur and Hardoi, Lucknow sits on the northwestern shore of the Gomti River.

III. METHODOLOGY

The present study was conducted to around GIDA (5 Clusters) and Talkatora (3 Cluster) area during 2015-2016. The parameters were assessed including respirable particulate matter (RSPM), sulphur dioxide (SO₂) and nitrogen oxides (NOx).

For SPM and RPM analysis, the high volume air sampler (HVAS) APM 460 NL was used. The concentration was measured using quantitative analysis with glass fiber filter paper of 20.3×25.4 cm.

The sulphur dioxide (SO₂) concentration was measured using Potassium Tetrachloro mercurate (TMC) as absorbent and titrated with mercuric chloride, 0.066g EDTA and 6g potassium chloride in water and bring to the mark in 1 liter volumetric flask. In this measurement Improved West and Geake Methods are used.

The oxides of nitrogen (NOx) concentration was measured using 4g of sodium hydroxide in distilled water, add 1 g of sodium arsenite and diluted to 1 liter with distilled water. In this measurement Modified Jacob and Hochheiser Methods are used.

IV. AIR QUALITY INDEX (AQI)

The Minister for Environment, Forests & Climate Change Shri Prakash Javadekar launched The National Air Quality Index (AQI) in New Delhi on 17 September 2014 under the Swachh Bharat Abhiyan. It is outlined as ‘One Number- One Color- One Description’ for the common man to judge the air quality within his vicinity. The index constitutes part of the Government’s mission to introduce the culture of cleanliness. Institutional and infrastructural measures are being undertaken in order to ensure that the mandate of cleanliness is fulfilled across the country and the Ministry of Environment, Forests & Climate Change proposed to discuss the issues concerned regarding quality of air with the Ministry of Human Resource Development in order to include this issue as part of the sensitization programmed in the course curriculum.

During monitoring the concentration of different air pollutants within study area are evaluated which are further used to calculate Air Quality Index. An air quality index is one of the important tools available for analyzing and representing air quality status uniformly. The relative change may also be with respect to the concentrations of pollutants and respective stipulated standards (Chelani et al., 2002).

To calculate the IND-AQI for a given time period, the sub-index values (sub-AQI) for all eight air pollutants or three pollutants at the minimum (SO2, NOx and SPM) are first calculated using the adopted sub-index functions (i.e. sub-index vs. concentration). Out of all sub-AQIs, the highest value becomes the overall index and reported as IND-AQI.

<table>
<thead>
<tr>
<th>Table – 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Air Quality Category and Breakpoint Concentration with averaging times)(Units: μg/m³ unless mentioned otherwise)</td>
</tr>
<tr>
<td>AQI category (Range)</td>
</tr>
<tr>
<td>Good (0-50)</td>
</tr>
<tr>
<td>Satisfactory (51-100)</td>
</tr>
<tr>
<td>Moderate (101-200)</td>
</tr>
<tr>
<td>Poor (201-300)</td>
</tr>
<tr>
<td>Very Poor</td>
</tr>
</tbody>
</table>

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V. METHODS USED TO CALCULATE AQI

A number of methods are used to calculate AQI in different countries. Some of the common methods are listed below:

1) Oak Ridge Air Quality Index (ORAQI) Method

The Oak Ridge National Air Quality Index (ORNAQI) can be considered for the relative ranking of an overall air quality status at different locations of the study area.

AQI for each location in the study area has been estimated with the help of a mathematical equation developed by the Oak Ridge National Laboratory (ORNL), USA as given below:

$$\text{AQI} = \left[39.02 \sum X_i / X_s \right]^{0.967}$$

Where

$X_i$: value of air quality parameters (RSPM, SO$_2$ and NO$_2$)

$X_s$: Standard and prescribed for Air quality parameters.

AQI then measured and compared relative ORAQI value given in table 4.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>Clean air</td>
<td>None, or minimal health effects</td>
</tr>
<tr>
<td>26-50</td>
<td>Light air pollution</td>
<td>Possible respiratory or cardiac effect for most sensitive individuals</td>
</tr>
<tr>
<td>51-75</td>
<td>Moderate air pollution</td>
<td>Increasing like hood of respiratory and cardiovascular symptoms and illnesses</td>
</tr>
<tr>
<td>76-100</td>
<td>Heavy air pollution</td>
<td>Aggravation of heart or lung disease. Increased risk of death in children (heart and lung disease) increased effects in general population</td>
</tr>
<tr>
<td>&gt;100</td>
<td>Servers air pollution</td>
<td>Serious aggravation of heart or lung disease, Increased risk of premature death. Serious risk of cardio respiratory symptoms in general population.</td>
</tr>
</tbody>
</table>

(Source: USEPA, 2014)

A. Arithmetic Mean Method:

Air quality index (AQI) is calculated based on arithmetic mean of the ratio of concentration of pollutant to standard value of that pollutant such as PM10, SO2 and NO2. The average is then multiplied by 100 to get the AQI index. For individual pollutant AQI was calculated by the following formula

$$\text{AQI} = (C/C_s) \times 100$$

Where

AQI= Air Quality Index

C= the observed value of the air quality parameters pollutant (PM$_{10}$, NO$_2$ and SO$_2$)
CSP = CPCB Standard for Industrial Area (CPCB, 2009)

**B. Geometric Mean Method**

Air quality index (AQI) is calculated based on Geometric mean of the ratio of concentration of pollutant to standard value of that pollutant such as PM10, SO2 and NO2. The average is then multiplied by 100 to get the AQI index. For individual pollutant AQI was calculated by the following formula

\[
\text{AQI} = \left( \frac{C}{C_{SP}} \right) \times 100
\]

Where

- AQI = Air Quality Index
- C = the observed value of the air quality parameters pollutant (PM\(_{10}\), NO\(_2\) and SO\(_2\))
- C\(_{SP}\) = CPCB Standard for Industrial Area (CPCB, 2009)

**C. Break Point Concentration**

Air Quality Index was done on dose response relationships of pollutants to obtain break point concentration. The individual air quality for a given pollutant concentration (CS) as based on linear segmented principle is calculated as

\[
I_P = \left[ \left( \frac{I_{HI} - I_{LO}}{B_{HI} - B_{LO}} \right) \times (C_P - B_{LO}) \right] + I_{LO}
\]

Where

- \(I_{HI}\) = AQI value corresponding to \(B_{HI}\) (from table 2)
- \(I_{LO}\) = AQI value corresponding to \(B_{LO}\) (from table 2)
- \(B_{HI}\) = Breakpoint concentration greater or equal to given concentration (from table 2)
- \(B_{LO}\) = Breakpoint concentration smaller or equal to given concentration (from table 2)
- \(C_P\) = the pollutant concentration
- \(I_P\) = the (Air Quality) index

Finally,

\[
\text{AQI} = \text{Max}(I_P)
\]

Where

- \(P = 1, 2, 3 \ldots \ldots n\); denotes n pollutants

**VI. RESULT AND DISCUSSION**

Monthly average concentration and calculated AQIs value of criteria pollutants like RSPM, SO\(_2\) and NO\(_2\), have been plotted in graphs for the year 2015 to 2016 for industrial area GIDA, Gorakhpur and Talkatora, Lucknow (U.P).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Method</th>
<th>(\text{SO}_2)</th>
<th>(\text{NO}_2)</th>
<th>(\text{PM}_{10})</th>
<th>AQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oak Ridge Air Quality Index (ORAQI)</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>38.5</td>
</tr>
<tr>
<td>2</td>
<td>Arithmetic Mean</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>111.8</td>
</tr>
<tr>
<td>3</td>
<td>Geometric Mean</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>78.4</td>
</tr>
<tr>
<td>4</td>
<td>Break Point Concentration</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>172.84</td>
</tr>
</tbody>
</table>

Fig. 1: (Analysis of Average Data (GIDA))
Table 6
(Analysis of Average Data (GIDA))

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Method</th>
<th>SO₂</th>
<th>NO₂</th>
<th>PM₁₀</th>
<th>AQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oak Ridge Air Quality Index (ORAQI)</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>32.58</td>
</tr>
<tr>
<td>2</td>
<td>Arithmetic Mean</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>94.09</td>
</tr>
<tr>
<td>3</td>
<td>Geometric Mean</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>38.96</td>
</tr>
<tr>
<td>4</td>
<td>Break Point Concentration</td>
<td>27.85</td>
<td>53.23</td>
<td>209.6</td>
<td>176.61</td>
</tr>
</tbody>
</table>

Fig. 2: (Analysis of Average Data (Talkatora))

VII. CONCLUSION

The overall AQI can give clear view about ambient air and the critical pollutant mainly responsible for the quality of air quality which can be easier for a common man to understand. The AQIs were calculated to assess the ambient air quality at two different sites namely the GIDA (Gorakhpur) and Talkatora (Lucknow) sites in Uttar Pradesh during the year 2015-16. The AQIs were calculated according to Indian Air quality Index (IND-AQI). The AQI study reveals that Respirable Suspended particulate matter (RSPM) was mainly responsible for maximum times in all month in Talkatora and SO₂ and NO₂ was mainly responsible for pollution in GIDA. It has been found that Air Quality status GIDA, Gorakhpur is comparatively poorer than Talkatora, Lucknow. For minimizing the pollution in the surrounding areas, some remedial measure like plantation and green belt can be formed that area for betterment of human life. Traditional methods of power supply should be modernised.

ACKNOWLEDGMENT

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REFERENCES AND FOOTNOTES