Respirable Particulate Matter Pollution Characteristics and their Correlation with Meteorological parameters in Kota city

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Abstract
In recent years, air pollution is getting worse in Kota Region, Rajasthan. The particulate matter pollution characteristic researches are playing a significant role especially in the districts where higher concentration of particulate matter causes air pollution. In this study, daily data for respirable particulate matter (PM10), mass concentration data from a particular air pollution monitoring station in Kota City was observed. These data were observed over a period of 12 months from January to December to investigate particulate matter pollution characteristics and their relationship with meteorological parameters. Statistical results show that respirable particulate matter (PM10) is the major pollutant in Kota City.

Keywords:
Respirable Particulate Matter (PM10), Air Pollution, Meteorological Factors, Precipitation

1. Introduction
According to a report of World Health Organisation (WHO), the environmental condition of five big cities of Rajasthan; Jaipur, Jodhpur, Alwar, Udaipur and Kota is deteriorating day by day. Annual mean of concentration of PM2.5 (atmospheric dynamics equivalent diameter \( \leq 2.5 \) μm) is 59 μg/m\(^3\) is in India. The annual mean concentration of PM2.5 in Jodhpur, Jaipur and Kota is well above the annual mean in India. Alwar has lower mean concentration than in India. Alwar has PM2.5 concentration as 38 μg/m\(^3\), while Kota and Udaipur have PM2.5 concentrations as 64 μg/m\(^3\) and 62 μg/m\(^3\), respectively. In terms of PM10 (atmospheric dynamics equivalent diameter \( \leq 10 \) μm), Jodhpur has higher concentration in the contrary to Jaipur, Kota and Udaipur having PM10 concentration as 155 g/m\(^3\), 146 g/m\(^3\), 143 g/m\(^3\) respectively. These particles are accounted for as these particles penetrate deeply into the respiratory tract and become the cause of respiratory infections and diseases, lung cancer and selected cardiovascular diseases.

This paper is based on correlation analysis and the following data were used as shown in Table 1, which are provided by Rajasthan State Pollution Control Board and Indian Meteorological Department. These data were analysed to study the characteristics of particulate pollution during precipitation period and a relationship was established using correlation analysis method.

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average high temp (°C)</td>
<td>23.7</td>
<td>26.9</td>
<td>32.9</td>
<td>38.8</td>
<td>42.1</td>
<td>40</td>
<td>34.2</td>
<td>32</td>
<td>33.7</td>
<td>34.3</td>
<td>29.9</td>
<td>25.3</td>
</tr>
<tr>
<td>Average low temp (°C)</td>
<td>10.9</td>
<td>13.7</td>
<td>19.1</td>
<td>25</td>
<td>29.3</td>
<td>29.2</td>
<td>26.5</td>
<td>25.4</td>
<td>25</td>
<td>21.8</td>
<td>16.3</td>
<td>11.9</td>
</tr>
<tr>
<td>Relative humidity (%)</td>
<td>48</td>
<td>38</td>
<td>25</td>
<td>19</td>
<td>23</td>
<td>43</td>
<td>67</td>
<td>74</td>
<td>58</td>
<td>40</td>
<td>41</td>
<td>48</td>
</tr>
<tr>
<td>Precipitation (mm)</td>
<td>5.4</td>
<td>4.4</td>
<td>4</td>
<td>3.2</td>
<td>10.3</td>
<td>62.9</td>
<td>257</td>
<td>245.8</td>
<td>98.5</td>
<td>19.6</td>
<td>7.8</td>
<td>3.5</td>
</tr>
<tr>
<td>PM10(μg/m(^3))</td>
<td>240</td>
<td>147</td>
<td>149</td>
<td>208</td>
<td>150</td>
<td>134</td>
<td>89</td>
<td>44</td>
<td>54</td>
<td>135</td>
<td>208</td>
<td>226</td>
</tr>
</tbody>
</table>

Table 1  Meteorological Parameters and Particulate Matter Concentration (Jan.- Dec.’14)
2. **PM$_{10}$ Levels in Kota city**

During the period of Jan 2014 to December 2014, the data of pollution concentration of PM$_{10}$ was collected at the one of the monitoring sites of regional office Anantpura and meteorological data were taken from Indian Meteorological Department. In summer, the daily average concentrations (in μg/m$^3$) of PM$_{10}$ in ambient air was 154, exceeding the recently released ambient air quality standard. It can be seen as the air is polluted and is of serious concern.

3. **Graphical analysis of data**

The data presented in Table 1 were presented graphically in this section. Six graphs were prepared and presented for graphical analysis. Graph 1 shows the monthly variation of particulate matter concentration with respect to different months in a year. Graph 2 shows the monthly variation of temperature with respect to different months in a year. Graph 3 shows the relationship between concentrations of PM$_{10}$ and average high temperature. Graph 4 shows the relationship between concentrations of PM$_{10}$ and average low temperature. Graph 5 shows the relationship between concentrations of PM$_{10}$ and precipitation. Graph 6 shows the relationship between concentrations of PM$_{10}$ and humidity.
Graph 3 Relationship between conc. of PM$_{10}$ and average high temperature

Graph 4 Relationship between conc. of PM$_{10}$ and average low temperature

Graph 5 Relationship between concentrations of PM$_{10}$ and precipitation
4. Correlation analysis of particulate matter and other meteorological parameters

As we are aware of the fact that temperature, precipitation and other meteorological factors can preferably related with concentration of particulate pollutants \[^5\]. To explain the relationship between concentrations of particulate matter and meteorological factors correlation analysis was performed and correlation coefficient was generated as shown in Table 2. Meteorological factors and concentrations of particulate matter have shown a negative correlation but the impact is different. Therein, Precipitation was significantly influencing on particulate matter, followed by air temperature and humidity.

<table>
<thead>
<tr>
<th>Meteorological factors</th>
<th>PM$_{10}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Temperature</td>
<td>-0.3497518</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>-0.56834</td>
</tr>
<tr>
<td>Precipitation</td>
<td>-0.75596</td>
</tr>
<tr>
<td>Lower Temperature</td>
<td>-0.63046</td>
</tr>
</tbody>
</table>

4.1. Relationship between Particulate Matter Concentrations and Air Temperature

It can be observed from Graph 3 and Graph 4, that concentration of particulate matter had an obviously negative correlation with air temperature. As air temperature rose, concentrations of particulate matter were significantly decreased. The reason behind is the intense radiation of heats underlying the city surface. The lower atmosphere is not very stable and turbulent strengthens, which is advantageous to the diffusion of pollutants. Therefore, the probability of atmospheric pollution decreased with the increase of air temperature in summer. While the temperature of surface is low, the situation is contrary.\[^6\]

4.2. Relationship between Concentrations of Particulate Matter and Precipitation

In summer, precipitation has a great impact on concentrations of particulate matter. It can be observed in Graph 5, that the concentration of PM$_{10}$ decreases significantly in the month of June onwards to the month of July, August and September with heavy precipitation in these three months. It can be concluded that precipitation can reduce dust and it mainly gets rid of coarse particles while have little effect on fine particles.
4.3 Relationship between Conc. of Particulate Matter and Relative humidity

From Table 1, it can be observed that concentrations of particulate matter had an obviously negative correlation with Relative humidity. It can be observed from Graph 6 shows that, as relative humidity rose during summer and monsoon season, concentrations of particulate matter were significantly decreased. This might be due to increase in rate of absorption of particulate with increase in relative humidity and in rainy season most of the particulate concentration is washed out.

Jayaraman has studied the effects of seasonal variation on particulates in Delhi and found that SPM concentration was inversely related to relative humidity during all seasons [3]. Giri has studied the linkage between meteorological process and air pollution in Kathmandu in Nepal and found that the increase of humidity has negative correlation with concentration of particulate matter.[2]

5. Results

In summer, the monthly average concentrations (in μg/m³) of PM₁₀ in ambient air were 134 μg/m³ to 208 μg/m³, which is more than the permissible level of the ambient air quality standard (PM₁₀ daily average 150 μg/m³). But the average annual concentration of PM₁₀ lies within the standards i.e. 148.7 μg/m³. However PM₁₀ is still the primary pollutant in the atmospheric environment in Kota. It shows a minimum value of PM₁₀ as 44 μg/m³ during rainy season and maximum value of 240 μg/m³ in the month of January.

6. Conclusion

The meteorological factors, such as air temperature, precipitation and humidity may have an influence on the atmospheric pollutants concentration. Air temperature and concentrations of particulate matter had shown an obviously negative correlation. As temperatures rose, pollutant concentrations were significantly decreased. Relative humidity and concentrations of particulate matter were significantly negatively correlated. As the relative humidity increased, the concentration of particulates also decreased. Precipitation has a great impact on concentration of particulate matter.

It can be, therefore, concluded that PM₁₀ is still the primary pollutant in the atmospheric environment in Kota and had a correlation with various meteorological parameters like temperature, humidity and precipitation.

References

5. Tai, A.P.K., Mickley, L.J. and Jacob, D.J. (2010), Correlations between Fine Particulate Matter (PM₂.₅) and Meteorological Variables in the United States: Implications for the Sensitivity of PM₂.₅ to Climate Change. Atmospheric Environment, 44, 3976-3984.