In recent years, Dehradun is developing as a capital and business centre of Uttarakhand state and it is at its verge of urbanization and industrialization. Due to growing centre of business, education, culture and industries, Dehradun facing a large inversion of vehicles, industries and population, which are not coming alone but with a large impact on the climate conditions. Since, Dehradun is one of Himalayan locations of northern India and, the northern part of India is among the most populated and polluted regions of the world where the ambient atmospheric conditions are continuously deteriorated due to urbanization, industrialization, lack of environmental awareness, poor maintenance of motor vehicles and poor road conditions. The increasing uses of fossil fuel, releasing industrial byproducts and other anthropogenic sources lead to gigantic atmospheric aerosol loading in this region. In Dehradun region, the industrial emission and gas to particles conversion by transport vehicles including several hazardous pollutants such as SO$_2$, CO, NO$_x$ metal oxides, volatile organic compounds (VOCs), and particulate matters (respirable suspended particulate matter (RSPM) and suspended particulate matter (SPM)), are the major sources of pollution. These atmospheric pollutants are continuously accumulating in this region and aggravating the environmental condition.

Data Analysis: In India, the pollutants levels at different sites across the country is monitoring by central pollution control board (CPCB), which is an independent government body. Dehradun region come under its National Ambient Air Quality Monitoring network. In the present study, we investigated the air quality data of the concentrations of NO$_2$, SO$_2$, RSPM and SPM recorded by CPCB (http://www.cpcb.nic.in) for six years in between 2005-2012 except 2009 and 2010 on daily basis. Furthermore, the meteorological effects on air pollutants in the ambient air of Dehradun were also studied during the study period.

Repairable Suspended Particulate Matter (RSPM/PM10): RSPM is the particulate matter having aerodynamic diameter less than or equal to 10 µm size. It represents the fraction of total suspended particulate matter which is considered to enter into the respiratory system. Sources of RSPM include road dust, emission from petrol and diesel engine exhaust, construction and fireplaces. RSPM can also be formed from other pollutants like NO$_x$, SO$_x$, volatile organics and incomplete combustion of other fuel. RSPM was measured gravimetrically with GFA/ EPM 2000 filter paper (20.3 x 25.4 cm) using repairable dust sampler.

Suspended Particulate Matter (SPM/PM100): SPM is particulate/aerosol having diameter less than 100µm but greater than 10µm that tends to remain suspended in the atmosphere for longer time. The natural sources of total suspended particulates are sea salt, soil dust, volcanic particles and smoke from forest fires. The anthropogenic sources of suspended particulate matter are burning of fossil fuel and industrial processes. Monitoring of SPM was also carried out for 24 hours with 8-hourly sampling using the gravimmetrical
The similar variation as that of NO
November 30.67±1.97 µgm
value of 21.07±3.60 µgm
in the concentration with a dunk around August with a lowest
whole study period, while in case of NO
throughout the years (i.e. January to December) during the
figure that the mean concentration of SO
2(a-d) and also tabulated in Table-1. It is observed from the
pollutants in Dehradun from 2005 to 2012 are shown in Fig.-
monthly mean variability in mass concentrations of the air
the air pollution data were analyzed on monthly basis. The
For the closer investigation of the variation in air pollutants,
parameters during study period i.e 2005 to 2012.
Fig.-1 shows monthly mean variability of surface meteorological
due to large-scale biomass burning in the Indo-Gangetic plane.
particles by southwesterly winds from Thar Desert (Sikka et
November). During pre-monsoon season, air mass carries dust
monsoon (June-September) and post-monsoon (October-
winter (December-February), pre-monsoon (March-May),
Dehradun region has lower value in April month and has the
reversal trend as that of the concentrations of RSPM and SPM.
The visibility has the lowest values during the months of January
Post-monsoon period and again attend highest value.
In July -September months and again increases with starting
of post-monsoon period and again attend highest value.
It is observed from the Table that in Dehradun, the concentration
of SO2 and NO2 is always under the Indian air quality standard.
But the concentration of RSPM and SPM exceeds the Indian
air quality levels in this area, which need a special attention to
maintain the quality of air. The mean variability of surface
meteorological parameters over Dehradun has also been studied
on monthly basis during the study period (2005 to 2012) as
shows in Fig.- 1 (a-d). Wind speed has the similar variation
behavior as that of RSPM and SPM. Both are initially increase
January to April and then start decreasing and reach to their
lowest values (wind speed of 0.46±0.25 km/hr in July and wind
direction of 93.18±47.36 in August) in the months of July/
August and again start increasing to achieve relatively higher
values. This behavior of wind speed and direction is completely
independent to SO2 concentration but follows up the trend of
NO2 concentration variation. The behavior of visibility has just
reversal trend as that of the concentrations of RSPM and SPM.
The visibility has the lowest values during the months of January
and December while in these months both RSPM and SPM
have relatively higher concentrations. On the other hand visibility
is higher in the months of June (28.37±2.92m) when both RSPM
and SPM are at their decreasing trend. Temperature of
Dehradun has the similar trend as that of most of north India,
where temperature rises from January to June and then
decreases from June to December. Relative humidity in
Dehradun region has lower value in April month and has the
highest value in August month. This relative humidity behavior
is also very similar to other North India locations and has least
effect of aerosols expect of RSPM and SPM.
Frequency distribution of air pollutants: Frequency
distribution of mass concentration of the measured air
pollutants such as NO2, SO2, RSPM and SPM during the study
EFFECT OF AEROSOL PARTICLES ON THE METROLOGICAL PARAMETERS AT DEHRADUN

Table 1. Monthly mean mass concentration of NO₂, SO₂, RSPM and SPM along with their standard deviation (std.) in Dehradun during 2005 to 2012 except 2009 and 2010.

<table>
<thead>
<tr>
<th>MON</th>
<th>NO₂ (µg/m³)</th>
<th>SO₂ (µg/m³)</th>
<th>RSPM (µg/m³)</th>
<th>SPM (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAAQ 80(24)</td>
<td>NAAQ 80(24)</td>
<td>60 TO 100(24)</td>
<td>140 to 200(24)</td>
</tr>
<tr>
<td>Jan</td>
<td>27.47</td>
<td>24.29</td>
<td>154.19</td>
<td>290.57</td>
</tr>
<tr>
<td>Feb</td>
<td>26.09</td>
<td>24.16</td>
<td>151.08</td>
<td>319.88</td>
</tr>
<tr>
<td>Mar</td>
<td>26.44</td>
<td>26.73</td>
<td>141.13</td>
<td>306.87</td>
</tr>
<tr>
<td>Apr</td>
<td>26.84</td>
<td>25.83</td>
<td>157.22</td>
<td>341</td>
</tr>
<tr>
<td>May</td>
<td>28.08</td>
<td>25.40</td>
<td>150.66</td>
<td>320.88</td>
</tr>
<tr>
<td>Jun</td>
<td>27.93</td>
<td>25.23</td>
<td>129.03</td>
<td>294.67</td>
</tr>
<tr>
<td>Jul</td>
<td>26.07</td>
<td>24.24</td>
<td>93.40</td>
<td>227.18</td>
</tr>
<tr>
<td>Aug</td>
<td>21.07</td>
<td>23.42</td>
<td>95.40</td>
<td>228</td>
</tr>
<tr>
<td>Sep</td>
<td>25.92</td>
<td>23.60</td>
<td>90.35</td>
<td>220.42</td>
</tr>
<tr>
<td>Oct</td>
<td>27.07</td>
<td>26.04</td>
<td>118.69</td>
<td>241.17</td>
</tr>
<tr>
<td>Nov</td>
<td>30.67</td>
<td>27.39</td>
<td>142.36</td>
<td>296.82</td>
</tr>
<tr>
<td>Dec</td>
<td>27.72</td>
<td>25.46</td>
<td>145.23</td>
<td>316</td>
</tr>
</tbody>
</table>

Fig:-1 (a to d). Monthly mean variability of surface meteorological parameters during study period.

Fig:-2 (a to d). The monthly mean variability in mass concentrations of the air pollutants Dehradun from 2005 to 2012 except 2009 and 2010.

Fig:-3 (a to d). Frequency distribution of mass concentration of the measured air pollutants such as NO₂, SO₂, RSPM and SPM during the study period.
The variability of atmospheric aerosols and their effects on meteorological parameters such wind speed, temperature, visibility and relative humidity have been systematically analyzed. The mass concentrations of various air pollutants like NO$_2$, SO$_2$, RSPM and SPM have shown large variation on monthly basis. The variability in these air pollutants strongly affects the meteorological parameters and responsible for frequent environmental changes in this region and health issues. During this study period, however, the mass concentration of NO$_2$ and SO$_2$ remained under NAAQ standard value for quality of air but the mass concentrations of RSPM and SPM are always greater than the NAAQ standard value for quality of air and may be responsible for respiratory problem in Dehradun. The high wind speed and high temperature in Dehradun, however, help to flush out the pollutants and try to maintain the environmental conditions under control.

REFERENCES