AMBIENT AIR QUALITY AT DIFFERENT ENVIRONMENTAL BACK DROPS OF KAKINADA CITY, INDIA

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INTRODUCTION
Atmospheric particulate matter (PM) have been of significant environmental attention due to their impact on human health, plants, aquatic life and materials (Banerjee and Pandey, 1989; Pradeepa K.Bhuyan et al., 2010). The major sources for atmospheric particles are industrial activities; energy production, construction, urban waste treatment and vehicle exhaust (Bilos et al., 2001). The trends of urbanization and population growth has resulted more number of vehicles and contributing vehicular gaseous emissions such as SO\textsubscript{2}, NO\textsubscript{x}, CO, O\textsubscript{3}, benzene and hydrocarbons (Bhanarkar et al., 2005). According to Economic Survey of India (2007-08), the total number of vehicles in India is more than 85 million in 2006 i.e. about 1% share of the world. TERI (2003) is projecting the vehicular growth in India is about 300 million by 2026. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at near-ground level. The second major sector affecting air quality is industrial sector. The industrial sector is diversified with large and small-scale industries, along with growing population has contributed to the growing rate of air pollution. The major industrial sectors such as textiles, pharmaceuticals, basic chemicals etc. have significant environmental costs in terms of air emissions (State of Environment, 2009). The economic boom has also led to an increase in investments and activities in the construction, mining and iron and steel and coal based power plants. Thus the industrial development has contributed significantly to economic growth at significant cost to the environment. The air quality has been, therefore, an issue of social concern in the back drop of various developmental activities. Hence, monitoring of ambient air pollutants in an urban or industrial area is important to assess the air quality and the present study is undertaken to find out the ambient air quality at different environmental backdrops of Kakinada city.

MATERIALS AND METHODS

Study area: Kakinada Port City is situated in the East Godavari District of Andhra Pradesh on the sea shore of bay of Bengal and lies between 16°55' and 17°10' NL and 82°10' and 82°21' EL at about 3.9 Meters above mean sea level. The area is almost a plain terrain slightly sloping towards the Bay of Bengal with the elevation varies from 2.6 to 3.9 Meters.

Selection of sampling sites: The sampling sites were selected in such a way that the collected samples represent air that is actually breathed by the population exposed. And for the collection of the samples, the sampler were located at a height of about three meters above the ground level based on the structures of the towers located in the city. Keeping the importance of the present study, sampling sites were selected in different environmental backdrops such as control site (Kovvada, a rural place) for reference, residential areas, commercial areas, industrial areas, etc. have significant environmental costs in terms of air emissions (State of Environment, 2009).

ABSTRACT
This study was undertaken to investigate the quality of air in Kakinada, a port and fertilizer city at selected sites covering residential, commercial and industrial areas during 2008-2010 with reference to RSPM, NO\textsubscript{x} and SO\textsubscript{2}. During the study period, the ambient air quality at Kakinada in relation with RSPM concentration was high in different environmental backdrops and much above the prescribed standards. RSPM concentrations ranged from 60.85 ± 1.63μg/m\textsuperscript{3} to 210.55 ± 6.63μg/m\textsuperscript{3} in all the study areas. Results for RSPM in industrial area are ranged in between 142 and 184 μg/m\textsuperscript{3}. The average concentrations of SO\textsubscript{2} and NO\textsubscript{x} in the entire study area during the study period ranged from 9.00 ± 2.70μg/m\textsuperscript{3} to 71.61μg/m\textsuperscript{3} and from 31.48 ± 1.57μg/m\textsuperscript{3} to 31.59 ± 3.66μg/m\textsuperscript{3}, respectively. The concentration of gaseous pollutants were within the permissible limits. The Air Quality Index (AQI) of residential areas reported as moderately polluted whereas in commercial and industrial areas it was reported as polluted. The air quality rating in all the areas of the study is polluted with respect to RSPM. The values ranged from 53.47μg/m\textsuperscript{3} to 142 μg/m\textsuperscript{3} in residential, 78.21 μg/m\textsuperscript{3} to 90.48 μg/m\textsuperscript{3} in commercial and 82.63 to 91.53 μg/m\textsuperscript{3} in industrial areas. The presence of high values of RSPM at the roadside locations indicate that in commercial areas especially from the road shoulders, the dust get suspended/resuspended due to heavy vehicular movement.

KEY WORDS
RSPM, Gaseous Pollutants
Ambient air quality, Kakinada city

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Kakinada city have a fairly clear-cut seasonal character with dispersion and dilution of pollutants. The surface winds over pollutants. The stronger the winds the greater will be the turbulence near the ground during moderate to strong winds. Jagannaickpur, Port area and Bhanugudi areas situated towards western side of the city, lower RSPM is due to dense tree cover all along the roadside which resulted due to high RSPM level at important junctions of the city where resulted high RSPM level in industrial areas. Further special attention has given during the monitoring that the selected site was not overshadowed by taller buildings and trees etc. which would obstruct the free flow of air movement.

Description of the sampling sites: Keeping in view of the above criteria, samples were collected from ten sampling sites and the details are presented below (Table 1).

Respirable Suspended particulate matter (RSPM) present in air was measured as the concentration of all solid particles averaged over a period of 24 h by sucking known quantity of air through Glass micro fiber filters by using Respirable Dust Sampler (RDS) (Envirotech APM 451 RDS based on CSIR NEERI know-how) and Envirotech APM 411 TE Thermo electrically cooled Gaseous sampling attachment for Gaseous pollutants and estimated gravimetrically. Glass micro fiber filter papers with a collection efficiency of at least 99% for particles of 0.3 Microns and larger in diameter. The filter paper was conditioned at 105ºC in an oven and numbered before weighing.

Concentration of Oxides of Nitrogen was estimated in Ambient Air using Jacob and Hochheiser method. Sulphur dioxide (SO2) was determined by modified West and Geake method. All the protocols such as the RSPM, NOx and SOx etc. were analyzed as per the prescribed standard methods of CPCB guidelines. Altogether 104 measurements in year at a particular site were taken at uniform interval during March 2008 to February, 2010. In monsoon, the monitoring was carried out during the non-rainy days occurrence for 3 consecutive days.

Air Quality Index (AQI) is calculated based on the average of the sum of the ratios of three pollutants (RPM, SO2 and NOx) to their respective air quality standards. The average is then multiplied by 100 to get the AQI index (Rao and Rao, 2001). The AQI values compared with rating scale.

RESULTS AND DISCUSSION

The annual mean concentrations of RSPM, SO2 and NOx for the years 2008-10 were shown in Fig. 1 and 2. The meteorological data was collected from National Institute of Hydrology, Deltaic Regional Centre, Kakinada. Wind speed and wind direction play a major role in the dispersion of air pollutants. The stronger the winds the greater will be the dispersion and dilution of pollutants. The surface winds over Kakinada city have a fairly clear-cut seasonal character with

<table>
<thead>
<tr>
<th>S. No</th>
<th>Sampling station</th>
<th>Zone</th>
<th>Nature of environmental backdrop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control (Kovvada)</td>
<td>Residential</td>
<td>Rural areas, residential and agricultural fields, cultivation of paddy and vegetable</td>
</tr>
<tr>
<td>2</td>
<td>R-1 (APSP Quarters)</td>
<td>Residential</td>
<td>Bus Stand, Residential and small shopping complexes. Residential areas of high and middle income groups</td>
</tr>
<tr>
<td>3</td>
<td>R-2 (Jagannaickpur)</td>
<td>Residential</td>
<td>Bus Stand, Residential and agricultural field cultivates mainly paddy. Residential areas of low and middle income groups</td>
</tr>
<tr>
<td>4</td>
<td>R-3 (Indrapalem)</td>
<td>Industrial</td>
<td>Bus Stand, Residential and small shopping complexes.</td>
</tr>
<tr>
<td>5</td>
<td>C-1 (Jagannaickpur)</td>
<td>Commercial</td>
<td>Bus Stand, commercial complexes, Hospitals, Educational Institutions and government offices</td>
</tr>
<tr>
<td>6</td>
<td>C-2 (Port Area)</td>
<td>Commercial</td>
<td>Bus Stand, Port railway station, FCI Godowns import and export of cargo through railways</td>
</tr>
<tr>
<td>7</td>
<td>C-3 (Bhanugudi Junction)</td>
<td>Commercial</td>
<td>Bus Stand, Commercial complexes, Hospitals, Education Institutions and Government offices</td>
</tr>
<tr>
<td>8</td>
<td>F-1 (NFCL Road)</td>
<td>Industrial</td>
<td>Small and heavy Industrial</td>
</tr>
<tr>
<td>9</td>
<td>F-2 (Vakalapudi)</td>
<td>Industrial</td>
<td>Small and heavy Industrial</td>
</tr>
<tr>
<td>10</td>
<td>F-3 (Dairy farm)</td>
<td>Industrial</td>
<td>Small and Industrial</td>
</tr>
</tbody>
</table>

Figure 1: Annual mean concentration of RSPM (μg/m³) in different sampling stations; 1 = Control Kovvada; 2 = APSP-Qrts R-1; 3 = Atchutapuram R-2; 4 = Indrapalem R-3; 5 = Jagannaickpur C-1; 6 = Portarea C-2; 7 = Bhanugudi In C-3; 8 = NFCL Road F-1; 9 = Vakalapudi F-2; 10 = Dairy farm F-3

SW, SSW, NW during May to October NE, NNE and SE during November to April as predominant directions.

During the study period, the ambient air quality at Kakinada in relation with RSPM concentration was high in all the sampling areas and much above the standards prescribed by CPCB (2009) compared to NOx and SO2. RSPM concentrations ranged from 60.85 ± 1.63μg/m³ to 210.55 ± 6.63μg/m³ in all the study areas. Results for RSPM in industrial area ranged in between 142 and 184μg/m³ and the results are similar to the studies of various workers from different cities in India (Agarwal and Khanam, 1997; Chandrasekharan et al., 1998; Tiwari and Mishra, 2005; Kushwaha et al., 2008).

In residential areas, the RSPM values exceeded in APSP Quarters and Atchutapuram and recorded the mean concentration of 138.06 ± 21.68μg/m³ and 120.73 ± 9.76μg/m³ respectively. The APSP Quarters is adjacent to State Highway whereas Atchutapuram is mainly connected to important junctions of the city where resulted high RSPM level from berms and roads. The prevailing wind from south to north and north east also contributed RSPM from commercial and industrial areas. In Indrapalem and Kovvada residential areas situated towards western side of the city, lower RSPM is due to dense tree cover all along the roadside which enhanced the turbulence near the ground during moderate to strong winds. Jagannaickpur, Port area and Bhanugudi areas of Kakinada are commercial areas, which are densely
Atchutapuram R-2; 4 = Indrapalem R-3; 5 = Jagannaickpur C-1; 6 = Portarea C-2; 7 = Bhanugudi Jn; C-3; 8 = NFCL Road I-1; 9 = Vakalapudi I-2; 10 = Dairy farm I-3

Figure 2: Annual mean concentration of SO$_2$ and NOx (µg/m$^3$) in different sampling stations; 1 = Control Kovvada; 2 = APSP-Qrts R-1; 3 = Atchutapuram R-2; 4 = Indrapalem R-3; 5 = Jagannaickpur C-1; 6 = Portana C-2; 7 = Bhanugudi Jn; C-3; 8 = NFCL Road I-1; 9 = Vakalapudi I-2; 10 = Dairy farm I-3

The results clearly show that the RSPM will play a significant role in near future keeping in view of rising RSPM and developmental activities. The average concentrations of SO$_2$ and NO$_x$ in the entire study area during the study period ranged from 9.00 ± 2.70µg/m$^3$ to 31.48 ± 1.57µg/m$^3$ and from 31.59 ± 3.66µg/m$^3$ to 59.9 ± 3.72µg/m$^3$, respectively and the concentration of gaseous pollutants are within the permissible limits prescribed by CPCB.

Seasonal variations of RSPM, SO$_2$ and NO$_x$ were found least during the rainy seasons in entire study period at all the sampling sites. The minimum and maximum concentration of Respirable Suspended Particulate Matter (RSPM) in ambient air at different locations of Kakinada was recorded at 102 - 185 µg/m$^3$ in summer, 94 - 172 µg/m$^3$ in monsoon and 109 - 195 µg/m$^3$ in winter season. The concentration of pollutants were more during the winter season in comparison with summer and rainy seasons in all the sampling locations except Kovvada residential area (Fig. 3). The rise in pollutants concentration during winter may be due to its proximity to sea shore which might have some influence on RSPM with contribution of sea salt spray. Generally the conditions of sea salt spray percentage on RSPM in TSPM would have been near to 50 % as observed by APPCB (2007). The local atmospheric factors tend to condense pollutants closer to the ground level due to poor inversion that minimizes their diffusion to the upper strata of the atmosphere (Chelani et al., 2005).

The AQI is a measure of the average of the ratios of the pollutant’s concentrations to the respective prescribed standard concentration at a given place (Rao and Rao, 1989; Chauhan et al., 2010; Bhuyan et al., 2010). The AQI is a compilation of terms that define the air quality as understandable by public community. In contrast, the air quality data in its original form is complex and cannot be comprehended by all groups of people. Air Quality Index (AQI) for all the sampling sites in the present study holds the order of Control Kovvada < Indrapalem R-3 < Atchutapuram R-2 < APSP Qrts. R-1 < Port area C-2 < Dairy farm I-3 < Vakalapudi I-2 < Bhanugudi Jn; C-3 < Jagannaickpur C-1 <

Table 2: Ambient Air Quality Index (AQI) for all the sampling sites of the study area

<table>
<thead>
<tr>
<th>Zone</th>
<th>Name of the Sampling Station</th>
<th>AQI</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Control Kovvada</td>
<td>53.47</td>
<td>Moderately polluted</td>
</tr>
<tr>
<td></td>
<td>APSP-Qrts R-1</td>
<td>71.61</td>
<td>Moderately polluted</td>
</tr>
<tr>
<td></td>
<td>Atchutapuram R-2</td>
<td>62.08</td>
<td>Moderately polluted</td>
</tr>
<tr>
<td></td>
<td>Indrapalem R-3</td>
<td>57.25</td>
<td>Moderately polluted</td>
</tr>
<tr>
<td>Commercial</td>
<td>Jagannaickpur C-1</td>
<td>90.48</td>
<td>Polluted</td>
</tr>
<tr>
<td></td>
<td>Port area C-2</td>
<td>78.21</td>
<td>Polluted</td>
</tr>
<tr>
<td></td>
<td>Bhanugudi Jn C-3</td>
<td>83.93</td>
<td>Polluted</td>
</tr>
<tr>
<td>Industrial</td>
<td>NFCL Road I-1</td>
<td>91.53</td>
<td>Polluted</td>
</tr>
<tr>
<td></td>
<td>Vakalapudi I-2</td>
<td>82.70</td>
<td>Polluted</td>
</tr>
<tr>
<td></td>
<td>Dairy farm I-3</td>
<td>82.63</td>
<td>Polluted</td>
</tr>
</tbody>
</table>
NFCL Road I-1. The ambient Air Quality Index (AQI) for all the sampling sites of the study area during the study period is presented in Table 2. The commercial and industrial areas have reported more than 40% of RSPM as compared with residential areas. Similarly, Ratan and Kumar (2005) calculated the AQI for different locations in Delhi among which most of the sites have shown the critical level of air pollution in Delhi for the years 2000-2004. Rajesh Kumar et al. (2008) calculated the air quality indices using the average values of air pollutants at Korba industrial area, Dhanbad and the air quality depreciation indices for all the locations indicated the substantial deterioration of air quality for Korba industrial belt. The results clearly shown that RSPM is playing a significant role because of rapid urbanization especially construction activities in residential areas followed by industrialization in and around Kakinada city.

CONCLUSION

It has been concluded from the present study that the SO\textsubscript{2} and NO\textsubscript{x} concentrations are well below the national standards, while the RSPM concentrations are found to be in much excess. The presence of high values of RSPM at the roadside locations indicate that in commercial areas especially from the road shoulders, the dust get suspended/resuspended due to vehicular movement. In these stations the air quality management programme may be initiated.

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REFERENCES


CPCB. 2009. National Ambient Air Quality Standards. cpcb.nic.in / National Ambient Air Quality Standards.php


