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Ambient air quality in and around industrial area, Visakhapatnam, AP, India

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Abstract
Monitoring of air quality is mainly focused on consequences and present status of air quality of the study area. Monitoring was done at 3 different sampling locations i.e., Paravada, Vadachipurapalli and Appikonda. In the present study, four air quality parameters selected and analysed i.e., PM10, PM2.5, SO_2 and NO_2 at three different locations during three seasons covered within two calendar years of 2016 and 2017. PM2.5 and PM10 concentrations recorded in higher during July 2016 to June 2017 and it decreases during July-October and increases from the month of February 2017 to June 2017. All the parameters were seasonally varied, the higher in winter seasons and decreased in rainy seasons. The annual concentration of PM10 and PM2.5 were recorded at all the sampling locations were higher than National Ambient Air Quality Standard (NAAQS) during study period. Both NO_2 and SO_2 concentration were below the NAAQS levels during all the seasons. The present study can be reveals that the air pollution is deteriorating rapidly, and it is high time to implement the clean air act immediately to reduce such destruction.

Keywords: air quality, season and Visakhapatnam

1. Introduction

Ambient air pollution in urban areas is a major concern for many countries in the worldwide (Tabaku *et al*., 2011; Franchini *et al*., 2016; Mannucci *et al*., 2015; Franchini *et al*., 2015; Newby *et al*., 2015; Franchini and Mannucci, 2011) [32, 8, 9, 10, 22] and major sources of air pollution is due to anthropogenic activities since few decades (Helmut, 1999; Hossain *et al*., 2019; Al Nayeem *et al*., 2019) [11, 1, 12]. These sources contribute various air pollutants such as Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Particulate Matter (PM2.5 and PM10) and among these PM2.5 and PM10 cause an adverse effect on human health (Li *et al*., 2017) based on aerodynamics size of the pollutants (Pier Mannuccio and Massimo Franchini, 2017) [10]. In most of the developed and developing countries, the air pollution and airborne particulate matter (PM) such as PM10, PM2.5 and PM10 has increased rapidly in the last few decades. Particulate matter concentration and increase in air pollutants degraded the air quality and also has brought many health hazards problems by inhaling these small particulates (Puneet and Mamtaz, 2020) [25].

2. Material and Methods

According to the national ambient air quality monitoring, manual monitoring procedure was followed and four parameters like PM2.5, PM10, SO_2 and NO_2 were analyzed. For PM2.5 and PM10 parameters were analyzed by using gravimetric method while SO_2 and NO_2 gases parameters were analyzed by using wet-chemical methods. For the investigation of the seasonal variation, the year was divided into three seasons: winter (November to February), summer (March to June) and monsoon (July to October) as per the regional meteorological considerations. The concentrations of air pollutants viz. SO_2, NO_X, SPM and PM10 were analyzed for all the three seasons for the period of 2016 - 2017 in Visakhapatnam at different 3 air quality monitoring stations. Collecting data predominant upward and downward wind direction and velocity from Indian Meteorological Data, Government of India. All collected data was analysed using the Microsoft Excel was also used for data presentation as well as for making tables and graphs.

3. Results & Discussion

Seasonal variations of PM2.5 concentration

Natural sources of PM2.5 is due to desert dust, forest fire, sea salt, and sulphates from volcanoes, but increasing anthropogenic interferences in the environment have significantly increased (Zhang *et al*. 2015; Schwartz, 1996). PM2.5 concentration were ranges from 77.1 to 127.1 $\mu g/m^3$ with mean of 102.6 $\mu g/m^3$ at Parawada, 52.1 to 120.8 $\mu g/m^3$ with mean of 89.0 $\mu g/m^3$ and 82.9 to 128.5 $\mu g/m^3$ with mean of 103.5 $\mu g/m^3$ during all the three seasons. In the present study, all sampling locations and major metropolitan cities in India violate the annual mean national ambient air quality standard (NAAQS) for PM2.5 (CPCB, 2013; Sharma and Maloo, 2005) [30].

Seasonal variations were distinct with higher pollution load in winter and lower in rainy season (CPCB, 2013). During the rainy season, PM2.5 concentrations in all the sampling locations were exceeded the NAAQS level is 60$\mu g/m^3$ of PM2.5 for during the months of July, August and September in the present study except Vada Chipurapalli. Ununiformly, the PM2.5 concentrations were recorded higher during the rainy season and during rainy months, the dust and other gases are washed away resulting very low ambient values in the actual condition. In the present study, during the winter season, the concentrations of PM2.5 of all the sampling locations were exceeded the NAASQ level is 60$\mu g/m^3$ for residential and industrial area and crossed the air quality standard and 2 times higher than the standard values when compared to both seasons of rainy and summer.

During summer the concentration of PM2.5, in all the sampling locations were exceeded than the NAAQS level is 60µg/m^3. The reason has been explained and the source of higher levels could be due to construction activity, burning of solid wastes, residential activities and emissions from thermal power plant, which may indicate slightly elevated relative levels of PM2.5, possibly due to seasonality and the use of solid fuel burners in the study area.

It can be observed that seasonal variations indicating rainy seasons having lower concentrations when compared winter and summer in all the sampling locations during study. Higher values were obtained during winter months and lower values were obtained during rainy days. Generally, the daily average PM2.5 concentrations and the similar temporal trend, i.e. high values presented in cold season and low values in warm season. There were however also opposite trends, i.e. low PM2.5 concentrations accompanied (Fang *et al*., 2017) [7]. It has been shown that levels of urban pollution can be strongly influenced by both meteorological conditions and the topography of the area (Singh *et al*., 2013; Schauer *et al*., 2008; Ronkko *et al*., 2006; Jamriska *et al*., 2008; Morawska *et al*., 2008; Li *et al*., 2015; Rybarczyk and Zalakeviciute, 2016; Kleine *et al*., 2017) [31, 28, 26, 13, 21, 14]. Traffic is identified as a major cause of such higher PM2.5 level in India (CPCB, 2013). Similar studies reported (Tiwari *et al*., 2009) [33].

Seasonal variations of PM10 concentration

Main source of concentration of PM10 of the agricultural, industrial, automobile and fuel wood burning are the reasons for the atmospheric dust particles in the environment (USEPA, 2012). In the present study, the concentration of PM10 values ranges from 120.1 to 214.6µg/m3 with mean of 163µg/m3 at Parawada, 98.5 to 206.3µg/m3 with mean of 159µg/m3 at Vada Chipurapalli, 121.5 to 189.6µg/m3 with mean of 154.3µg/m3 at Appikonda were exceeded the National Ambient Air Quality Standards (NAAQS). All the season the concentrations of PM10 values at Parawada, Vada Chipurapalli and Appikonda locations were exceeded the National Ambient Air Quality Standards level is 100µg/m3. Lower levels were observed during the months of July and August when compared to September and October during rainy season and maximum exceedance occurred during winter season (Chatterjee *et al*. 2012) [3]. The highest concentration of PM10 was recorded season studied and showed values up to 206.3 µg/m^3 in winter season.

Seasonal variations of SO2 concentration

Studies found an association between increased concentrations of SO2 and daily mortality (with coexisting particulate matter), as well as morbidity of bronchial asthma, persistent cough and phlegm, bronchoconstriction, and irritability of the respiratory system (Mazumbar *et al*., 1982; Koening *et al*., 1980; Lawther *et al*., 1975) [20, 15, 17]. In the present study, SO2 concentrations were ranges from 5.4 to 9 µg/m^3 with means 7.1 µg/m^3 at Parawada, 5.6 to 9 µg/m^3 with mean of 7.3 µg/m^3 at Vada Chipurapalli, 5.8 to 8.3 µg/m^3 with mean of 7 µg/m^3 at Appikonda during all the seasons in 2016 and 2017. All the sampling locations SO2 concentration were not exceeded the National Ambient Air Quality Standards of 24 hrs and annual mean value.

During the rainy season, the month of July, very lower SO2 levels were observed when compared to the months of August, September and October of the rainy season. The maximum levels were recorded during the months of January and February at Parawada (8.3µg/m^3) and Vada Chipurapalli (8.3µg/m^3). Lower levels of SO2 were observed at during the month of July in the winter season. Lower levels were observed during the months of May and June at Parawada (6.3µg/m^3), Vada Chipurapalli (6.3µg/m^3) and Appikonda (5.8µg/m^3). The concentration of SO2 in all the study stations was within the National Ambient Air Quality Standards for residential area and industrial areas (CPCB, MoEF, 1998, 2009).

Seasonal variations of NO2 concentration

In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant (Omidvarborna, 2015; Annamalai *et al*., 2007) [23, 2]. NOx concentrations in the present study, ranges 9.6 to 31.9 with mean of 23.1 at Parawada, 10.2 to 29.2 with mean of 19.8 at Vada Chipurapalli, 12.5 to 23.6 with mean of 17.8 at Appikonda recorded during all the seasons in 2016 and 2017.

In the present study, during the rainy season, concentrations were recorded during the month of July at Parawada (9.6µg/m^3) while highest concentrations were observed during the months of August, September and October at Parawada (31.9µg/m^3) and Vada Chipurapalli (28.5µg/m^3) in the rainy season. Maximum NO2 levels were observed during the months of November, December and February and minimum concentrations were observed in the month of January when compared to all the sampling locations during winter season. Lowest values were observed during the months of May and June at Vada Chipurapalli (12.6µg/m^3) and Appikonda (12.5µg/m^3) while highest concentrations were observed during the months of March and April at Parawada (29.9µg/m^3) and Appikonda (23.6µg/m^3) in the summer season. Inhalation of such particles causes or worsens respiratory diseases, such as emphysema or bronchitis, and aggravates existing heart disease (USEPA, 2008) and the direct effect of the emission of NO*x* has positive contribution to the greenhouse effect (Lammel *et al*., 1995) [16].

Table 1: Concentration of PM2.5, PM10, SO2 and NO2 at Parawada

Season	Month & Year`	PM2.5	PM10	SO2	NO2
Rainy Season	July - 2016	87.9	156.2	7.0	9.6
	August - 2016	111.1	185.4	6.9	11.1
	September - 2016	77.1	129.2	6.9	31.9
	October - 2016	98.6	120.1	8.3	21.5
Winter Season	November - 2016	103.8	149.5	6.5	28.8
	December - 2016	98.4	138.9	5.8	28.9
	January - 2017	85	124.1	6.2	18.5
	February - 2017	127.1	211.1	8.3	27.8
Summer Season	March - 2017	127.1	214.6	8.3	27.8
	April - 2017	123.6	212.5	9	29.9
	May - 2017	95.1	154.3	5.4	19.6
	June - 2017	96.3	159.5	6.3	21.6
	Min	77.1	120.1	5.4	9.6
	Max.	127.1	214.6	9	31.9
	Mean	102.6	163.0	7.1	23.1
NAAQ Standards		60	100	60	60

All values are expressed in µg/m3

Table 2: Concentration of PM2.5, PM10, SO2 and NO2 at Vada Chipurapalli

Season	Month & Year`	PM2.5	PM10	SO2	NO2
Rainy Season	July - 2016	56.9	98.5	7.8	19.1
	August - 2016	52.1	102.8	5.6	28.5
	September - 2016	61.1	104.9	9	24.3
	October - 2016	94.4	204.9	5.6	18.8
Winter Season	November - 2016	93.5	177.2	7.1	14.1
	December - 2016	92.1	175.8	6.3	11.1
	January - 2017	85.2	152.3	6.9	10.2
	February - 2017	120.8	206.3	8.3	29.2
Summer Season	March - 2017	117.4	199.3	9	26.4
	April - 2017	119.4	198.6	9	25.7
	May - 2017	90.2	144	6.5	17.9
	June - 2017	85.3	143.2	6.3	12.6
	Min	52.1	98.5	5.6	10.2
	Max.	120.8	206.3	9	29.2
	Mean	89.0	159.0	7.3	19.8
NAAQ Standards		60	100	60	60

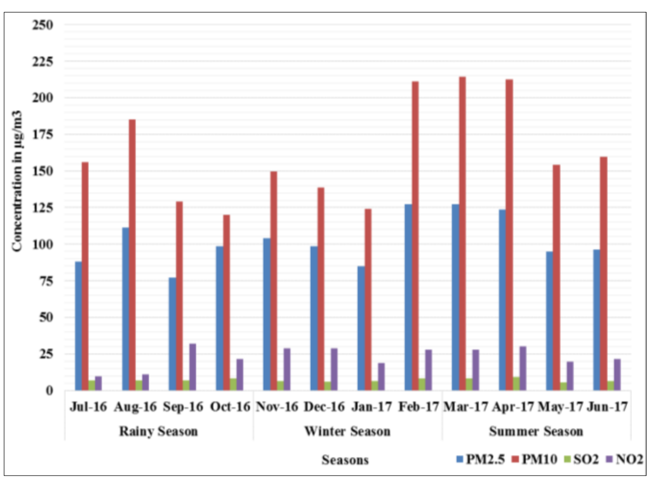
All values are expressed in µg/m3

Table 3: Concentration of PM2.5, PM10, SO_2 and NO_2 at Appikonda

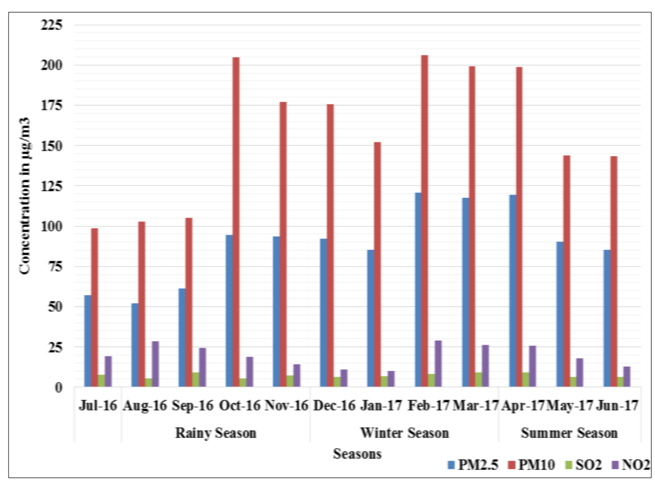
Season	Month & Year`	PM2.5	PM10	SO2	NO2
Rainy Season	July - 2016	86.3	121.5	7.5	15.4
	August - 2016	88.9	140.3	6.9	17.4
	September - 2016	99.3	154.2	6.9	16.7
	October - 2016	123.6	167.4	6.9	16.7
Winter Season	November - 2016	99.5	145.7	6.5	18.5
	December - 2016	100.5	145.8	6.3	18.9
	January - 2017	82.9	123.1	7.2	15.4
	February - 2017	128.5	186.8	7.6	21.5
Summer Season	March - 2017	121.5	189.6	8.3	22.2
	April - 2017	124.3	185.4	7.6	23.6
	May - 2017	90.8	138.6	6	12.5
	June - 2017	95.8	153.7	5.8	14.2
	Min	82.9	121.5	5.8	12.5
	Max.	128.5	189.6	8.3	23.6
	Mean	103.5	154.3	7.0	17.8
NAAQ Standards		60	100	60	60

All values are expressed in µg/m3

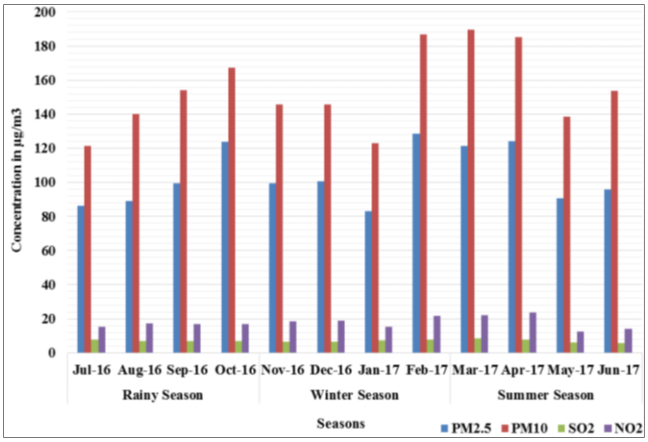
Fig 1: Showing the sampling locations in the present study



Graph 1: PM10, PM2.5, NO_2 and SO_2 concentrations during the study at Parawada Location



Graph 2: PM10, PM2.5, NO_2 and SO_2 concentrations during the study at Vada Chipurapalli



Graph 3: PM10, PM2.5, NO_2 and SO_2 concentrations during the study at Appikonda location

5. Summary and Conclusion

Air quality in the recent studies shows impacts on human health in India and all over the world due to naturally and anthropogenic activities. In this aspect, the study conducted on the status of air quality in three different locations nearby parawada industrial area. PM2.5 concentrations in the study, all the sampling locations were exceeded the NAAQS level is 60µg/m^3. Ununiformly, the PM2.5 concentrations were recorded higher during the rainy season and during rainy months and maximum PM2.5 concentrations were recorded during rainy season when compared to both winter and summer seasons in the present study. Meteorological factors like higher temperature, relative humidity, higher rainfall content and lower wind velocities recorded but the PM2.5 concentrations were observed inversely and Relative Humidity affects the natural deposition process.

PM10 concentrations were higher than the NAAQS level is 100µg/m^3 in all the different locations during the three seasons in the present study. Ununiformly, the PM10 concentration were recorded like other parameter like PM2.5, NO_2 and SO_2 during all the seasons in the present study. The highest concentration of PM10 was recorded season studied and showed values up to 206.3 µg/m^3 in winter season when compared to than the other seasons. Both NO_2 and SO_2 concentrations were below the higher than the NAAQS level is 60µg/m^3 in all the different locations during the three seasons in the present study and lower risk than when compared to PM10 and PM2.5 concentrations during the study period. Inhalation of such particles causes or worsens respiratory diseases, such as emphysema or bronchitis, and aggravates existing heart disease. The study reveals that the particulate matter concentration higher in the study area and it impacts on respiratory related health problem.

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