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RESEARCH ARTICLE

AMBIENT AIR QUALITY ANALYSIS OF KURNOOL CITY, INDIA

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ABSTRACT

This study reports the analysis of the ambient air in Kurnool city, Andhra Pradesh State, India employing air quality index (AQI) simplified public information and data interpretation. The frequency of sampling is twice a week with 24 -hourly average concentrations of three major criteria pollutants, viz. Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon monoxide (CO) for the year 2015 (December) to 2016 (November) at four different selected locations in Kurnool city. They are KALLUR Estate (industrial), NANDYAL Check post Junction (City outskirts), RAJ VIHAR Junction (Commercial) and Old bus stand Fort area (Residential). It has been observed that due to various variations in meteorological parameters, concentrations of air pollutants exhibit typical diurnal, weekly and annual cycle's changes. The AQIs were calculated using IND-AQI procedure. NO_2 and SO_2 are the primary causes of pollution at Location -1 and Location-2 which canbe attributed to industrial emissions It has been observed that the calculated AQIs values CO fall under "good" and "satisfactory" categories with varying percentages. At present the study shows that pollution is under "Moderately polluted" category. Suitable measures are suggested to improve the situation and prevent further deterioration of the atmospheric conditions.

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INTRODUCTION

Air pollution is considered as serious problem for public health all around the world. Many countries have been facing this problem. The studies on air pollution began after the London fog in the Mid 20th century due to rapid increase of industrialization (Pradeepta *et al*., 2010). Air pollution is primarily gases due to major air pollutants like Particulate matter, Sulphur dioxide, Nitrogen dioxide, Carbon monoxide, Ozone (Ankita Shukla *et al*., 2010) and this can be directly related to climate change. According to World Health Organization, India ranks second for most number of deaths due to outdoor air pollution. Many factors like industrialization, urbanization, lack of awareness about pollution, poor maintenance of motor vehicles and bad road conditions have contributed to the deterioration of atmospheric conditions in India (Srinivas and Purushotham, 2013). The combined efforts of National and State level authorities have taken measures to reduce pollution and improve air quality but due lack of proper planning and unprecedented growth in the Transport, Industrial sectors have led to worsen the situation (Guttikunda and Jawahar, 2011). The increase of air pollution causes Respiratory problems, Skin diseases and sometimes may lead to hypoxic conditions which could be fatal. So there is an urgent need to control air pollution. But to control it, there is a need of effective tool to measure so that we can reduce it to safe level. The word AQI abbreviated as "Air Quality Index" is an used as a tool for measuring air quality with respect to its effect on human health (Murena, 2004). This tool was first introduced by Environment Protection Agency (EPA), USA and is being used in many countries in the world for measuring air pollution. Many countries in the world are using AQI as a tool for measuring air pollution (USEPA, 2014; Shenfold, 1970). An AQI is defined as an overall scheme that transforms weighted values of individual air pollution related parameters into a single number or set of numbers (Mukesh Sharma, 2003). Different countries have adopted different methods for determining the AQI (Inhaber, 1974). In the present study as specified by Central Pollution Control Board (CPCB), the AQI was calculated using IND-AQI. The index has been developed based on the dose-response relationship of various pollutants. The concept of AQI is based on the concept of transforming the values of individual air pollutants into some set of numbers which can easily be understood and can be communicated to the general public to know how the pollution and forecast it. This IND-AQI has 6 categories and each category has color code and descriptor (Chaurasia *et al*., 2013) as shown in Table 1. In the present study, air pollutants which effects the ambient air quality are measured for four

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different area locations (Industrial area, Residential area, Commercial area and Outskirts area) of Kurnool city, Andhra Pradesh State, India. The study period is from December 2015 to November 2016 and during this period weekly, monthly and seasonal variations of the pollutants have been measured. On the basis of the monthly average, the indexes for each of the pollutants were obtained and cumulative impact of air pollution with meteorological factors was examined in the light of corresponding AQI (Sharma Sanjeev Kumar and Sharma Kriti 2016).

Table 1. Various Categories of IND-AQI (National Air Quality Index, CPCB, October 2014)

Category	AQI Range
Good	0 - 50
Satisfactory	51 - 100
Moderately Polluted	101 - 200
Poor	201 - 300
Very poor	301 - 400
Severe	401 - 500

Kurnool is one of the major and important cities of Andhra Pradesh (Annual Report, 2013). Kurnool is endowed with good mineral resources like Iron ore, Dolomite, Limestone, Barytes and Silica as a result many industries for manufacture of Cement, Ceramics, Refractories, Chemicals, Granite, Marble & Limestone cutting & polishing units, Slate cutting units, Granite monuments manufacturing units, Pulverizing units, stone crushers, Mosaic & Ceramic tile units, Lime Kilns, and Manufactured Rocksand units have been setup leading to increase of industrial pollution. With growing population the vehicular pollution is also increasing. So this area has been chosen for the study as the Government of Andhra Pradesh is planning to setup more and more industries particularly after the bifurcation of the state. In this paper an attempt has been made to study the air quality status of Kurnool, using AQI (Air Quality Index).

MATERIALS AND METHODS

Study Area

Kurnool city shown in Figure 1 is a district headquarters of Kurnool district of Andhra Pradesh state, India and is referred as the Gateway of Rayalaseema (District Census Handbook : Kurnool, 2015).

Figure 1. The Kurnool city

According to the 2011 census, Kurnool is the fifth most populous city in the state with a population of 4, 60,184 (Sarkar, Siddhartha, 2011). It was the capital of Andhra State from 1 October 1953 to 31 October 1956.Kurnool is located at 15.8333°N 78.05°E. It has an average elevation of 273 metres (898 feet). Kurnool is generally drought prone with an average rainfall of 670mm. The climate is tropical with temperatures ranging from 26 °C (78.8 °F) to 46 °C (114.8 °F) in the summer and 12 °C (53.6 °F) to 31 °C (87.8 °F) in the winter.

Site Description

The sampling was done at four different locations which are KALLUR Industrial Estate (Location 1), NANDYAL Check post Junction (Location 2), RAJVIHAR Junction (Location 3), and Old Bus stand Fort area (Location 4) shown in Figure 2. Location 1 is an industrial area surrounded by Granite, Marble & Limestone cutting & polishing units, Slate cutting units. Location 2 is in the outskirts of the City, Location 3 is the Commercial area which has heavy traffic flow and Location 4 is the residential area.

Figure 2. The google map of the Locations

The samples of the pollutants was recorded continuously for 24-hours on two days in each week and 104 samples in a year using a portable Automatic Weather system. The automatic weather monitoring system is fixed in a 10 × 35 × 50 cm^3 box and mounted on the top of the vehicle as shown in the Figure 3 and moved to any remote location.

Figure 3. Monitoring system fixed on the vehicle

The monitoring system as shown in Figure 4 consists of Arudino MEGA ADK board with microcontroller and sensors for detecting pollutant gases, temperature, pressure, humidity and the GPS receiver interfaced to it gives the exact location and time. The pollutant data is stored in the memory card. This is stored in the computer for further analysis.

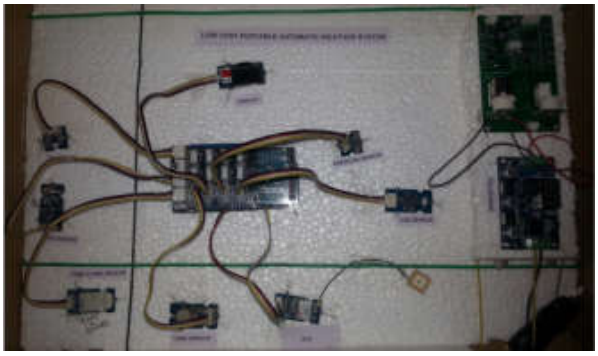


Figure 4. The overall view of the system

Where, I = Air Quality Index,
C = Concentration of pollutant,
C_{low}= Concentration breakpoint that is ≤ C,
C_{high}= Concentration breakpoint that is ≥C,
I_{low}= Index breakpoint corresponding to C_{low},
I_{high}= Index breakpoint corresponding to C_{high}.

RESULTS AND DISCUSSION

Monthly average of the air pollutants at four different locations of Kurnool City is calculated for the period December 2015 to November 2016 is calculated and shown in the Table 3. It has been observed that due to various variations in meteorological parameters concentrations of air pollutants exhibit typical diurnal, weekly and annual cycle's changes. The concentration of NO_2 and SO_2 are maximum (47.45 µg/m3 & 5.64 µg/m3) during the winter months. This is because during winter the atmospheric condition is stable due to the slow dispersion of pollutants. The concentration of NO_2 and SO_2 are minimum (17.84 µg/m3 & 3.4 µg/m3) in the months of May and June.

Table 2. Break Points of various pollutants (National Air Quality, CPCB, October 2014) U*nits :µg/m^3*

AQI Category Range	PM10 (24hr)	PM2.5 (24hr)	SO2 (24hr)	NO2 (24hr)	CO (8hr)
Good (0-50)	00-50	0-30	0-40	0-40	0-1.0
Satisfactory (51– 100)	51-100	31-60	41-80	41-80	1.1-2.0
Moderately Polluted (101–200)	101-250	61-90	81-380	81-180	2.1-10
Poor (201-300)	251-350	91-120	381-800	181-280	10.1-17
Very Poor (301-400)	351- 430	121-250	801-1600	281-400	17.1-34
Severe (401-500)	>430	>250	>1600	>400	>34

Table 3. The Monthly Average of the Pollutants

Month	KALLUR			NANDYAL CP			RAJ VIHAR			OLD BUSTAND FORT		
	SO_2 Monthly average (µg/m^3)	NO_2 Monthly average (µg/m^3)	CO Monthly average (µg/m^3)	SO_2 Monthly average (µg/m^3)	NO_2 Monthly average (µg/m^3)	CO Monthly average (µg/m^3)	SO_2 Monthly average (µg/m^3)	NO_2 Monthly average (µg/m^3)	CO Monthly average (µg/m^3)	SO_2 Monthly average (µg/m^3)	NO_2 Monthly average (µg/m^3)	CO Monthly average (µg/m^3)
Dec2015	5.13	47.45	0.74	5.47	36.47	0.72	5.61	41.25	0.83	3.77	27.4	0.51
Jan2016	5.11	39.87	0.73	5.48	31.23	0.68	5.64	40.2	0.89	3.78	24.5	0.56
February	5.04	36.74	0.67	5.36	32.54	0.71	5.72	37.28	0.77	3.57	21.6	0.48
March	4.86	29.45	0.54	5.19	30.14	0.61	5.22	31.4	0.68	3.61	22.56	0.43
April	4.57	26.37	0.49	5.1	28.68	0.54	4.76	25.7	0.59	3.42	19.54	0.37
May	4.61	19.78	0.5	4.89	21.23	0.47	4.65	20.13	0.54	3.4	17.84	0.39
June	4.32	27.56	0.41	4.54	24	0.46	4.34	22.7	0.48	3.34	19.25	0.32
July	4.09	34.87	0.38	4.19	27.58	0.39	4.12	23.54	0.42	3.53	21.3	0.3
August	4.13	27.68	0.46	4.28	27.41	0.44	4.14	25.7	0.51	3.62	21.7	0.38
Sep	4.4	32.65	0.54	4.47	30.4	0.52	4.52	33.43	0.62	3.66	22.4	0.41
October	4.57	35.1	0.61	4.74	32.2	0.6	4.68	34.6	0.74	3.59	23.4	0.43
Nov 2016	4.86	39.68	0.69	5.14	33.1	0.66	5.42	33.5	0.87	3.68	24.6	0.47

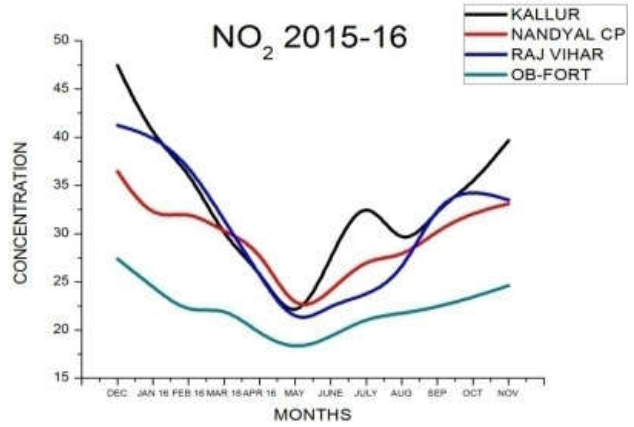
Air pollutants and meteorological parameters were monitored continuously for 24-hours in a day from December 2015 to November 2016. Air pollutant (SO2, NO2, NH_3) concentrations are expressed in (µg/m^3) and concentration of CO is expressed in (mg/m^3). The AQI method involves formation of sub indices for each pollutant and aggregation of sub-indices. It has been developed on the dose-response relationship of various pollutants (Prakash Mamta and Bassin, 2010). The Table 2 shows the Linear segmented relationship for sub-index values and the corresponding pollutant concentrations that are calibrated to Indian conditions.

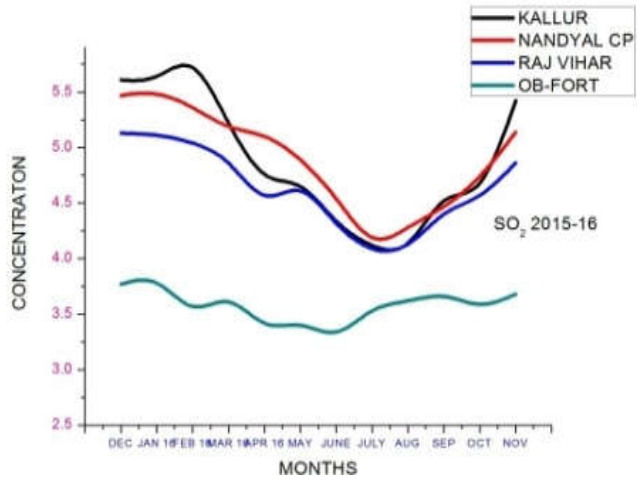
The mathematical equations for calculating sub-indices is as follows (Upadhyaya and Dashore, 2010; Bishoi et al., 2009; Gufran et al., 2010):

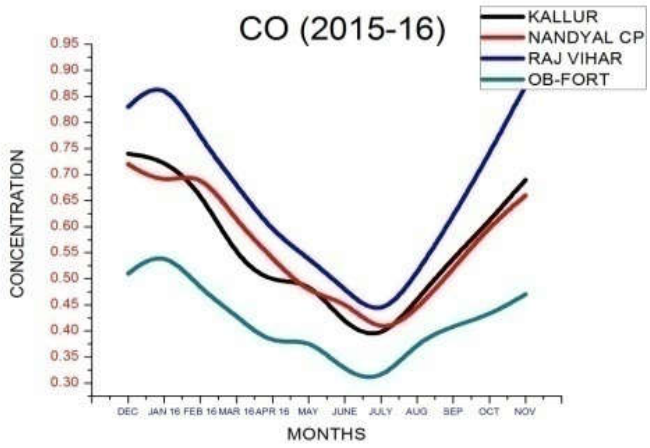
$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

The maxima and minima values of the pollutants in Kurnool city as much lower when compared to the studies made in Chennai during the year 2014 (Thilagaraj *et al*., 2014) and for Delhi city (Prakash Mamta and Bassin, 2010). Similar observations were reported in Vapi, Gujarat (Gowtam Sarella and Anjali K. Khambete, 2015). Unlike this study maximum observed values of NO_2 and SO_2 were reported during summer and minimum values during winter in Joda area, Orissa (Dash and Dash, 2015). In the present study, all observed values of NO_2, SO_2 and CO were found to be lower than NAAQ, Indian Standards. Highest concentrations of SO_2 and CO were obtained in the month of December (5.72 µg/m3 and 3.78 µg/m3) at RAJ VIHAR Junction (Location-3) compared to other locations. This may be due to the reason that Location – 3 happens to commercial location having heavy traffic and high fuel combustion result in the build up of higher concentrations of SO_2 and CO in the air.The study shows that the minimum and maximum concentration of NO_2 was 20 & 48 µg/m^3 at Kallur Industrial Estate, 21 &36 µg/m3 at Nandyal Checkpost

area, 20 &41 µg/m3 at Rajvihar Junction, 17 &27 µg/m3 at Fort area . The average concentration of SO_2 was 4.1 & 5.6 µg/m3 at Kallur Industrial Estate, 4.2 & 5.8 µg/m3 at Nandyal Checkpost, 4 & 5.2 µg/m3 at Rajvihar Junction, 3.3 & 3.8 µg/m3 at Fort area. The average concentration of CO was 0.38 & 0.74 µg/m3 at Kallur Industrial Estate, 0.39 & 0.74 µg/m3 at Nandyal Checkpost, 0.42 &0.89 µg/m3 at Rajvihar Junction, 0.3 & 0.56 µg/m3 at Fort area.







The Figures 5,6,7 shows the monthly variations of NO_2, SO_2 and CO at different locations.

AQI values for the monthly average of SO_2, NO_2 and CO concentrations at four different locations were calculated and are plotted in the figure 8. Highest AQI of the three values of the pollutants is considered as AQI for that particular location.

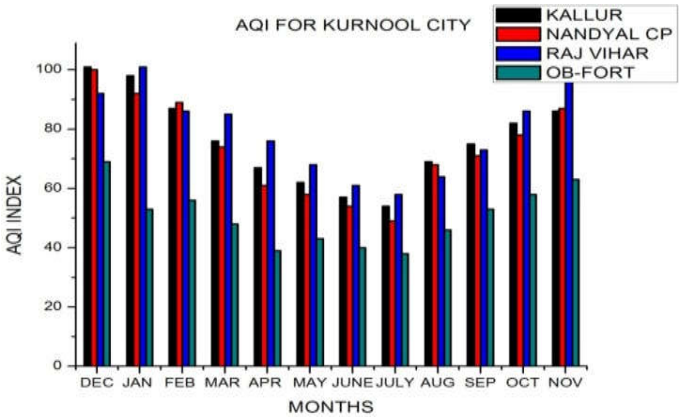


Figure 8. The AQI values at four different locations of Kurnool City

The greater the value of index indicates high concentration of air pollution and more adverse impact on human health. The study shows the air quality is good during the months of June, July, and August is adverse during the winter months. The overall AQI is categorized as "Satisfactory and Moderately Polluted" at all locations.

Conclusion

This study reveals that the pollutant concentrations are within the permissible limits. This study is similar to other research studies made over different cities of India where in most of the cases the pollutants are high and above permissible limits. The CO concentration is high at Location -3 (RAJ VIHAR Junction). This may be attributed to traffic congestion resulting high combustion fuel emissions. This can be reduced by improving roads, providing alternate routes, avoiding heavy vehicles movement and educating people to maintain the vehicles in good condition. NO_2 and SO_2 are the primary causes of pollution at Location -1 and Location-2 which canbe attributed due to industrial emissions. At present the study shows that pollution is under "Moderately polluted" category. Establishment of new industries may increase the level of pollutants and AQI may shift to "poor" category. Green plantation, Awareness programmes for public on environment protection should be encouraged. Continuous monitoring systems should be installed near industries for regularly check the emissions. Thus the need of the hour are strict implementation of environmental regulations and adoption of pollution control measures.

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