

Determination of Air Quality Index Status near Bileipada, Joda Area of Keonjhar, Odisha, India

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Abstract

Air Quality Index near Keonjhar, Odisha was carried out based on monitoring of four ambient air quality parameters like PM_{10} , $PM_{2.5}$, SO_2 and NO_2 at eight different locations. Monitoring was carried out for one year starting from March, 2014 February 2015. APM-460 DXNL Respirable Dust Sampler and Fine Particulate Sampler APM-550 were used followed by cyclonic and impactor based technique for measurement of PM_{10} and $PM_{2.5}$ respectively. Ambient air samples were continuously drawn in solution of potassium tetrachloromercurate for SO_2 and sodium hydroxide and sodium arsenite for NO_2 . Statistical interpretation like ANOVA and DMRT test was done. The evaluation of Air Quality Index is important because it is a useful tool for the area based management of air pollution followed by subsequent health impact and to mitigate the pollution level. It is a measure of the ratio of the pollutants concentration to the status of ambient air in the places. The present investigation shows a significant variation in AQI with respect to variation in both stations and seasons. Industrial activity, mining activity, mineral transportation and allied activities are the major pollution sources in the area which determines the ambient air pollution status of the area. It was observed that the causes of variation in AQI in the study are multi-faced. As per AQI category most of the stations are either coming under light air pollution category or moderately air pollution category. As there is no literature available on the AQI study of the area, it can be used as a reference for future research in the area.

Keywords: Air Quality Index, Ambient Air, Air Sampler, ANOVA, DMRT

1. Introduction

Air pollution has become a major environmental issue for both developed and developing countries which affects both acute and chronic effects where human health is concern^{1,2}. The short term health impacts of air pollution have been studied extensively since the London fog in the mid-20th century and the subsequently series of dramatic episodes in industrialized countries^{3,4}. Some investigator have attempted to explain the heterogeneity of effect estimates among regions in term of different levels of air pollutants^{5,6}, characteristics of pollutants and potential confounders including temperature and humidity⁷⁻¹⁰. However, the magnitude of effect estimates varies across cities and countries¹¹⁻¹³ hindering interpretation

and generalization of the causal association between air pollution and health.

Climate change has directly related to air pollution which includes greenhouse gases and major air pollutants like particulate matter, sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone¹⁴. According to WHO India is second highest after China in terms of number of death registered for outdoor air pollution. Particulate matter represents a mixture of solid and/or liquid particles suspended in the air¹⁵⁻¹⁸ which is a complex mixture of carbon, ammonia, nitrates, sulphates, minerals, trace elements and water. Sulphur dioxide, nitrogen dioxide and suspended particulate matter are regarded as major air pollutants in India¹⁹ which are appearing as a result of the burning of fossil fuels spread in the atmosphere and affect the living being²⁰⁻²³. Motor vehicles have

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been regarded as the primary cause of air pollution in the urban areas and account of 60-70 % of the pollution found in the urban environment²⁴⁻²⁶. The effect of particulates^{27,28} depends on its size, shape, concentration and time of exposure in relation to its mass and composition.

AQI is a tool which is used to find out overall environmental status and trends based on a specific standard²⁹. It was developed on the lines of health index and measured by the degree of human suffering. There are several methods and equations used for determining the AQI³⁰. In the present study, an attempt has been carried out to find out the concentrations of four ambient air pollutants PM_{10} , $PM_{2.5}$, SO_2 and NO_2 for one year during March, 2014-February, 2015 at eight different locations covering all the seasons i.e. summer, monsoon and winter and expressed the result in the form of Air Quality Index.

2. Materials and Methods

2.1 Study Area

Bileipada, Joda area is located at $22^{\circ} 3' 43.2216''$ latitude and $85^{\circ} 28' 31.0368''$ longitude near Joda-Barbil highway which is rich in natural sources like iron and manganese ore. The abundance of raw materials is available at close proximity which has encouraged the establishment of several mineral based industries like sponge iron, beneficiation and pelletisation. Besides this open cast mining in the area include land clearing, removal of overburden, vehicular movement, excavation at mining site and loading and unloading of minerals are the major sources of atmospheric emission in this region. Figure 1 and Figure 2 shows the location map of the study area and the ambient air sampling stations respectively. Details of eight sampling stations with their directions and geographical locations are shown in Table 1.

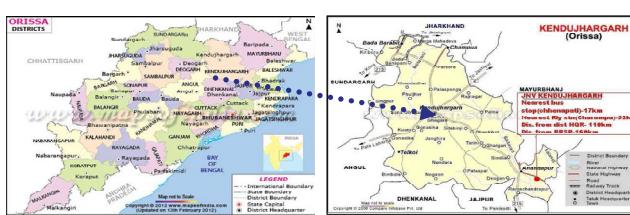


Figure 1. Location map of the study area.

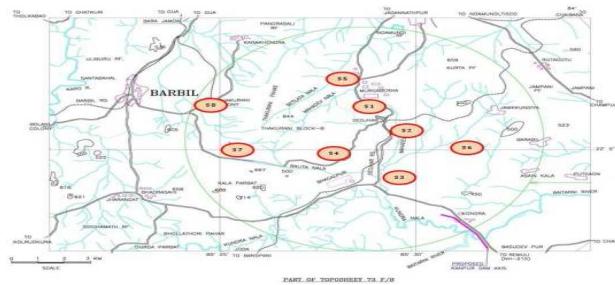


Figure 2. Sampling stations in the study area.

Table 1. Name and geographical locations of the ambient air monitoring stations

Sl. No.	Station Name	Station Code	Direction	Latitude	Longitude
1	Deojhar	S1	NNE	$22^{\circ}05'37.7''$	$85^{\circ}28'43.4''$
2	Kitabeda	S2	E	$22^{\circ}05'08.6''$	$85^{\circ}28'50.3''$
3	Ananda Bazar	S3	SE	$22^{\circ}04'46.3''$	$85^{\circ}28'42.9''$
4	Gobardhanpur	S4	S	$22^{\circ}05'05.8''$	$85^{\circ}28'11.8''$
5	Murgabeda	S5	N	$22^{\circ}06'59.6''$	$85^{\circ}28'7.0''$
6	Hundula	S6	E	$22^{\circ}04'41.1''$	$85^{\circ}29'50.7''$
7	Balita	S7	SW	$22^{\circ}04'22.8''$	$85^{\circ}27'20.3''$
8	Soyaballi	S8	WNW	$22^{\circ}05'13''$	$85^{\circ}28'24''$

2.2 Sampling Method and Analysis Procedure

2.2.1 Particulate Matters

In the present study, APM-460 DXNL Respirable Dust Sampler (RDS) and Fine Particulate Sampler APM-550 were used followed by cyclonic and impactor based technique for measurement of PM_{10} and $PM_{2.5}$ respectively. The sampling inlet was placed 3-10 meter above the ground level for monitoring of the air samples basing upon the site availability. For PM_{10} the atmospheric air was drawn for 24 hours by using Glass Fiber Filter (GFF) paper at a flow rate of $1.1 \text{ m}^3/\text{min}$, whereas for $PM_{2.5}$ the air was drawn through Tetra Fluoro Ethylene (PTFE) filter paper at a flow rate of $16.2 \text{ L}/\text{min}$. The mass concentrations of particulates pollutants were estimated by taking the difference of the final and initial of the filter paper used for air sampling. The results are finally expressed as weight of particulates collected per cubic meter of air sampled ($\mu\text{g}/\text{m}^3$).

2.2.2 Sulphur dioxide

Ambient air samples were continuously drawn in the solution of potassium tetrachloromercurate³¹.

A dichlorosulphitomercurate complex was formed. After collecting the gas in the absorbent, sulphamic acid, formaldehyde and pararosaniline reagents were added which forms the intensively colored pararosanilinemethylsulphonic acid. The absorbance of the colour was measured after half an hour by taking optical density at a wavelength of 560 nm.

2.2.3 Nitrogen dioxide

Ambient air samples were continuously drawn by bubbling air through a solution of sodium hydroxide and sodium arsenate³² which forms a stable solution of sodium nitrite. Nitrite ion produced during sampling was determined calorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and NEDA. The intensity of the colour was measured by taking the optical density at a wavelength of 540 nm.

2.2.4 Air Quality Index

Air Quality Index is an environmental index that describes the overall ambient air status and trends of a particular place based on specific standard. It is a measure of the ratio of the pollutants concentration to the status of ambient air in the places. The following computation^{33,34} was used to derive the air quality index values of the monitoring sites under consideration. The higher the AQI value, greater is the level of air pollution and greater the damage to health. The AQI scale was divided into five categories (Table 2) that describe the range of air quality and associated potential health effect³⁵. Research on various aspects

Table 2. Air quality categories based on Air Quality Index

Sl. No.	AQI Value	Remarks	Health Concern
1.	00–25	Clean Air	None / minimum health effect
2.	26–50	Light Air Pollution	Possible respiratory or cardiac effect for most sensitive group
3.	51–75	Moderate Air Pollution	Increasing symptoms of respiratory and cardiovascular illness
4.	76–100	Heavy Air Pollution	Aggravation of heart and lung diseases
5.	>100	Sever Air Pollution	Serious aggravation of heart and lung diseases risk of death in children

of ambient air study like modeling of air quality index³⁶, air pollution climatology³⁷, air quality monitoring³⁸⁻³⁹ and PM₁₀ monitoring⁴⁰ etc. has been carried out by different scientists.

$$AQI = \frac{1}{4} (I_{PM10}/S_{PM10} + I_{PM2.5}/S_{PM2.5} + I_{SO2}/S_{SO2} + I_{NO2}/S_{NO2}) \times 100$$

Where;

I_{PM10} , $I_{PM2.5}$, I_{SO2} and I_{NO2} are the individual values of PM₁₀, PM_{2.5}, SO₂ and NO₂ respectively obtained during sampling.

S_{PM10} , $S_{PM2.5}$, S_{SO2} , S_{NO2} are the standards of ambient air quality prescribed by Central Pollution Control Board.

3. Results and Discussions

Table 3 shows the season wise AQI value for different parameters like PM₁₀, PM_{2.5}, SO₂ and NO₂.

Table 4 shows the results obtained due to the application of two-way Analysis of Variance (ANOVA) test for different parameters based on monitoring stations and seasons. The F value computed as 29.242 due to variation in stations are found to be highly significant ($P<0.01$). This indicates that there exists a significant variation among the different AQI due to variation in stations. Further, the F values computed as 333.411 due to variation in seasons are also found to be highly significant ($P<0.01$). This also shows a significant variation in different AQI due to variation in seasons.

Table 5 shows the results obtained due to the application of one-way ANOVA test on AQI due to variations in seasons. The F values were calculated to be 183.84 which is found to be significant ($P<0.01$). However, in order to find out the similarities or difference in mean values for AQI between one or more seasons, the one-way ANOVA with Duncan's Multiple Range Test (DMRT) for homogenous means is applied. The season wise mean with SD for AQI with the application of DMRT (Table 6 and Figure 3).

Application of DMRT for mean AQI with respect to different seasons, the superscript A, B and C are given for monsoon, summer and winter seasons respectively, which indicates that all the three means are different to each other. The lowest AQI was recorded during monsoon followed by summer and the highest were recorded during winter season. The lowest value AQI during monsoon might be due to the rainfall and other meteorological conditions in the atmosphere leading to suppression of

Table 3. Average ambient air quality data for different parameters on season wise

Sl. No.	Station Code	Summer				Monsoon				Winter			
		PM ₁₀	PM _{2.5}	SO ₂	NO ₂	PM ₁₀	PM _{2.5}	SO ₂	NO ₂	PM ₁₀	PM _{2.5}	SO ₂	NO ₂
1	S1	79.7	41.1	14.7	18.8	47.4	20.9	8.4	12.6	88.1	43.8	18.2	16.8
2	S2	102.6	48.7	18.6	22.8	56.6	29.5	10.1	14.3	99.9	50.2	20.6	18.8
3	S3	98.7	47.2	16.1	21.2	52.8	22.5	8.9	12.9	94.5	50.2	18.8	17.9
4	S4	72.4	35.8	12.2	16.4	48.8	24.0	8.4	11.8	74.0	37.7	13.6	12.1
5	S5	78.8	36.2	12.7	17.3	41.4	21.5	8.9	12.3	86.7	44.3	18.2	16.3
6	S6	67.8	33.5	11.8	18.5	40.4	18.3	8.1	11.9	79.9	40.3	18.5	16.0
7	S7	60.8	30.0	9.3	13.2	42.3	17.3	8.1	12.0	66.5	32.5	12.7	11.4
8	S8	61.3	32.8	11.0	17.2	39.3	18.7	7.9	11.6	68.9	35.3	14.9	13.1

Table 4. Two-way ANOVA test for AQI based on stations and seasons

Parameters	Source	Sum of Squares	Degree of Freedom	Mean Squares	F-Values
AQI	Station	8469.50	7	1209.929	29.242**
	Season	27590.23	2	13795.116	333.411**
	Station x Season	1993.567	14	142.398	3.442**
	Error	10923.184	264	41.376	
	Total	48976.48	287		

(**is 'F' Significant at P<0.01)

Table 5. One-- way ANOVA Test for AQI Based on Seasons

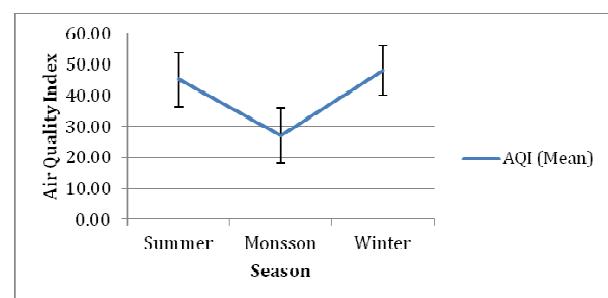
Parameters	Source	Sum of Squares	Degree of Freedom	Mean Square	F-Values
AQI	Between Seasons	27590.23	2	13795.12	183.84**
	Within Seasons	21386.25	285	75.04	
	Total	48976.48	287		

(**is 'F' Significant at P<0.01)

Table 6. Season wise mean with SD for AQI

Season Name	Summer	Monsoon	Winter
AQI (Mean)	45.18 ^B + 8.75	27.10 ^A + 9.01	48.10 ^C + 8.14

N.B. - Different superscripts over the means of AQI indicate significant difference (P<0.01) between them.

**Figure 3.** Season wise mean with SD for AQI.

air borne dust particles in the ambient air and the results shows that the area comes under “clean air category (AQI = 0-25)” to “light air pollution category (AQI = 26-50)” with an average range of value 27.10^A. The maximum dispersion and turbulence of wind during summer season leads to the higher value of AQI in comparison to monsoon. Further the lower mixing height and because of formation of inversion layer during winter season resulted to highest AQI value in the study area. In both summer as well as winter season the area comes under “light air pollution category (AQI = 26-50)” to “moderate air pollution category (AQI = 51-75)” with an average range of value 45.18^B and 48.10^C respectively.

Table 7 shows the results obtained on application of one-way ANOVA on AQI due to variation in stations. The F values was calculated to be 8.36 which was found to be significant (P<0.01).

From Table 7, it was understood that, the variation in AQI values based on stations are significant at P<0.01. However, in order to find out the pin-point results with respect to similarities or difference in mean values for

various parameters between one or more stations, the one-way ANOVA with DMRT for homogenous means was applied. The station wise mean with SD for AQI with the application of DMRT (Table 8). Figure 4 shows the station wise mean with standard deviation for AQI.

On application of DMRT for AQI values, the superscript 'a' over the means of the monitoring stations S6, S7 and S8 indicates that they are similar. This may be because of both the stations are situated within the forest area having thick canopy density and no industrial activities nearby the stations. The result shows that all three stations are comes under "clean air category (AQI = 0-25)" to "light air pollution category (AQI = 26-50)"

with an average range of values 35.94^a, 31.25^a and 32.90^a respectively. DMRT for the AQI values, the superscript 'b' over the mean S4 indicates that the station comes under "light air pollution category (AQI = 26-50)" with an average range of value 36.46^b. DMRT for the AQI values, the superscript 'c' over the means S1, S2, S3 and S5 stations are shows that these stations comes under "light air pollution category (AQI = 26-50)" to "moderate air pollution category (AQI = 51-75)" with an average range of values 40.23^c, 48.31^c, 44.92^c and 38.81^c respectively. This may be due to developmental activities like industrial complex, mining activities and transportation of minerals from the mining sites near the study area.

Table 7. One-way ANOVA test for AQI based on stations

Parameters	Source	Sum of Squares	Degree of Freedom	Mean Square	F-Values
AQI	Between Stations	8469.50	7	1209.93	8.36**
	Within Stations	40506.98	280	144.67	
	Total	48976.48	287		

(**is 'F' Significant at P<0.01)

Table 8. Station-wise mean with SD for AQI

Season Name	S1	S2	S3	S4	S5	S6	S7	S8
AQI (Mean)	40.23 ^c + 12.93	48.31 ^c + 15.30	44.92 ^c + 15.02	36.46 ^b + 8.55	38.81 ^c + 12.71	35.94 ^a + 11.82	31.25 ^a + 8.15	32.90 ^a + 9.47

N.B. - Different superscripts over the means of AQI indicate significant difference (P<0.01) between them.

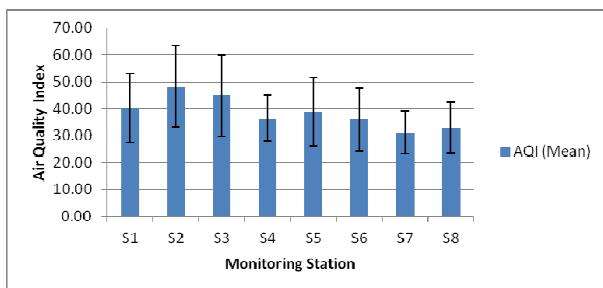


Figure 4. Station wise mean with standard deviation for AQI.

4. Conclusion

The present investigation was carried out to find out the seasonal variation in AQI at eight different locations near Bileipada, Joda area of Keonjhar, Odisha. Industrial activity (point source), mining activity (area source), mineral transportation (line source) and allied are the major pollution sources in the area which determines the ambient air pollution status of the area. The lowest AQI was observed during monsoon, followed by summer and winter. Further, the lowest AQI was found at the monitoring station S7 followed by S8, S6, S4, S5, S1, S3 and highest was recorded at S2. While comparing the AQI values with the scale of AQI, it was observed that, all the eight monitoring stations are coming under light air pollution category to moderate air pollution category.

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