Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 10 ~ Issue 1 (2024) pp: 10-19
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Assessment of Ambient Air Quality in and Around Jharsuguda, an Industrial Town Of Odisha, India

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ABSTRACT: *A work was envisaged out to assess the ambient air quality in and around Jharsuguda, an industrial town of Odisha, India to judge the degree of effect of large number of industries and mines operating surrounding the town, huge number of vehicles plying in the town and its periphery and rapid expansion of human habitation areas. It was carried out for one year during the period from Mid-June 2018 to Mid-June 2019 at 12 sampling stations situated over four directions (East, West, North, & South) at a radius of 0 - 2, 2 - 5 and 5 - 10 Km from the center of the town. The results showed that the concentrations of the particulate matters PM_{10} and $PM_{2.5}$ exceeded the 24h standard value (100 µg/m^3 for PM_{10} and 60 µg/m^3 for $PM_{2.5}$) prescribed by the NAAQS (2009). But the gaseous pollutants have not exceeded the standard value (80 µg/m^3 for SO_2 and 80 µg/m^3 for NO2). On the other hand, the observed figure of API proved that the town suffered Severe Air Pollution (>100). Hence, measures like enhancement of efficiency of existing pollution control devices, installation and 24 X 7 hours' operation of pollution controlling equipments, adoption of advanced clean and green technology, appropriate vehicular movement with adequate traffic control, massive green belt development with good governance are suggested.*

KEY WORDS: *Ambient Air Quality, Particulate Matter, Gaseous Pollutant, Air Pollution Index, Industrial Town.*

Received 15 Jan., 2024; Revised 26 Jan., 2024; Accepted 28 Jan., 2024

I. INTRODUCTION

Air is one of the extremely important ingredient required for the sustenance of life on the earth. Air has been polluted since the human civilization invented the fire and learned its use. At present air pollution has become a major concern all over the world including India due to rapid industrialisation, urbanization and motorization [1] India occupies the seventh place in industrialization among the developing countries of the world and industries have become one of the major sources for air pollution in India [2]. Industrial activities discharge a variety of particulate and gaseous pollutants (both primary and secondary) as well as heavy metals from various operating units and spoil the ambient air quality of mostly urban areas [3] The vehicular emission is also responsible for the higher values of particulate matters, gaseous pollutants, organic and inorganic pollutants and is also reason for more than half of the air pollution in the urban areas [4, 5]. Coupled with these, excessive exploitation of natural resources due to enormous human population growth and increased consumption pattern have aggravated the pollution problems in cities and towns of India [6].

Further, air pollution index (API) is usually computed to know the real representation of the air quality of an area. It also highlights and validates the pollutant(s) those are mostly responsible for the deterioration of the air quality. It is a collective value of different pollutants undertaken for study. The computation is based on the comparison of pollutant concentration obtained with that of the prescribed standard [7, 8].

In addition, meteorological parameters of the area such as air temperature, rainfall, relative humidity, wind speed and direction, play an important role in the accumulation and dispersal of pollutants of the atmospheric environment [9]. Therefore, the air pollution study of an area always requires meteorological information for better interpretation [10].

Air pollution has also emerged as a major concern to the different life forms including human beings and other segments of the environment [11,12,13]. Pollutants like particulate matter, carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide and heavy metals can pose a serious threat to human health if exceeds the permissible limit [14, 15]. According to World Health Organization [16] air quality of urban areas is the reason for two million premature deaths per year. Further, WHO [16] has reported that, nearly ninety-two percent of the world's population lives in areas where the air quality exceeds WHO standards, leading to considerable morbidity and mortality. The occurrence of respiratory and cardiovascular diseases and cardiopulmonary mortality following exposure to air pollutants are also well documented in the literature [17, 18].

Central Pollution Control Board (CPCB) has identified three industrial clusters; Angul-Talcher, Ib-valley and Jharsuguda as critically polluted area in the State of Odisha, India. Out of the three industrial clusters, Jharsuguda is has become an important industrial hub in the eastern zone of the India and western part of Odisha. It has grown significantly in industrialization as well as population due to set up of many iron and steel, power and aluminium industries and in consequence causing severe air pollution in and around the town. Coal, iron ore and bauxite ore being the main raw materials, the transportation of these materials also adding up air pollution in this area. Based on the above backdrop, a work was envisaged to study the ambient air quality (through the measurement of $PM_{10,}$ $PM_{2.5}$, SO_2 and NO_2) and the overall pollution status (through computation of Air Pollution Index) in and around Jharsuguda, an industrial town of Odisha, India.

II. STUDYSITE AND MATERIALS AND METHODS

Study Site

The study site Jharsuguda town, is the largest town and the Head Quarter of the Jharsuguda district in Odisha, India. It is located at 21.85°N to 84.03°E and situated at an elevation of 218 meters above mean sea level. The town is well connected with all parts of the country by rail and road and to some extent by flight. The population of the Jharsuguda is 5,79,505 with population density of 274 people per sq. km. (as per census 2011).

Sampling Stations and Sampling Frequency

Ambient Air quality monitoring was carried out for one year during the period from Mid-June 2018 to Mid-June 2019 at 12 sampling stations situated over four directions (East, West, North, & South) at a radius of 0 - 2, 2 - 5 and 5 - 10 Km from the center of the town i.e., the Rail Junction of Jharsuguda. The details of sampling stations along with locations is presented in Table 1 and Figure 1. The sampling stations were selected keeping various aspects into account like accessibility to the area, continuous electrical supply and platform for instrument installation. The sampling was carried out at monthly intervals (during 3rd week of every month) in all the stations for 24 hours.

Table 1: Details of the Sampling stations in and around Jharsuguda Town

Station Code	Name of the Sampling station	Distance from the centre of the town (km)	Direction from the centre	Geographical Coordinates
E1	Badheimunda	1.32 Km	East	21.8618°N, 84.0316°E
E2	Debadihi	4.46 Km	East	21.8620°N, 84.0621°E
E3	Kelendamal	9.73 Km	East	21.8611°N, 84.1131°E
W1	Chowkipara	1.48 Km	West	21.8619°N, 84.0046°E
W2	Marakuta	4.95 Km	West	21.8606°N, 83.9707°E
W3	Nuadihi	8.88 Km	West	21.8627°N, 83.9327°E
N1	Bijjunagar	1.57 Km	North	21.8775°N, 84.0175°E
N2	Amalipali	4.84 Km	North	21.9068°N, 84.0184°E
N3	Tangarpali	8.69 Km	North	21.9407°N, 84.0300°E
S1	Shantinagar	1.60 Km	South	21.8488°N, 84.0175°E
S2	Sunarimunda	4.20 Km	South	21.8248°N, 84.0178°E
S3	Tumbekela	9.20 Km	South	21.7804°N, 84.0183°E

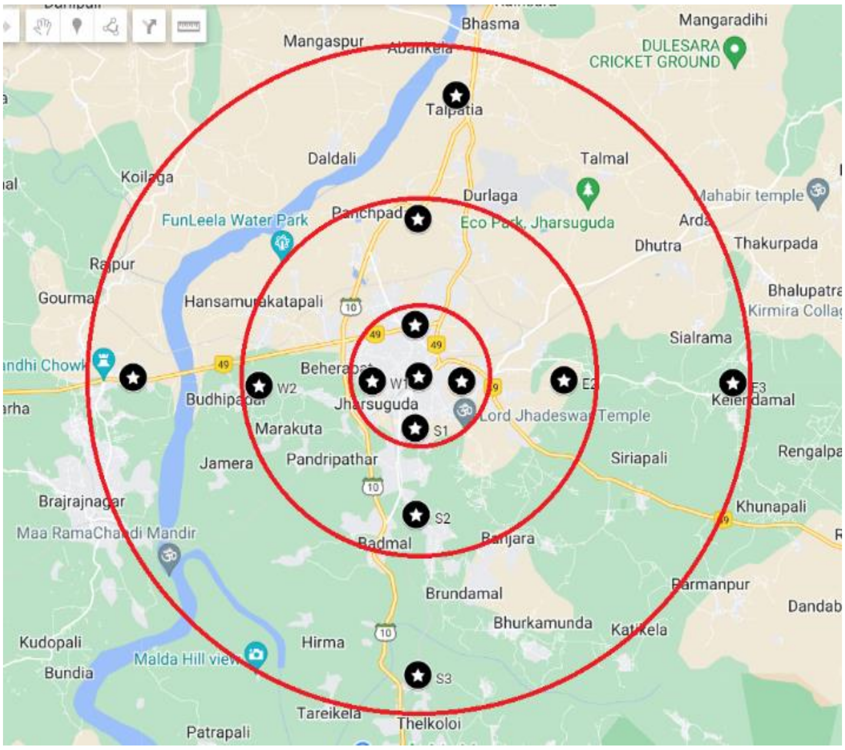

Figure- 1 Locations of Sampling Stations in and around Jharsuguda Town

Sampling and Analysis of Air Quality Parameters

The sampling and analysis of the particulate matters (PM_{10} and $PM_{2.5}$) and gaseous pollutants (SO_2 and NO_2) was carried out following the methods as prescribed by Central Pollution Control Board [19]. The sampling of PM_{10}, SO_2 and NO_2 was done by a Respirable Dust Sampler (RDS). The sampling of $PM_{2.5}$ was done by a Fine Particulate Sampler (FPS). The instruments were fixed at 6–8 meters above the ground to eliminate all possibilities of sample contamination due to the dust generated from pedestrian walking and uplift from the ground surface. The sampling was carried out for 24 h (4 h in each run × 6 times) at a constant air flow rate of 1.0 –1.3 m^3/h for PM_{10} and gaseous pollutants,and at an air flow rate of 1.0 m^3/h for the $PM_{2.5}$ as per the manual of the instrument. The particulate matter analysis was carried out gravimetrically, taking the initial and final weights of the filter papers (Whatman for PM_{10} and Polytetrafluoroethylene for $PM_{2.5}$). Similarly, the gaseous pollutants were analyzed by passing the air through their respective absorbing reagents (sodium tetrachloromercurate for SO_2 and a mixture of sodium hydroxide and sodium arsenite for NO_2). Colorimetric analysis was conducted for SO_2 by improved West and Geake method and NO_2 by modified Jacob and Hochheiser method [19]. The concentrationof particulate matter (PM_{10} and $PM_{2.5}$) and gaseous pollutants (SO_2 and NO_2) in ambient air was expressed in µg/ m^3.

Computation of Air Pollution Index

API was calculated from the actual and standard concentrations of the particulate (PM10 and PM2.5) and the gaseous pollutants (SO2 and NO2) as per the formula given by Ziauddin and Siddiqui [7].

$$\text{Air Pollution Index (API)} = \frac{1}{4}\left(\frac{IPM10}{SPM10} + \frac{IPM2.5}{SPM2.5} + \frac{ISO2}{SSO2} + \frac{INO2}{SNO2}\right) \text{ x } 100$$

Where IPM_{10}, $IPM_{2.5}$, ISO_2, and INO_2 are the concentrations of the individual values found in samples for PM_{10}, $PM_{2.5}$, SO_2, and NO_2, respectively and SPM_{10}, $SPM_{2.5}$, SSO_2, and SNO_2 represent their respective 24-hourly standard values prescribed in NAAQS (National Ambient Air Quality Standards) by CPCB, New Delhi.

Software Used

All the statistical analysis including two way ANOVA and Correlation matrix were performed using MS- Excel 2019 software. Windrose diagram has been prepared using software available in the website, http://windrose.xyz.

III. RESULTS AND DISCUSSION

Meteorological Parameters

The meteorological parameters of Jharsuguda during the study under report has been given in Table 2. The rainfall was minimum in March 2019 (13.9mm) and maximum in July 2018 (462.9mm) with the annual precipitation of 1442 mm. The relative humidity varied from 27% (May 2019) to 89% (August 2018). The minimal wind speed fluctuated from 2-4 Km/Hr to maximal 8 -20Km/Hr in different months. The minimum temperature was recorded in January 2019 (10.7 ºC) and maximum was recorded in May 2019 (42.1 ºC). The Solar radiation was minimum in August 2018 ($416.55X10^3$ KJ/m^2) and maximum in May 2019 ($700.74X10^3$ KJ/m^2).

Table 2. Meteorological parameters of Jharsuguda

Month/ Year	Rainfall (mm)	Relative Humidity RH(%)			Wind Speed(Km/Hr)			Temperature (ºC)			Solar Radiation
	Monthly	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	10^3 KJ/m^2
June 18	210.5	56	72	64.0	2	12	7	26.10	35.90	31.00	463.39
July 18	462.9	78	85	81.5	2	16	9	25.60	31.30	28.45	463.26
Aug 18	402.1	82	89	85.5	4	16	10	25.10	31.50	28.30	416.55
Sep 18	140.8	73	84	78.5	2	12	7	24.90	32.20	28.55	428.23
Oct 18	0.0	53	69	61.0	2	8	5	20.90	33.90	27.40	490.52
Nov 18	0.0	51	68	59.5	2	8	5	16.50	31.70	24.10	445.81
Dec 18	108.3	56	76	66.0	2	4	3	12.20	26.20	19.20	425.63
Jan 19	0.0	45	75	60.0	2	6	4	10.70	27.00	18.85	473.65
Feb 19	44.0	39	72	55.5	2	8	5	14.90	30.80	22.85	498.83
Mar 19	13.9	39	60	49.5	4	8	6	19.60	34.10	26.85	625.47
Apr 19	34.6	32	53	42.5	2	12	7	24.20	39.70	31.95	654.27
May 19	24.9	27	49	38.0	4	20	12	26.60	42.10	34.35	700.74
June 19	172.2	51	68	59.5	4	12	8	27.20	39.50	33.35	463.39

Windrose

Figure- 2 presents the annual windrose diagram of Jharsuguda town during the study year 2018-19. Ambient air quality of an area is largely dependent on the wind speed and its direction since wind plays a vital role in the dispersion of pollutants. From the Windrose diagram it is clearly evident that in most of the occasions the wind blew from the South-West direction. So the areas located to the opposite direction i.e. the north-east area were likely to be affected due to the dispersion of pollutant concentrations.

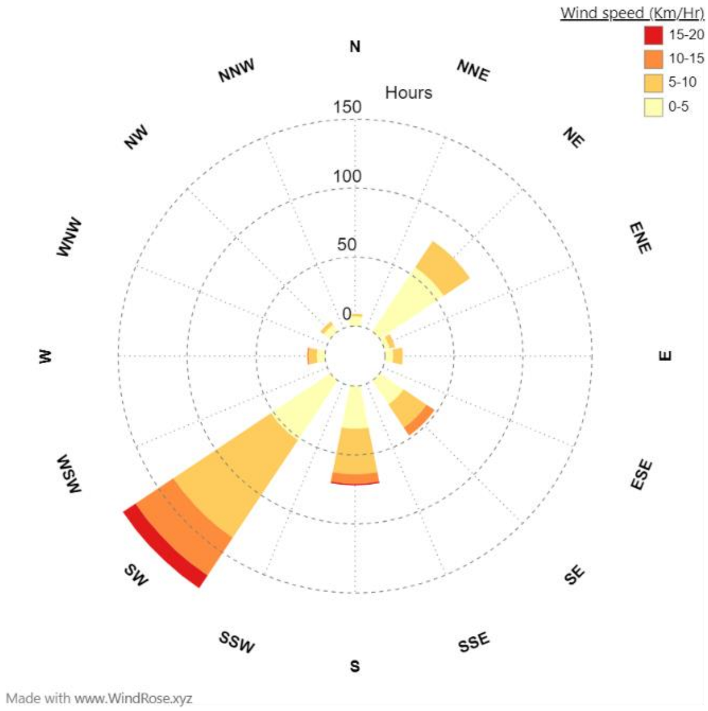

Figure -2 Windrose Diagram for the study period

Ambient Air Quality

Table 3 shows the concentration of PM_{10} at different sampling stations with their minimum, maximum and average values. From the table it is evident that the PM_{10} concentrations was minimum (78 µg/m^3) at station N3 and maximum (292 µg/m^3) at station S2 with average concentration fluctuating between 130.31 µg/m^3 and 170.85 µg/m^3 . Irrespective of stations, the PM_{10} concentration varied from 89.08 µg/m^3 to 264.42 µg/m^3 with average value of 153.60 µg/m$^{3.}$

Table 3. PM_{10} Concentrations of various stations in and around Jharsuguda Town during the study period (2018-19)

STATIONS CODE	Name of the Sampling Location	Min	Max	Average ± SD
E1	Badheimunda	89	261	155.62 ± 55.11
E2	Debadihi	82	241	138.31 ± 53.96
E3	Kelendamal	87	258	150.46 ± 55.70
W1	Chowkipara	92	272	157.31 ± 56.65
W2	Marakuta	102	287	170.85 ± 57.27
W3	Nuadihi	83	252	146.38 ± 54.63
N1	Bijjunagar	88	263	154.54 ± 56.05
N2	Amalipali	85	255	145.31 ± 55.70
N3	Tangarpali	78	233	130.31 ± 51.47
S1	Shantinagar	91	278	157.62 ± 58.34
S2	Sunarimunda	93	292	168.85 ± 60.68
S3	Tumbekela	99	281	167.69 ± 58.42
	Average	89.08	264.42	153.60 ± 56.07

Table 4 depicts the concentration of $PM_{2.5}$ at different sampling stations with their minimum, maximum and average values. From the table it is marked that the $PM_{2.5}$ concentrations was minimum (54 µg/m^3) at station N3 and maximum (186 µg/m^3) at station S3 with average concentration changing between 89.69 µg/m^3 and 112.92 µg/m$^{3.}$ Irrespective of stations, the $PM_{2.5}$ concentration fluctuated from 65.17 µg/m^3 to 167.58 µg/m^3 with average value of 101.35 µg/m^3

Table 4. $PM_{2.5}$ Concentrations of various stations in and around Jharsuguda Town during the study period (2018-19)

STATIONS CODE	Name of the Sampling Location	Min	Max	Average ± SD
E1	Badheimunda	66	169	102.31 ± 32.78
E2	Debadihi	60	155	94.77 ± 32.40
E3	Kelendamal	62	162	98.15 ± 32.91
W1	Chowkipara	65	168	101.85 ± 32.73
W2	Marakuta	75	185	111.77 ± 35.21
W3	Nuadihi	61	158	95.69 ± 32.67
N1	Bijjunagar	63	176	100.54 ± 35.25
N2	Amalipali	58	156	94.54 ± 32.53
N3	Tangarpali	54	148	89.69 ± 32.13
S1	Shantinagar	65	170	103.15 ± 33.25
S2	Sunarimunda	76	178	110.85 ± 32.53
S3	Tumbekela	77	186	112.92 ± 34.52
	Average	65.17	167.58	101.35 ± 33.17

Table 5 gives the concentration of SO_2 at different sampling stations with their minimum, maximum and average values. From the table it is clear that the SO_2 concentrations was minimum (38 µg/m^3) at station N3 and maximum (122 µg/m^3) at station W2 with average concentration fluctuating between 57.62 µg/m^3 and 71 µg/m^3 . Irrespective of stations, the SO_2 concentration ranged from 43.50 µg/m^3 to 114 µg/m^3 with average value of 64.78 µg/m^3

Table 5. SO_2 Concentrations of various stations in and around Jharsuguda Town during the study period (2018-19)

STATIONS CODE	Name of the Sampling Location	Min	Max	Average ± SD
E1	Badheimunda	44	118	65.92 ± 22.33
E2	Debadihi	39	110	59.85 ± 21.33
E3	Kelendamal	42	114	64.00 ± 22.18
W1	Chowkipara	43	117	66.00 ± 21.10
W2	Marakuta	48	122	71.00 ± 20.93
W3	Nuadihi	41	108	61.08 ± 20.50
N1	Bijjunagar	45	116	65.08 ± 21.06
N2	Amalipali	40	107	60.15 ± 20.02
N3	Tangarpali	38	101	57.62 ± 19.55
S1	Shantinagar	46	115	67.00 ± 20.60
S2	Sunarimunda	49	119	69.54 ± 20.88
S3	Tumbekela	47	121	70.15 ± 21.76
	Average	43.50	114.00	64.78 ± 20.99

Table 6 illustrates the concentration of NO_2 at different sampling stations with their minimum, maximum and average values. From the table it is apparent that the NO_2 concentrations was minimum (41 µg/m^3) at station N3 and maximum (136 µg/m^3) at station W2 with average concentration fluctuating between 63 µg/m^3 and 80.77 µg/m^3 . Irrespective of stations, the NO_2 concentration was in the range of 47.50 µg/m^3 to 126.50 µg/m^3 with average value of 72.01 µg/m^3

Table 6. NO_2 Concentrations of various stations in and around Jharsuguda Town during the study period (2018-19)

STATIONS CODE	Name of the Sampling Location	Min	Max	Average ± SD
E1	Badheimunda	49	128	74.00 ± 24.45
E2	Debadihi	44	121	66.46 ± 23.19
E3	Kelendamal	46	125	70.23 ± 24.86
W1	Chowkipara	47	126	71.92 ± 24.60
W2	Marakuta	51	136	80.77 ± 26.54
W3	Nuadihi	45	123	68.08 ± 24.73
N1	Bijjunagar	50	129	72.46 ± 25.40
N2	Amalipali	42	119	66.08 ± 23.97
N3	Tangarpali	41	115	63.00 ± 23.10
S1	Shantinagar	48	127	73.15 ± 25.68
S2	Sunarimunda	53	135	79.31 ± 24.94
S3	Tumbekela	54	134	78.69 ± 25.69
	Average	47.50	126.50	72.01 ± 24.72

Table 7 demonstrates the values of API at different sampling stations with their minimum, maximum and average values. From the table it is evident that the API was minimum 66.69 at station N3 and maximum 229.46 at station W2 with average concentration fluctuating between 107.64 and 136.71. Irrespective of stations, the API varied from 77.86 to 211.09 with average value of 123.38.

Table 7. API (Air Pollution Index) of various stations in and around Jharsuguda Town during the study period (2018-19)

STATIONS CODE	Name of the Sampling Location	Min	Max	Average ± SD
E1	Badheimunda	78.81	212.54	125.26 ± 41.61
E2	Debadihi	71.44	197.02	113.54 ± 40.39
E3	Kelendamal	75.08	206.69	120.46 ± 41.92
W1	Chowkipara	78.21	213.94	124.86 ± 41.68
W2	Marakuta	87.69	229.46	136.71 ± 43.44
W3	Nuadihi	73.04	201.02	116.83 ± 40.99
N1	Bijjunagar	77.94	215.65	123.51 ± 42.78
N2	Amalipali	71.04	199.38	115.17 ± 40.77
N3	Tangarpali	66.69	187.42	107.64 ± 39.14
S1	Shantinagar	79.21	215.96	126.18 ± 42.52
S2	Sunarimunda	86.79	226.54	134.91 ± 42.75
S3	Tumbekela	88.40	227.44	135.49 ± 43.40
	Average	77.86	211.09	123.38 ± 41.76

A two-way ANOVA was computed to find out the significance of the source of variation i.e. within the Sampling stations and the pollutants. The Analysis of Variance (ANOVA) indicated significant variation with respect to different stations and the pollutants ($F \geq 35.39$, $p < 0.05$) (Table 8).

Table 8. Two- way ANOVA among various stations and air pollutants

Source of Variation	*Sum of Squares (SS)*	*Degrees of freedom(df)*	*Mean of Sum of Squares (MS)*	*F*	*P-value*	*F crit(Critical Values)*	*S/NS*
Stations	1931.38	11	175.58	35.39	4.37E-15	2.09	S
Pollutants	26423.91	3	8807.97	1775.31	1.57E-36	2.89	S

A correlation matrix was also worked out to get an insight into the relationship between the meteorological parameters and air pollutants and it is given in Table – 9. It is apparent from the table that the particulate matters (i.e. PM_{10} and $PM_{2.5}$). showed significant negative correlations with the rainfall ($r \geq -0.525$, $p < 0.05$). The gaseous pollutants (SO_2 and NO_2) also displayed significant negative relationships with rainfall ($r \geq -0.433$, $p < 0.05$). Both particulate as well as gaseous pollutants showed significant negative correlations with the temperature ($r \geq -0.734$, $p < 0.05$). Also all the pollutants showed significant negative correlation with wind speed ($r \geq -0.660$, $p < 0.05$). The API showed significant positive correlations with all individual pollutants ($r \geq 0.980$, $p < 0.05$). and significant negative correlations with temperature, wind speed and the rainfall ($r \geq -0.503$, $p < 0.05$). However, relative humidity and solar radiation did not show any relationship with any of the studied parameters ($p > 0.05$).

Table 9. Correlation matrix between various air pollutants and meteorological parameters

	PM_{10}	$PM_{2.5}$	SO_2	NO_2	Rainfall	Temp	WS	RH	SR	API
PM_{10}	1.000									
$PM_{2.5}$	0.994*	1.000								
SO_2	0.957*	0.960*	1.000							
NO_2	0.969*	0.975*	0.995*	1.000						
Rainfall	-0.526*	-0.525*	-0.433*	-0.458*	1.000					
Temp	-0.781*	-0.783*	-0.734*	-0.782*	0.235	1.000				
WS	-0.703*	-0.702*	-0.660*	-0.701*	0.486*	0.803*	1.000			
RH	-0.274	-0.242	-0.164	-0.154	0.770*	-0.208	0.020	1.000		
SR	-0.132	-0.169	-0.210	-0.227	-0.444*	0.452*	0.366	-0.839*	1.000	
API	0.994*	0.996*	0.980*	0.989*	-0.503*	-0.782*	-0.702*	-0.226	-0.175	1.000

'*' – $p < 0.05$

IV. DISCUSSION

A Comparison of ambient air quality parameters recorded in the present study with that of NAAQ Standards has been given in Table 10. From the table it is apparent that the present findings witnessed higher value particulate matters (PM_{10} & $PM_{2.5}$) at all the12 stations of Jharsuguda town during the study period. Both the particulates were found to be much higher than the standard value (100 µg/m^3 for PM_{10} and 60 µg/m^3 for $PM_{2.5}$) prescribed by the NAAQS [20]. However, the values of the gaseous pollutants have not exceeded the permissible limit (80 µg/m^3 for SO_2 and 80 µg/m^3 for NO_2). There are various sources from which both particulate and gaseous pollutants are released into the atmosphere of Jharsuguda town. The major sources responsible are manufacturing and production processes in plants, crushing of ores in crushers, coal burning in power plants, vehicular movements, transportations and construction activities etc. [6, 21, 22, 23]. This is in agreement with the findings reported for other cities of India [24, 25].

Table- 10: Comparison of ambient air quality parameters with that of NAAQ Standards

Stations	PM10		PM2.5		SO2		NO2	
	Observed Value	NAAQ Standard	Observed Value	NAAQ Standard	Observed Value	NAAQ Standard	Observed Value	NAAQ Standard
E1	155.62	100	102.31	60	65.92	80	74.00	80
E2	138.31	100	94.77	60	59.85	80	66.46	80
E3	150.46	100	98.15	60	64.00	80	70.23	80
W1	157.31	100	101.85	60	66.00	80	71.92	80
W2	170.85	100	111.77	60	71.00	80	80.77	80
W3	146.38	100	95.69	60	61.08	80	68.08	80
N1	154.54	100	100.54	60	65.08	80	72.46	80
N2	145.31	100	94.54	60	60.15	80	66.08	80
N3	130.31	100	89.69	60	57.62	80	63.00	80
S1	157.62	100	103.15	60	67.00	80	73.15	80
S2	168.85	100	110.85	60	69.54	80	79.31	80
S3	167.69	100	112.92	60	70.15	80	78.69	80
Average	153.60	100	101.35	60	64.78	80	72.01	80

From the meteorological data of the present study, it is observed that the area experiences a distinct seasonality with extreme summer extending from March to Mid-June, heavy rainfall form mid-June to September and severe winter from October to February. The highest and lowest temperature recorded was 42.10°C and 10.70°C in summer and winter respectively. The annual rain fall was 1442_mm out of which monsoon received 1216.3 mm (84 %). The wind speed was more during summer season and minimum during winter season. Our finding depicted strong negative correlations with rainfall, temperature and wind speed. Further, wind direction as observed from the wind rose diagram reveals the greater accumulation of pollutants in the north -east directions. There was cooler air temperature during the post-monsoon and quite hot temperature during pre-monsoon season. Therefore, it may be inferred that the concentrations of various pollutants are also highly influenced by the meteorological parameters in the Jharsuguda town.

Air Pollution Index (API) is an accrued figure of different pollutants studied and is an index of pollution status of a place. From the pollution status of the various sampling stations in and around the Jharsuguda, as given in Table 11, it is evident that all the stations in particular and Jharsuguda town in general coming under Severe Air Pollution category (SAP >100). The API of a place also reflects the human health concern to different degree (Table 12). Our API value of >100 indicates the greater possibility of serious aggravation of heart and lung diseases as well as risk of death in children.

Table-11. Pollution Status of the various sampling stations in and around the Jharsuguda town.

STATIONS	AIR POLLUTION INDEX	POLLUTION STATUS
E1	125.26	Severe Air Pollution (SAP)
E2	113.54	Severe Air Pollution (SAP)
E3	120.46	Severe Air Pollution (SAP)
W1	124.86	Severe Air Pollution (SAP)
W2	136.71	Severe Air Pollution (SAP)
W3	116.83	Severe Air Pollution (SAP)
N1	123.51	Severe Air Pollution (SAP)
N2	115.17	Severe Air Pollution (SAP)
N3	107.64	Severe Air Pollution (SAP)
S1	126.18	Severe Air Pollution (SAP)
S2	134.91	Severe Air Pollution (SAP)
S3	135.49	Severe Air Pollution (SAP)
TOWN	**123.38**	**Severe Air Pollution (SAP)**

Table 12: API index range, quality of air and its related health concerns [7]

Range	Quality of Air	Health Concerns
0 – 25	Clean Air (CA)	None/ minimal health effects
26 – 50	Light Air Pollution (LAP)	Possible respiratory or cardiac effect for the most sensitive group
51 – 75	Moderate Air Pollution (MAP)	Increasing symptoms of respiratory and cardiovascular illness
76 – 100	Heavy Air Pollution (HAP)	Aggravation of heart and lung diseases
>100	Severe Air Pollution (SAP)	Serious aggravation of heart and lung diseases. Risk of death in children.

V. CONCLUSION

Industries, mines as well as vehicular emissions in industrial town have a huge impact on the ambient air quality. The present study reveals that the cumulative impacts of all sources of pollutions have depleted the ambient air quality of the Jharsuguda town especially due to particulate pollution and this town is therefore categorized as one of the highly polluted towns of India (Central Pollution Control Board, CPCB, Report, 2010). Even if the observed values of gaseous pollutants in and around the town as of now is under prescribed limits, it may likely to exceed in near future if precautionary measures are not taken well ahead. Hence, immediate measures like enhancement of efficiency of existing pollution control devices, installation and 24 X 7 hours' operation of pollution controlling equipments (such as electrostatic precipitator, bag filters, wet and dry scrubber, cyclone etc.) and adoption of advanced clean and green technology are exclusively suggested for industries and allied operations. Also massive green belt development in and around the town should be given priority for reducing the pollutants to a significant level in the surrounding atmosphere. In addition to the above, appropriate vehicular movement with ample traffic control and good governance with strict enforcement of law will attenuate the present pollution level of the town to a large extent.

ACKNOWLEDGEMENT

The Authors thank the Sambalpur University for providing the necessary facilities to carry out this study. Also they are thankful to the State Pollution Control Board, Regional office Jharsuguda, Odisha for providing necessary support during the course of work.

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