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Influence of Meteorological Variables on Ambient Air Pollutants of a Coastal District in Eastern India

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ABSTRACT

The study of various air pollutants and meteorological parameters are very important for all the researchers. Baleswar was known to be a seaside districts of odisha which is the economic and cultural heart of Northern Odisha. The aim of this study is to measure the air pollutants, meteorological parameters and to enumerate the air pollution index at three specific sites (Sahadevkhunta, Mallikashpur, Rasalpur) according to CPCB procedures. The air pollutants analysed by supplying through specific absorbing reagents and the pollutants were analysed up to 3 year (2017, 2018 and 2019) with a regularity of thrice per week. Analyses of our data sets showing that SO_2 and NO_2 concentration during summer, rainy and winter season are within the prescribe standard of NAAQS by CPCB but PM_{10} and $PM_{2.5}$ are above the prescribed standard except $PM_{2.5}$ concentration of rainy season in year 2019. Air pollution index is remaining in the condition between clean air (CA) to moderate air pollution (MAP) and it shows that the pollution index in all the sites are reducing from the year 2017 to 2019 may be due to enhancing technologies to reduce the pollutant concentration in air.

Keywords: Air pollution, Air pollution index, Meteorological parameters, Multidimensional scaling, Baleswar.

INTRODUCTION

Our earth was created before 4.5 billion years ago *(Wikispedia)*. All the systems of our mother earth were remains in the balanced state. From the day human beings came to this earth the natural balances of the earth have started disturbance. Air is most essential element for survival of the entire organism present on this earth (Abbas *et al.,* 2019). But due to fulfilment of own demand human beings are enhancing industrialization and urbanization which leads to interference of various pollutants in to the air (Manisalidis *et al.,* 2019). Air pollution is the process through which the original air constituents' detoriates with interaction of various pollutants (Graueetal. 2013).

Air pollution is directly influencing the climate of an area. Air pollutants includes Various greenhouse gases (GHGs) and different air pollutants (PM, SO_2, NO_2, CO, O_3, etc). With respect to world health organization, the number of deaths registered for outdoor air pollution was highest in china followed by India. India is developing country, various industrial developments, infrastructural activities and vehicular emissions were releasing to the atmosphere as primary and secondary pollutants (De sario *et al.,* 2013). Air contamination was known as great enemies of our age by causing significant danger to health of all age group peoples (Venkatesan 2016, Landrigan 2017). The World Health Organization (WHO) in 2004 assessed that about 91% population were living in the area having higher air pollutants and in year 2012 announces that there were 3 million deaths in whole world due to outdoor air pollution and 6.5 million death associated with both indoor and outdoor air pollution (World Health Organization). In Asia approximately 4.3 million people die due to household air pollution and 3.7 million from ambient air pollution (Apte and Salvi., 2017).

Air contamination was connected to malignancy, respiratory sicknesses, negative pregnancy outcomes, cardiovascular illnesses, infertility, stroke, intellectual decrease and other unfavorable medical conditions (Khreis *et al.,* 2017, Jacobs *et al.,* 2017). From all the death cause by air pollution occurred in Low developed and developing countries, about 66% are occurring in the Western Pacific region and South East Asia. In Asia, due to rapid urbanization the air pollutants in the atmosphere increase which induces various health problems (Sweileh 2018, Katoto 2019). By the last century, Air pollution has ameliorated in developed countries but become worse in the developing and low developed countries like South Asia (Brauer *et al.,* 2016). Due to the rise in breathing of Nitrogen dioxide level, the problems related to respiratory are increasing. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections (Kim *et al.,* 2013) which leads to cause health problems like coughing, wheezing, common colds, bronchitis and flu. Nitrogen dioxide can also cause intense attacks which leads to asthma (Jarvis *et al.,* 2010). Major risk is there for the children having asthma and older age people with heart problems. Exposure to different particle pollution can cause various health problems like cardiovascular disease and respiratory problems (Kurt *et al.,* 2016). Human health is in greater risk if the sulfur dioxide is breathed in. Sulfur dioxide affects the health of human quickly and within ten to fifteen minutes the peoples get worst symptoms (Ghorani *et al.,* 2016).

Meteorology was significant for the reason of the impact of dependency of air quality on life. The meteorology was related to air quality, which indicates that the alteration of air pollutants expected to change the climatic condition of that region (Zhang *et al.,* 2015). Due to the climatic activity like (precipitation, vertical mixing and wind) the pollutant scattering and development in the air gets disturbed. Meteorological factors presume important role in air pollution which is influencing transport, emissions, air pollutants dispositions and arrangement (Khedairia *et al.,* 2012). These meteorological factors were found to be substantial for various problems like agriculture, forestry, water quality, avalanche warning system, renewable energy sectors and regional development planning (Wolski *et al.,* 2011).

The assessment of various air pollution in an area can be done by calculation of API (air pollution index) (Michele and Spyros 1997; Louise and Gareth 1993). API estimation is done by comparing real time pollutant concentration with the standard prescribed and the final API is the collective value of different pollutants which were studied (Kjellstrom *et al.,* 2006).

API can also explain and specify different the pollutants which affects the air quality of an area and also helps us to estimate different management strategies and air pollution quality. API is help us to know environmental status and trends by comparing with specific standard (Kookana *et al.,* 2014). With respect to above basics, this study was conducted to estimate the meteorological parameters, ambient air quality and compute the air pollution index (API) of Baleswar town, located in the East-Coast region of Odisha, India.

MATERIAL AND METHODS

Study area

Among six coastal districts of Odisha Baleswar is one of them, which is located at the northern east region of the state. This district is the northern end part of Odisha situated near Medinipur districts of West Bengal. The Baleswar region is situated at 21.98 to 20.69 of North Latitude with 87.29 to 88.30 of East Longitude. Baleswar is the economic and cultural heart of Northern Odisha. Its climate is generally hot with high humidity. The production of rice is maximum in baleswar district among all districts of Odisha.

Site selection

With respect to the guidelines given by CPCB 2011 and SPCB, Odisha four different sampling sites were designated to analyse the ambient air quality, by taking into attention of the area providing illustrative representation of human settlement, communication of that area, forest cover, etc. These stations are Rasalpur, Sahadevkhunta and Mallikashpur, located in south-east, west, and east regions of Odisha respectively (As shown in Fig. 1 and Fig. 2). All the four selected stations come under the commercial and residential area category (the primary sectors of air pollution in an urban area), and hence are appropriate to represent the actual picture of the ambient air quality of the urban area. The measurement of ambient air quality was carried out from August 2015 to July 2016 at the above four sampling stations with a frequency of twice per week, totalling to an annual sample of 104.

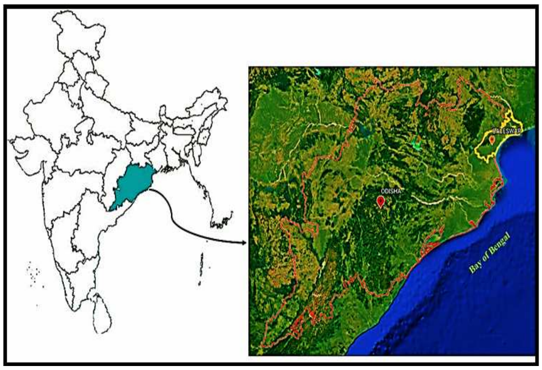

Fig. 1. Baleswar district in Odisha, India

Fig. 2. Sampling stations in Baleswar District

Table 1: The coordinates of sampling stations

Sl No.	Sampling Stations	Coordinates	
		Latitude	Longitude
1	Sahadevkhunta	21050'25.79"N	86092'36.87"E
2	Mallikashpur	21049'76.55"N	86073'76.89"E
3	Rasalpur	21019'34.54"N	86046'75.83"E

Sample collection and analysis

This study carried out by following the procedures which was given by CPCB, India (2011) for the estimation of gaseous pollutants as well as particulate matter. The analysis of respirable particulate matter ($PM_{2.5}$) were analysed by a sampler; which is known as fine particulate sampler (FPS) whereas the suspended particulate matter (PM_{10}) and the gaseous pollutants (SO_2 and NO_2) were analysed by a sampler; which is known as respirable dust sampler (RDS). Both FPS and RDS instruments were kept a distance of 6 to 8 meters from the ground level. According to the instrumental methods, the collection of samples were continuously carried out for 24 h at a particular flow rate of 1.11–1.44 m^3/min for PM_{10} and the gaseous pollutants and 1.0 m^3/hour for the $PM_{2.5}$ pollutants. 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 $PM_{2.5}$. The concentration of 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, and the values presented as the average of each month obtained from the daily mean.

The air pollution index (API) was calculated according to the following formula:

$$API = 1/4 \times ((IPM_{10} / SPM_{10}) + (IPM_{2.5} / SPM_{2.5}) + (ISO_2/SSO_2) + (INO_2 / SNO_2)) \times 100$$

Where IPM_{10}, $PM_{2.5}$, ISO_2 and INO_2 are the individual ambient concentrations of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 respectively. Similarly, SPM_{10}, $SPM_{2.5}$, SSO_2 and SNO_2 represent their respective 24 h standard values prescribed in National Ambient Air Quality Standards by Central pollution control board, India.

RESULT AND DISCUSSION

The current study investigates the air quality throughout four main criteria pollutants (NO_2, SO_2, PM_{10} and $PM_{2.5}$) and three meteorological parameters (Temperature, Rainfall and Humidity) at the selected study areas of Baleswar in year 2017, 2018 and 2019. The result of both air pollutants and meteorological parameters of summer season for all the years (2017 to 2019) were given in Table 2. SO_2 concentration was reported highest at site Mallikashpur in year 2019 and lowest concentration at site Rasalpur and Mallikashpur. It was seen that the SO_2 concentration increasing from 2017 to 2019. NO_2 concentration was found near site Sahadevkhunta in year 2019 and highest point near site Mallikashpur in year 2017. It seems that the NO_2 concentration was continuously decreasing with increase in year. PM_{10} concentration was found slightly increasing with increasing year from 2017 to 2019; highest concentration was reported at site Mallikashpur in year 2019 and lowest concentration at Mallikashpur in 2017. Maximum concentration of $PM_{2.5}$ was reported at site Mallikashpur in 2018 and lowest concentration at Rasalpur in 2019. The concentration of $PM_{2.5}$ in 2018 was seems to be greater than 2017 but during year 2019 the concentration was reduced which was a very good sign for reduction of pollution at baleswar. Temperature was seeming to be increasing slowly with years from 2017 to 2019. Humidity was showing higher in year 2017, slightly decrease during 2018 and again increase in year 2019. Rainfall was decreasing highly with rising years.

Table 2: Results of air quality and meteorological parameters during summer season

Year	Sampling Stations	Air Quality Parameters				Meteorological Parameters		
		SO_2 (μg/m³)	NO_2 (μg/m³)	PM_{10} (μg/m³)	$PM_{2.5}$ (μg/m³)	Temperature (°C)	Humidity (%)	Rainfall (mm)
2017	Sahadevkhunta	5.75	13.75	86	73	30.25	66.75	144.75
	Mallikashpur	4.25	14.75	84.5	74	30.25	66.25	116.25
	Rasalpur	4.25	13	87	71.75	30.5	65.5	124.25
2018	Sahadevkhunta	6	13.5	87.75	46.75	31	60	158.5
	Mallikashpur	5.25	13.25	88.75	89.25	31	59.25	141
	Rasalpur	5.25	14.25	87.25	89	31	59.75	129.25
2019	Sahadevkhunta	7.225	10.725	88.15	48.5	32.75	62	105
	Mallikashpur	7.6	10.9	89.25	49.075	32.5	62.25	78.175
	Rasalpur	7	10.875	88.225	49.079	32.5	62.25	84

The values of both air pollutants and meteorological parameters were given in Table 3. The result was analysed during rainy season in year 2017, 2018 and 2019. SO_2 concentration was shows increasing trend from 2017 to 2019, highest concentration was reported during 2019 at Sahadevkhunta and lowest concentration at site Sahadevkhunta in year 2018. NO_2 concentration was reported higher at Rasalpur in year 2018 and lower concentration was at Sahadevkhunta in 2019. Concentration of NO_2 was increasing in 2018 from 2017 but reducing at 2019. Highest concentration of PM_{10} was reported at Mallikashpur in 2019 and lowest concentration at Mallikashpur in 2017. PM_{10} concentrations in these sites were almost same and Mallikashpur showed increase concentration from 2017 to 2019. $PM_{2.5}$ concentration was reported highest at site Mallikashpur in 2017 and lowest at site Rasalpur. Concentration of $PM_{2.5}$ was decreasing highly from 2017 to 2019 which was very good for pollution level at Baleswar. Temperature was showing same in all the sites in year 2017, 2018 and 2019. Humidity was same in year 2017 and 2018 but slightly increasing in 2019. Rainfall was increase from year 2017 to 2018 but decrease in year 2019. The highest rainfall was reported at Sahadevkhunta in 2017 but Average rainfall in 2018 was showing higher than 2017 and 2019.

Table 3: Results of air quality and meteorological parameters during rainy season

Year	Sampling Stations	Air Quality Parameters				Meteorological Parameters		
		SO_2(μg/m³)	NO_2(μg/m³)	PM_{10} (μg/m³)	$PM_{2.5}$(μg/m³)	Temperature(°C)	Humidity(%)	Rainfall(mm)
2017	Sahadevkhunta	4.5	13	77.25	65.75	29.5	74.25	370.75
	Mallikashpur	5.75	13.5	77	67.25	29	73	218.25
	Rasalpur	4.75	14.25	78.25	66	29.5	73.75	263.5
2018	Sahadevkhunta	3.25	14	78.25	29.75	29.75	73.25	337.5
	Mallikashpur	4	14	77.75	56.5	30.25	72.75	313.5
	Rasalpur	4	13.25	77.5	56.75	29.75	73.25	304.25
2019	Sahadevkhunta	7.55	10.45	77.925	38.1	29.5	77	235.75
	Mallikashpur	7.375	10.75	81.85	38.15	29.5	77	262.25
	Rasalpur	7.425	10.675	78.525	38.05	29.5	78.5	233

The concentration of Air quality and Meteorological parameters of winter season was presented in Table 4. The table was showing result of three years (2017, 2018 and 2019). The SO_2 concentration was decrease from year 2017 to 2018 but during 2019 the concentration was increasing. The highest concentration was reported during 2019 at site Mallikashpur and lowest concentration near site Sahadevkhunta in year 2018. NO_2 concentration was showing slightly increasing from 2017 to 2018 followed by 2019. Highest concentration of NO_2 was reported near site Mallikashpur in 2019 and lower concentration near site Rasalpur in 2017. PM_{10} concentration was slightly increasing from 2017 to 2018 and decrease from 2018 to 2019. The lowest concentration was reported during 2019 in site Sahadevkhunta and highest concentration reported Sahadevkhunta in 2018. $PM_{2.5}$ concentration was decreased highly from 207 to 2019. Highest $PM_{2.5}$ concentration was found at site Sahadevkhunta in 2017 and the lowest concentration at Mallikashpur in 2019. Temperature and Humidity were showing slightly increasing from 2017 to 2019. Rainfall was very less in 2018 but during 2017 and 2019 concentration of rainfall was recorded higher. Maximum rainfall concentration was reported near site Sahadevkhunta in 2019 and lowest concentration at site Rasalpur in 2018.

Table 4: Results of air quality and meteorological parameters during winter season

Year	Sampling Stations	Air Quality Parameters				Meteorological Parameters		
		SO_2(μg/m³)	NO_2(μg/m³)	PM_{10}(μg/m³)	$PM_{2.5}$(μg/m³)	Temperature(°C)	Humidity(%)	Rainfall(mm)
2017	Sahadevkhunta	5.25	15.5	90.5	90.25	23.25	55	16.5
	Mallikashpur	5.5	15.25	89.25	89	22.25	53.5	12.5
	Rasalpur	4.25	14.5	91.25	88.75	22	52.75	14.5
2018	Sahadevkhunta	3.9	14.53	92.25	59.75	23.5	49.75	2.25
	Mallikashpur	4	14.25	91.25	85.75	23.5	50	2.5
	Rasalpur	4.5	15.25	90.5	85.5	24.25	49.75	0.75
2019	Sahadevkhunta	7.125	15.925	87.428	47.225	24.375	56.25	31.5
	Mallikashpur	7.625	17.25	88.05	47.15	24.6	56.5	25
	Rasalpur	7.525	16.35	87.425	47.475	24.5	57.5	22.5

Air Pollution Index of different sampling Stations

Air pollution index provides the pollution level of an area. From Table 5 we observed that, during winter season the pollution level is remains high. By observing the pollution levels in three year it was found that the pollution level of all the sites were reducing by proceeding the year from 2017 to 2019 may be due to enhancing technologies to reduce the pollutant concentration in air. During rainy season the pollution level was low with respect to other seasons. During winter season of year 2017, all the sites were remains in orange zone which indicates that the pollution level is unhealthy for sensitive groups. Rainy season during all the year were showing lower index value which is moderate levels of health concern. During summer season the pollution index value was increased at Mallikashpur and Rasalpur in year 2018 with compared to 2017. Overall, we found that during winter season the pollution value was remains higher followed by summer followed by rainy season. The highest pollution index value within these years (2017, 2018 and 2019) was reported at Sahadevkhunta during winter season of year 2017 and the lower value was reported at Sahadevkhunta during Rainy season of year 2019. The air pollution is directly proportional to the health status of particular environment. The classification of several ranges of Air pollution index and the related health concerns as described by (Zlauddin and Siddiqui. 2006) are presented in Table 6.

Table 5: Air pollution index (API) of all sampling stations

Year	Sampling Station	Air pollution index Summer	Rainy	Winter
2017	Sahadevkhunta	92.80	83.6	106.4
	Mallikashpur	92.50	85.4	105.5
	Rasalpur	91.30	85.1	104.25
2018	Sahadevkhunta	76.70	48.83	86.5
	Mallikashpur	103.40	78.2	102.25
	Rasalpur	103.63	77.9	102.6
2019	Sahadevkhunta	77.05	49.65	79.4
	Mallikashpur	78.13	68.3	80.7
	Rasalpur	77.50	49.91	80

Table 6: The range of Air pollution index (API), air quality and its health in environment

API value	Category of Air quality	Health issues
0 to 25	Clean air	The effects on health very negligible
26 to 50	Light air pollution	For sensitive group cardiac and respiratory issues arises
51 to 75	Moderate air pollution	generally, the symptoms of cardiovascular and respiratory disease are seen
76 to100	Heavy air pollution	Mostly the heart and lungs are affected
>100	Severe air pollution	The heart and lung diseases are damaged severely. In case of children possibility of death increases

Table 7: Correlation of parameters (Summer season)

Parameters	SO_2	NO_2	PM_{10}	$PM_{2.5}$	Temperature	Humidity	Rainfall
SO_2	1						
NO_2	-.850**	1					
PM_{10}	.691*	-.722*	1				
$PM_{2.5}$	-.731*	.712*	-.352	1			
Temp	.893**	-.930**	.735*	-.669*	1		
Humidity	-.204	.129	.304	.519	-.141	1	
Rainfall	-.562	.733*	-.324	.447	-.736*	.289	1

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Correlation analysis for both air quality and meteorological parameters were examined during summer season for the year 2017, 2018 and 2019 (Table 7). The results revels some of the relations like SO_2 showed significant positively correlated with the Temperature (r = + 0.893, $p < 0.05$), showed significant negatively correlated with NO_2 (r = - 0.850, $p < 0.05$) but not show any significant negatively correlated with $PM_{2.5}$ (r = -0.731, $p > 0.01$) and PM_{10} (r = 0.691, $p > 0.01$). NO_2 was showing significant negatively correlated with Temperature (r = -0.930, $p < 0.05$), but not show any significant positive correlate with $PM_{2.5}$ (r = 0.712, $p > 0.01$), Rainfall (r = 0.733, $p > 0.01$) and negative correlate with PM10 (r = - 0.722, $p > 0.01$). Temperature was showing not significant positive correlation with air pollutants like PM10 (r = 0.731, $p > 0.01$) and negative correlate with PM2.5 (r = -0.669, r > 0.01). Rainfall showed not significant negative correlate with Temperature (r = -0.736, $p > 0.01$).

Rainy Correlation

The correlation study during rainy season for year 2017, 2018 and 2019 was examined (Table 8). The outcomes of results were like SO_2 shows significant positive correlation with Humidity (r = 0.883, $p < 0.05$), significant negative correlated with NO2 (r = -0.909, $p < 0.05$) and not significant negative correlated with Rainfall (r = -0.746, $p > 0.01$). NO_2 shows significant negatively correlate with Humidity (r = -0.944, $p < 0.05$).

Table 8: Correlation of parameters (Rainy season)

Parameters	SO_2	NO_2	PM_{10}	$PM_{2.5}$	Temperature	Humidity	Rainfall
SO_2	1						
NO_2	-.909**	1					
PM_{10}	.476	-.510	1				
$PM_{2.5}$	-.339	.562	-.521	1			
Temp	-.476	.258	.015	-.197	1		
Humidity	.883**	-.944**	.534	-.575	-.242	1	
Rainfall	-.746*	.479	-.185	.098	.542	-.475	1

**At 0.01 level the 2-tailed correlation is significant

* At 0.05 level the 2-tailed correlation is significant

Winter Correlation

Correlation analysis for both air quality and meteorological parameters were examined during winter season for the year 2017, 2018 and 2019 (Table 9). The results revels some of the relations like SO_2 shows significant positive correlate with NO2 (r = 0.934, $p < 0.05$), Humidity (r = 0.915, $p < 0.05$) and Rainfall (r = 0.875, $p < 0.05$) but significant negative correlate with PM_{10} (r = -0.960, $p < 0.05$) and shows not significant negative correlate with $PM_{2.5}$ (r = -0.725, $p > 0.01$). NO_2 shows significant negative correlate with PM_{10} (r = -0.847, $p < 0.05$), significant positive correlate with Humidity (r = 0.817, $p < 0.05$), showed not significant positive correlate with Rainfall (r = 0.745, $p > 0.01$) and not significant negative correlate with $PM_{2.5}$ (r = -0.725, $p > 0.01$). PM_{10} shows significant negative correlate with Humidity (r = -0.864, $p < 0.05$) and Rainfall (r = -0.843, $p < 0.05$). $PM_{2.5}$ shows not significant correlate with Temperature (r = -0.736, $p > 0.01$). Humidity shows positive significant correlate with Rainfall (r = 0.940, $p < 0.01$).

Table 9: Correlation of parameters (winter season)

Parameters	SO_2	NO_2	PM_{10}	$PM_{2.5}$	Temperature	Humidity	Rainfall
SO_2	1						
NO_2	.934**	1					
PM_{10}	-.960**	-.847**	1				
$PM_{2.5}$	-.752*	-.667*	.647	1			
Temp	.598	.646	-.544	-.736*	1		
Humidity	.915**	.817**	-.864**	-.563	.326	1	
Rainfall	.875**	.745*	-.843**	-.612	.314	.940**	1

**At 0.01 level the 2-tailed correlation is significant
* At 0.05 level the 2-tailed correlation is significant

Overall Correlation

The correlation study during overall season for year 2017, 2018 and 2019 was examined (Table10). The outcomes of results were like SO_2 shows significant negative correlate with $PM_{2.5}$ ($r = -0.496$, $p < 0.05$). NO_2 shows significant positive correlation with $PM_{2.5}$ ($r = -0.496$, $p < 0.01$), significant negative correlate with Rainfall ($r = -0.440$, $p < 0.01$) and Temperature ($r = -0.691$, $p < 0.05$). PM_{10} shows not significant positive correlate with $PM_{2.5}$ ($r=0.452$, $p > 0.01$), negative correlate with Temperature ($r = -0.447$, $p > 0.01$) and significant positive correlate with Rainfall ($r = -0.920$, $p < 0.05$). $PM_{2.5}$ shows not significant negative correlate with Rainfall ($r = -0.418$, $p > 0.01$). Temperature shows significant positive correlate with Rainfall ($r = 0.605$, $p < 0.05$).

Table 10: Overall correlation between parameters

Parameters	SO_2	NO_2	PM_{10}	$PM_{2.5}$	Temperature	Humidity	Rainfall
SO_2	1						
NO_2	-.320	1					
PM_{10}	.064	.325	1				
$PM_{2.5}$	-.496**	.404*	.452*	1			
Temp	.160	-.691**	-.447*	-.371	1		
Humidity	-.015	-.216	-.159	.109	.361	1	
Rainfall	-.177	-.440*	-.920**	-.418*	.605**	.290	1

**At 0.01 level the 2-tailed correlation is significant
* At 0.05 level the 2-tailed correlation is significant

Multi-Dimensional Scaling (MDS)

Multidimensional scaling (MDS) is a technique helps to produce a map visualizing the level of similarity of individual cases of a dataset. By the help of MDS different air pollutants (SO_2, NO_2, PM_{10} and $PM_{2.5}$) and Meteorological Parameters (Temperature, Humidity and Rainfall) were grouped on the basis of similarities or distances between themselves. The MDS was done using SPSS Software. The summer season MDS was draw out three groups by integrating 7 variables as shown in Fig. 3. The groups were consisting of SO_2, PM_{10} and Temperature in one group, Humidity and $PM_{2.5}$ in second group, Rainfall and NO_2 in third group.

From Fig. 4 we observed that, the rainy season MDS was extracted three groups by combining seven parameters. Group one consists of NO_2, PM_{10} and Humidity. Second group is having Temperature and Rainfall. Third group consists of $PM_{2.5}$ and NO_2.

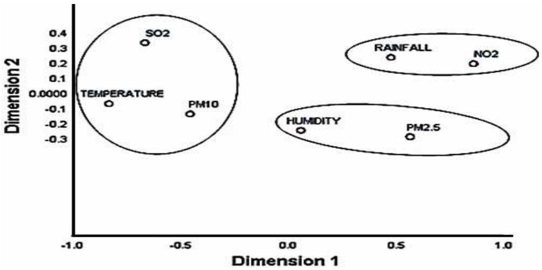

Fig. 3. MDS graph of summer season

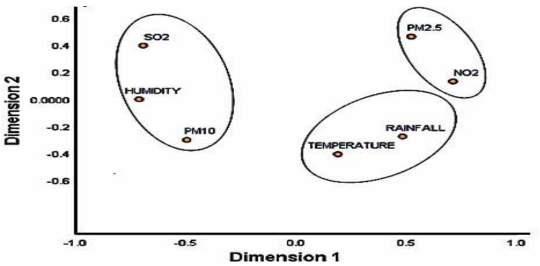

Fig. 4. MDS graph of Rainy season

From Fig. 5 we found that, the winter season MDS was takeout one single group excluding Temperature, PM_{10} and $PM_{2.5}$ from all the seven parameters. Parameters like, SO_2, NO_2, Humidity and Rainfall were present in a single group, but Parameters like Temperature, PM_{10} and $PM_{2.5}$ were present far apart they could not be grouped.

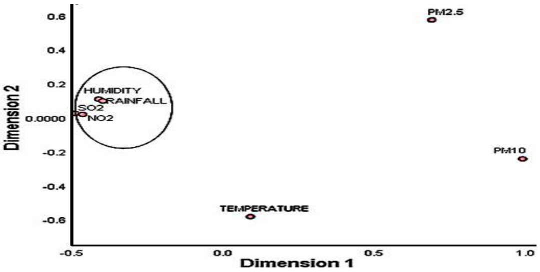

Fig. 5. Winter season MDS graph

From Fig. 6 we observed that, the Overall MDS extracted two groups by combining 7 variables excepting SO_2. Parameters like $PM_{2.5}$, NO_2 and PM_{10} were grouped in first one; Rainfall, Humidity and Temperature were present in second group. The SO_2 parameter was present at much distance from two groups.

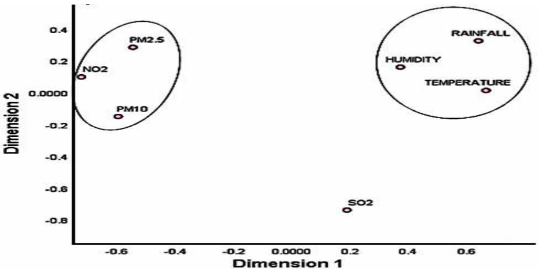

Fig. 6. Overall season MDS graph

Analysis of Variances (ANOVA) Two Factor Without Replication

ANOVA technique is used to analyse the differences along with group means in a sample. The ANOVA result of different parameters are given in Table 10. During summer season it was found that in between rows the F value was remains less then F critical value and the p-value was more than alpha (0.05), so the null hypothesis was accepted which indicate there was no relationship between different sites. But in between parameters the p-value was remains above the alpha value (0.05) and the F value was remains greater than F critical value which indicates that there are some statistically significant to the relationship between parameters and this leading you to reject the null hypothesis for the greater F value. During seasons the results of rainy, winter and overall season were showed similar to summer season.

CONCLUSION

The present study was attempted to record the seasonal variations of meteorological and air quality parameters along the city coastal state of Odisha, Baleswar. Analyses of our data sets showing that SO_2 and NO_2 concentration during summer, rainy and winter season are within the prescribe standard of NAAQS by CPCB but PM_{10} and $PM_{2.5}$ are above the prescribed standard except $PM_{2.5}$ concentration of rainy season in year 2019. Air pollution index is remaining in the condition between clean air (CA) to moderate air pollution (MAP) and it shows that the pollution index in all the sites are reducing from the year 2017 to 2019 may be due to enhancing technologies to reduce the pollutant concentration in air. The meteorological factors like temperature, rainfall and humidity are playing a vital role in determine air quality of a city and impacts up on health of human life. Temperature, rainfall and humidity are becoming worse day to day due to enormous industrial development around the city with increasing the numbers of population. Hence, there should be periodic and continuous monitoring of criteria air pollutants and meteorological parameters which will grant and imminent in to various issues over a long period of time. Since, arranged urban improvement gives off an impression of being troublesome in the nearby conditions and dealing with the contamination issue with basic info doesn't turn out to be simple as in numerous other urban zones over the globe, the plausible state of contamination might be disturbed in future. By the use of pollution control devices and various advance apparatus the air pollution can be controlled, as well as embracing relief measures by expanding vegetation spread or green belt.

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Conflicts of Interest

The authors declare no conflict of interest.

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