CHAPTER 4

Monitoring of Ambient Air Quality with reference Speciation and Concentration

In this chapter of the thesis, the air quality parameters regarding the particulate matter, nitrogen dioxide, and sulfur dioxide at different mining and residential sites around the Singrauli coalfield have been monitored. The obtained concentration of air pollutants was compared with the National Ambient Air Quality Standard notification.

4.1 Introduction

Ambient air quality is gradually deteriorating due to the increasing mining activities at many coalfields. Among these, industrialization is one of the significant causes of air pollution. The increasing air pollution problem adversely affects human beings' health, vegetation & machinery in mines. Due to industrialization and other activities complicity, a variety of pollutants are being generated in the surrounding area, and its concentration is increasing day by day **[61,150]**. In an Industrial area with the constant increase in high–grade highway mileage and the significant improvement in production technology of the high–speed diesel engine and increasing need for heavy–duty trucks for transportation, the number of fossils fuel–based vehicles is increasing, which resulted in the increase in smoke

emission to vehicular pollution in their surrounding area. Mining is also one of the significant contributions to air pollution.

In the mine, precious materials are extracted from the ground, pre–processed, and taken for further processing. Gas–phase and particulate matter emissions are polluting the environment around mining. Due to coal–mining practices in the area, there are many environmental degradations in the area, and air pollution is an important issue (the removal of vegetation and the topsoil) **[82,151]** and also water **[152]** pollution problems. Environmental problems related to coal mining include biological communities and disturbances in their physical environment. These disturbances in the ecosystem's balance are associated with biodiversity loss, erosion, soil and water pollution, and air pollution, mainly due to particulate matter **[9,152,153]**.

Due to these mining activities, the natural environment is adversely affected by the road, the health, and welfare of the surrounding human population **[154,155]**. However, surface coal mining's impact on air quality has only been briefly addressed **[12,115]** and therefore required comprehensive and systematic monitoring and compositional analysis. Activities related to surface coal mining are topsoil removal, drilling, blasting, coal handling operations, coal hauling, transportation and dumping of overburden and exposed surface air erosion.

All such activities emit particulate matter into the atmosphere of the ore. The major air pollutants in coal mines are particulate and gaseous. Hence, the mining operation, particularly opencast mining, is not an exception in contributing air pollutants into the atmosphere.

A detailed investigation of air quality has been done in the area for two consecutive years to monitor particulate matter of different sizes and nitrogen and sulphur dioxide. The results based on the concentration of particulate matter of different sizes along with nitrogen and

sulphur dioxide are summarised in **Tables** and **Figs.** in subsequent paragraphs and discussed.

4.2 Characterization of major air pollutants with reference to concentration

It is difficult to separate residential site areas from industrial areas and industrial areas to separate industries (Coal mining and thermal power plant areas). However, air quality monitoring sites have been selected so that the impact of coal mining and power plants has been assessed separately. Opencast coal mining and power plants' contribution on air quality has been evaluated for three different seasons (winter, summer, and rainy) at different (six) locations in the study area.

The air quality monitoring instruments for monitoring particulate matters, nitrogen, and sulfur dioxide have been fixed at the selected sites in the industrial cum–residential area of the Singrauli coalfield complex. The sampling stations are AQMS–01, AQMS–02, AQMS–03, AQMS–04, AQMS–05, AQMS–06 in the previous chapter 3, **Fig. 3.1**.

The particulate matter of different sizes has been monitored using different air samples (Instrumex IPM–FDS 2.5µ/10µ; APM 460 NL; APM550; ENVIROTECH APM 43–411). Nitrogen and sulfur dioxide have also been monitored with the help of ENVIROTRACK Air Sampler.

The particulate matter of different sizes (SPM, PM_{10}, $PM_{2.5}$, NO_2, and SO_2) has been observed at different pre–selected air quality monitoring stations. The details of concentrations for air pollutants at various sites have discussed below.

4.2.1 Spatial and temporal variation in the concentration of air pollutants

The concentration of particulate matter of various sizes along with SO_2 and NO_2 are summarized in **Tables 4.1 and 4.2**. These tables show minimum, average, maximum, geometric mean, standard deviation, kurtosis, and skewness of observed concentration of air pollutants in the study area of two consecutive years. It may be observed from **Table 4.1** that the average $PM_{2.5}$ levels varied from 68.5±38.8 μg m^{-3} to 84.5±26.6 μg m^{-3} at all six–monitoring station. The highest annual average concentration was measured (81.3±38.9 μg m^{-3}) in the years 2017, and the lowest average yearly level was measured (66.4±37.3 μg m^{-3}) in the year 2016. The concentration of PM_{10} was varying from 178±77.0 μg m^{-3} to 230.3±38.2 μg m^{-3}. The highest level was observed (351.2 μg m^{-3}) and the lowest concentration (28.1 μg m^{-3}) in 2017. The twenty–four hours PM_{10} concentrations in the industrial cum–residential area were higher than the National Ambient Air Quality Standards of 100 μg m^{-3}, respectively **[101]**.

As far as SPM is concerned, the average concentration was varied from 374.8±146.5 μg m^{-3} to 420.7±96.8 μg m^{-3} at all six monitoring stations during the sampling period, i.e., 24h. The annual highest level was measured 391.2±158.0 μg m^{-3} in the year 2017, and the lowest concentration 365.3±140.4 μg m^{-3} has measured in the year 2016. It may be observed from **Table 4.2** also that the Dudhichua industrial cum–residential area (AQMS–03) has the highest annual average concentration of $PM_{2.5}$ which is 79.1±32.6 μg m^{-3}, in the year 2016 and 81.3±38.9 μg m^{-3}, in the year 2017. The above observation shows an appreciable concentration of PM_{10} and $PM_{2.5}$ in the Singrauli industrial complex's ambient air. A few locations in the study area, the control measures may be deployed to reduce the concentration below the recommended permissible limit of the National Ambient Air Quality Standard of India **[101]**.

Table 4.1: Minimum, maximum, and average concentration of particulate matters and gaseous air pollutants of two consecutive years (2016 & 2017)

Locations	Min	Max	Average	Geometric mean	Kurtosis	Skewness
$PM_{2.5}$ concentration (µg m^{-3})						
AQMS–01	24.66	155.49	76.34±38.86	66.00	–0.09	0.64
AQMS–02	21.59	166.76	73.53±39.65	62.88	–0.07	0.64
AQMS–03	27.74	155.37	80.72±35.21	71.24	–0.16	0.41
AQMS–04	18.28	160.71	68.55±38.88	57.43	–0.02	0.67
AQMS–05*	40.53	155.72	80.13±25.06	71.02	–0.14	0.55
AQMS–06*	38.34	149.32	84.58±26.65	73.47	–0.10	0.48
PM_{10} concentration (µg m^{-3})						
AQMS–01	41.15	351.21	194.25±78.17	173.37	–0.06	–0.37
AQMS–02	32.50	340.89	184.69±77.69	162.14	–0.05	–0.36
AQMS–03	45.65	334.78	196.11±56.20	178.75	–0.47	0.08
AQMS–04	28.12	334.05	178.69±77.01	155.30	–0.05	–0.36
AQMS–05*	82.87	285.12	220.54±40.88	185.43	–0.03	0.01
AQMS–06*	80.12	300.56	230.34±38.28	200.02	0.02	0.01
SPM concentration (µg m^{-3})						
AQMS–01	145.38	771.93	382.01±147.94	357.85	0.28	0.93
AQMS–02	143.99	762.90	383.79±147.46	359.30	0.29	0.93
AQMS–03	149.07	763.98	384.87±147.46	360.44	0.29	0.93
AQMS–04	121.42	752.76	374.80±146.54	350.09	0.32	0.94
AQMS–05*	180.76	542.10	415.08±100.18	380.43	0.40	0.98
AQMS–06*	173.45	560.82	420.73±96.82	400.15	0.52	0.98
NO_2 concentration (µg m^{-3})						
AQMS–01	10.06	48.28	27.05±11.85	24.19	–1.24	–0.03
AQMS–02	9.56	44.66	25.33±11.05	22.67	–1.27	–0.05
AQMS–03	10.93	49.15	27.91±11.85	25.17	–1.24	–0.03
AQMS–04	8.74	43.37	24.21±10.92	21.47	–1.26	–0.04
AQMS–05*	20.76	40.21	30.21±8.58	26.34	–1.25	–0.04
AQMS–06*	18.24	38.52	31.05±8.23	26.08	–1.23	–0.03
SO_2 concentration (µg m^{-3})						
AQMS–01	8.25	24.20	15.58±4.22	15.01	–0.44	0.15
AQMS–02	7.79	21.90	14.39±3.84	13.88	–0.48	0.12
AQMS–03	8.47	24.42	16.92±4.22	15.24	–0.44	0.15
AQMS–04	7.23	21.16	13.75±3.77	13.23	–0.45	0.14
AQMS–05*	15.38	18.16	17.12±2.14	16.04	–0.44	0.12
AQMS–06*	16.02	18.98	17.67±2.05	16.12	–0.43	0.11

± = Standard deviation

** = Sampling during March, April, and May, 2016.*

Permissible limit for 24 h: $PM_{2.5}$=60 µg m^{-3}; PM_{10}=100 µg m^{-3}; NO_2=80 µg m^{-3}; SO_2=80 µg m^{-3} ***[101]***

Table 4.2: Comparison of range and average concentration of major air pollutants of two consecutive years (2016 & 2017)

Locations	2016		2017	
	Range	**Average**	**Range**	**Average**
$PM_{2.5}$ concentration (µg m^{-3})				
AQMS–01	24.66–148.59	74.83±38.37	25.98–155.49	79.10±42.90
AQMS–02	21.59–144.86	71.40±38.15	22.92–166.76	75.67±42.68
AQMS–03	27.74–137.37	79.14±32.68	28.37–155.37	81.30±38.97
AQMS–04	18.28–138.81	66.41±37.34	19.60–160.71	70.68±41.92
PM_{10} concentration (µg m^{-3})				
AQMS–01	51.21–316.35	186.09±74.43	41.15–351.21	202.42±84.21
AQMS–02	42.56–306.03	176.53±73.95	32.50–340.89	192.85±83.71
AQMS–03	45.65–312.59	193.47±52.78	46.14–334.78	201.75±60.75
AQMS–04	38.18–299.19	170.53±73.26	28.12–334.05	186.86±83.00
SPM concentration (µg m^{-3})				
AQMS–01	145.38–622.98	376.51±141.99	160.15–771.93	388.01±158.56
AQMS–02	144.08–613.95	375.30±141.48	143.99–762.90	391.29±158.08
AQMS–03	149.07–615.02	380.37±141.48	150.55–763.98	390.36±158.08
AQMS–04	121.42–603.81	365.30±140.46	125.61–752.76	380.29±157.20
NO_2 concentration (µg m^{-3})				
AQMS–01	10.06–42.61	25.20±11.69	11.82–48.28	28.89±12.22
AQMS–02	9.56–40.48	23.94±11.11	10.93–44.66	26.73±11.31
AQMS–03	10.93–43.47	26.07±11.69	12.69–49.15	29.76±12.22
AQMS–04	8.74–39.19	22.81±10.97	10.11–43.37	25.60±11.17
SO_2 concentration (µg m^{-3})				
AQMS–01	8.25–22.34	14.70±4.11	9.94–24.20	16.46±4.31
AQMS–02	7.79–21.11	13.89±3.89	8.99–21.90	14.90±3.90
AQMS–03	8.47–22.57	14.92±4.11	10.16–24.42	16.68±4.31
AQMS–04	7.23–20.38	13.25±3.81	8.52–21.16	14.25±3.82

± = Standard deviation

Annual permissible limit: $PM_{2.5}$=40 µg m^{-3}; PM_{10}=60 µg m^{-3}; NO_2=40 µg m^{-3}; SO_2=50 µg m^{-3} ***[101]***

24 h permissible limit: $PM_{2.5}$=60 µg m^{-3}; PM_{10}=100 µg m^{-3}; NO_2=80 µg m^{-3}; SO_2=80 µg m^{-3} ***[101]***

The highest annual average level of PM_{10} is 202.4±84.2 µg m^{-3} in the year 2017 and 193.4±52.7 µg m^{-3} in the year 2016 at AQMS–01 and AQMS–03, respectively. The annual average concentration of SPM was 380.3±141.4 µg m^{-3} in the year 2016 and 391.2±158.0 µg m^{-3} in the year 2017 at AQMS–03 and AQMS–02, respectively. The lowest particulate matter concentration of different sizes has measured at AQMS–04, and it is varied between 18.2 µg m^{-3} to 160.7 µg m^{-3} with an average of 68.5±38.8 µg m^{-3} for $PM_{2.5}$, 28.1 µg m^{-3} to 334.0 µg m^{-3} with an average of 178.6±77.0 µg m^{-3} for PM_{10} and SPM concentration was varied between 121.4 µg m^{-3} to 752.7 µg m^{-3} with an average value of 374.8±146.5 µg m^{-3}, respectively in the monitoring period of two consecutive years (2016 and 2017). The annual average SPM concentration at all four–monitoring stations was slightly higher than the National Ambient Air Quality Standards of the yearly average of 360 µg m^{-3}, respectively **[102]** (**Table 4.2**).

The particulate pollutant concentration was mostly similar at all four monitoring stations installed around Singrauli Coalfield because the monitoring station was located near mining and industrial activities. The influence of industrial activities may also be argued to discuss these polluted areas being suspicious sites not too far from industrial activities. All monitoring station has been located nearby the mining and industrial activities. A similar study of particulate matter in ambient air has been reported earlier **[156,157]**.

The average value of NO_2 concentration among all monitoring stations measured between 24.2±10.9 µg m^{-3} to 31.0±8.2 µg m^{-3} in two consecutive years (2016 and 2017), is well below the threshold limits of 40 µg m^{-3} **[101]**. The twenty–four hours average NO_2 concentrations were between 8.7 µg m^{-3} to 49.1 µg m^{-3}, which is also well within the standard limits of 80 µg m^{-3} in the study area. The highest annual average 29.7±12.2 µg m^{-3} has monitored in the years 2017 at AQMS–03, and lowest yearly average, 22.8±10.9 µg m^{-3} has followed in the year 2016 at AQMS–04. As far as SO_2 is concerned, the average

concentration varied from 13.7±3.7 μg m^{-3} to 17.6 μg m^{-3} at all six–monitoring stations during the sampling period for two consecutive years. The annual average level is lying between 7.2 μg m^{-3} to 20.3 μg m^{-3} with an average value of 13.2±3.8 μg m^{-3} and 10.1 μg m^{-3} to 24.4 μg m^{-3} with an average value of 16.6±4.3 μg m^{-3} in AQMS–04 and AQMS–03, respectively.

The SO_2 in the residential areas came from the open burning of raw coal and other domestic and commercial activities **[82]**. The annual and twenty–four hours of average SO_2 concentrations were well within the prescribed permissible limit at all the six–monitoring stations during the sampling period of two consecutive years **[101]**.

The variation fluctuation trends in the concentration of major air pollutants of two consecutive years were shown in **Fig. 4.1**. It maybe reveals that the fluctuation trend of monitored and observed air pollutants around the study area. It was noted that the major air pollutants observed have an increasing trend in the same month by a different year. The increasing concentration of monitored air pollutants is perhaps due to the increase in industrial activities and production. However, as per **Fig. 4.1**, it was found that the monthly average concentrations of particulate matter exceeded permissible limits **[101,102]**.

4.2.2 Seasonal variation in concentration of major air pollutants

The concentration of air pollutants was compared with three seasons (winter, summer, and rainy) occurring in this area. The summer season usually spread from March to June, rainy season from July to October, and winter season spread from November to February. These three seasons play an essential role in the dispersion of air pollutants in the area. The seasonal variation in air pollutants' concentration levels in two complete years and at all sampling locations is shown in **Fig. 4.2**. The statistical seasonal average and range concentration of air pollutants has given in **Table 4.3**.

Air quality monitoring investigation made in two consecutive years (January 2016 to December 2017) in the study area reveals a general trend of maximum concentration of major air pollutants ($PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2) during winter and minimum during rainy seasons **(Fig. 4.2 and Table 4.3)**.

During the winter season, the daily average of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 concentrations were found to be in the ranges of 67.4–166.7, 174.4–351.5, 389.7–771.9, 30.1–40.8, and 15.4–24.4 μg m^{-3}, respectively. Whereas it ranged between 45.5–83.19, 120.5–241.8, 239.2–493.6, 12.2–33.27, and 11.2–17.9 μg m^{-3} and 18.2–93.1, 28. 1–226.8, 181.4–329.6, 8.7–31.2, and 7.2–17.5 μg m^{-3} during summer and rainy seasons, respectively, at the study area in **Table 4.3**.

It may be observed from **Table 4.3** reveals that the maximum average concentrations of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 were found to be 120.2±25.7 μg m^{-3}, 243.1±51.5 μg m^{-3}, 553.7±119.6 μg m^{-3}, 40.8±4.6, and 20.04±2.7 μg m^{-3}, respectively during winter season followed by summer 72.9±10.9 μg m^{-3}, 214.6±21.4 μg m^{-3}, 354.7±80.1 μg m^{-3}, 26.0±6.7, and 15.3±1.8 μg m^{-3} then rainy 48.2±25.2 μg m^{-3}, 114.8±68.9 μg m^{-3}, 267.5±44.5 μg m^{-3}, 16.8±7.7 μg m^{-3}, and 12.0±3.2 μg m^{-3}, respectively in the industrial cum–residential area of Dudhichua.

The minimum concentrations of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 were found to be 35.4±23.7 μg m^{-3}, 100.6±67.9 μg m^{-3}, 251.9±43.4 μg m^{-3}, 13.9±7.0, and 12.0±3.2 μg m^{-3}, respectively during rainy season followed by summer 59.4±9.7 μg m^{-3}, 158.9±24.9 μg m^{-3}, 337.7±79.4 μg m^{-3}, 22.4±6.1, and 13.2±1.5 μg m^{-3} then winter 110.7±30.4 μg m^{-3}, 207.1±29.8 μg m^{-3}, 534.7±119.4 μg m^{-3}, 36.1±4.1 μg m^{-3}, and 17.5±2.4 μg m^{-3}, respectively in the industrial cum–residential area of Amlohri.

However, it may reveal that the air pollutant level concentration in the winter season is higher than rainy and summer. The concentration level of higher in the winter season due

to temperature inversion, dry condition, and low humidity. Due to high temperature and high mixing height (Due to high wind speed), the air pollutant concentrations were more moderate. The concentration values were lowest in the rainy season, perhaps due to coagulation and particulates' removal during precipitation **(Fig. 4.2)**. Thus, nearby, similar trends were reported at the coastal site of Tianjin, China **[158]**.

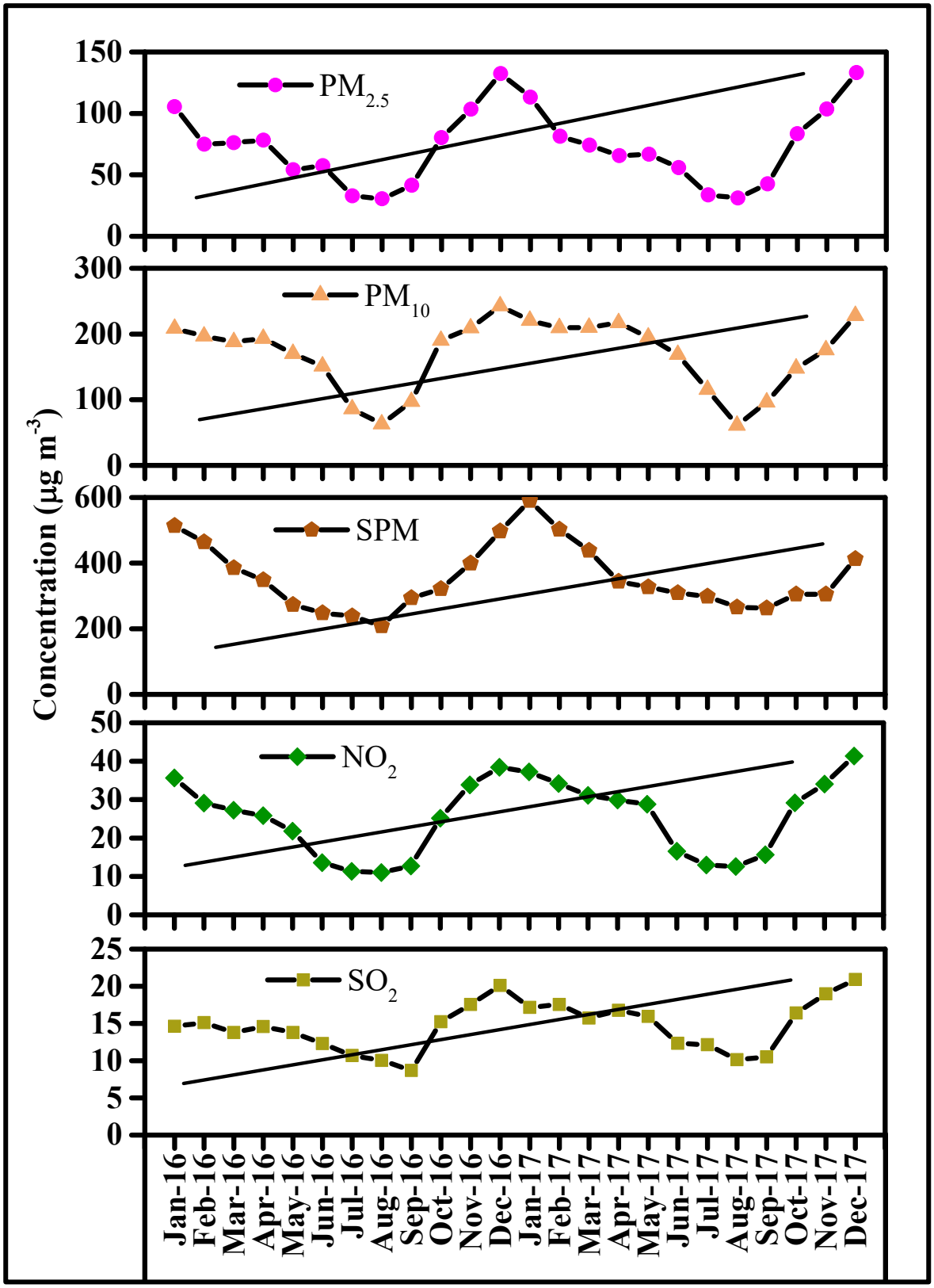

Fig. 4.1: Showing fluctuation in concentration of major air pollutants of two consecutive years (2016 & 2017)

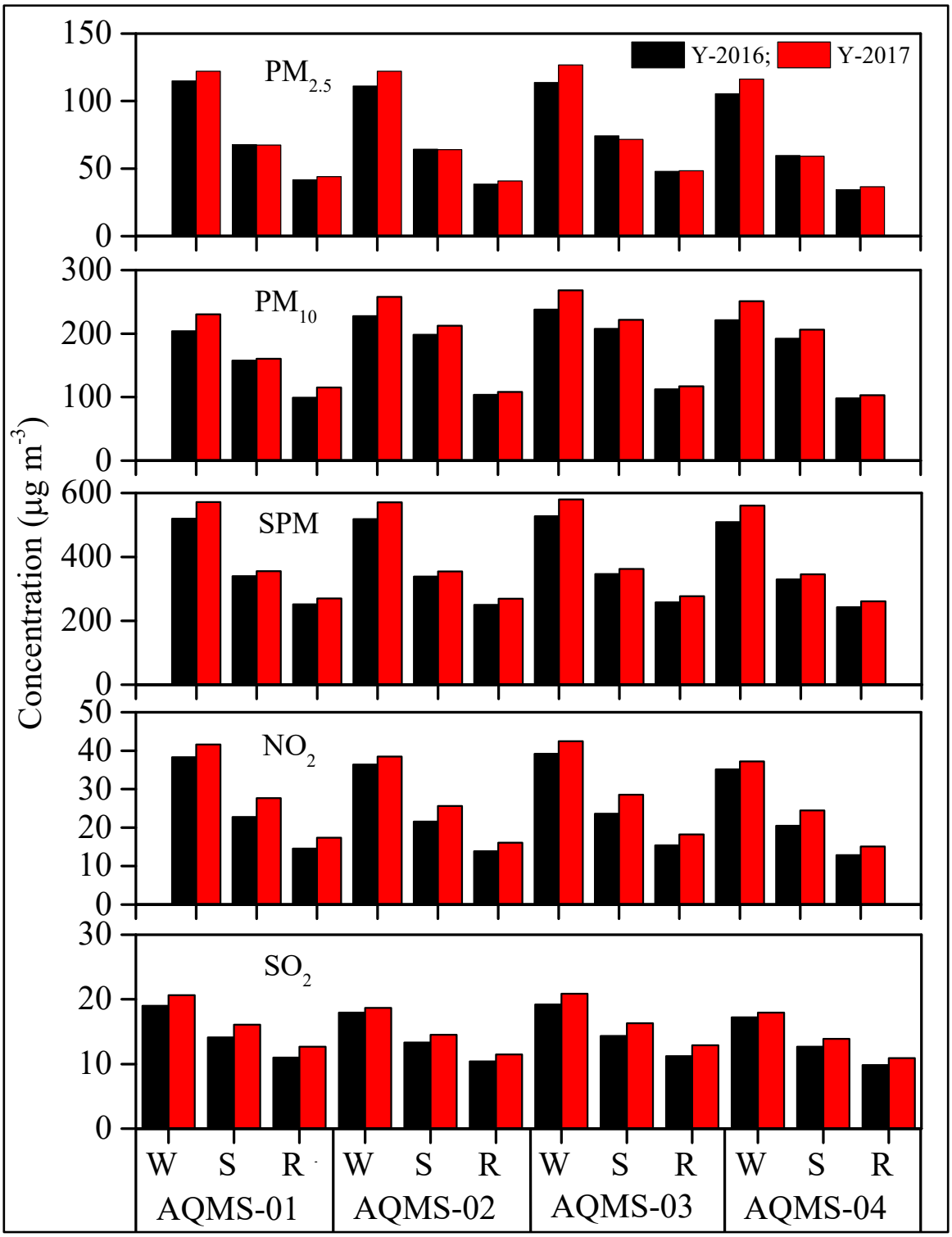

Fig. 4.2: Comparison of the level of average seasonal variation of major air pollutants around the study area of two consecutive years (2016 & 2017)

Table 4.3: Average seasonal variation in the concentration of major air pollutants of two consecutive years (2016 & 2017)

Locations	Winter		Summer		Rainy	
	Range	Average	Range	Average	Range	Average
$PM_{2.5}$ concentration (µg m^{-3})						
AQMS–01	76.8–155.4	118.5±27.3	53.3–81.4	67.5±10.2	24.6–84.2	42.9±24.6
AQMS–02	73.1–166.7	116.6±30.5	50.0–78.0	64.2±10.1	21.5–80.8	39.7±24.4
AQMS–03	82.1–155.3	120.2±25.7	51.6–83.1	72.9±10.9	27.7–93.1	48.2±28.2
AQMS–04	67.4–160.7	110.7±30.4	45.5–72.8	59.4±9.7	18.2–75.5	35.4±23.7
PM_{10} concentration (µg m^{-3})						
AQMS–01	183.2–284.7	226.1±51.5	164.3–226.0	199.3±21.3	69.6–190.5	107.2±41.2
AQMS–02	181.1–340.8	232.8±51.6	169.8–232.3	205.2±21.6	32.5–217.3	105.8±68.6
AQMS–03	191.4–351.2	243.1±51.5	178.9–241.8	214.6±21.8	41.1–226.8	114.8±68.9
AQMS–04	174.4–334.0	207.1±29.8	120.5–186.3	158.9±24.9	28.1–211.0	100.6±67.9
SPM concentration (µg m^{-3})						
AQMS–01	400.8–763.9	545.9±119.5	248.6–486.5	347.7±79.9	189.0–322.5	260.8±44.3
AQMS–02	399.7–762.9	544.8±119.5	247.5–485.4	346.6±79.9	187.9–321.4	259.8±44.3
AQMS–03	408.4–771.9	553.7±119.6	255.3–493.6	354.7±80.1	195.3–329.6	267.5±44.5
AQMS–04	389.7–752.7	534.7±119.4	239.2–475.8	337.7±79.4	181.4–312.0	251.9±43.4
NO_2 concentration (µg m^{-3})						
AQMS–01	33.0–39.9	39.9±4.6	13.9–32.4	25.2±6.7	10.0–30.3	15.9±7.7
AQMS–02	31.3–37.4	37.4±4.1	13.2–29.9	23.6±6.1	9.5–28.0	14.9±7.2
AQMS–03	33.8–40.8	40.8±4.6	14.8–33.2	26.0±6.7	10.9–31.2	16.8±7.7
AQMS–04	30.1–36.1	36.1±4.1	12.2–28.7	22.4±6.1	8.7–26.8	13.9±7.0
SO_2 concentration (µg m^{-3})						
AQMS–01	16.7–24.2	19.8±2.7	12.7–17.7	15.0±1.8	8.2–17.3	11.8±3.2
AQMS–02	15.8–21.9	18.3±2.4	11.7–16.0	13.9±1.5	7.7–15.7	10.9±2.9
AQMS–03	16.9–24.4	20.0±2.7	12.9–17.9	15.3±1.8	8.4–17.5	12.0±3.2
AQMS–04	15.0–21.1	17.5±2.4	11.2–15.3	13.2±1.5	7.2–15.0	10.3±2.8

± = Standard Deviation

24h permissible limit: $PM_{2.5}$=60 µg m^{-3}; PM_{10}=100 µg m^{-3}; NO_2=80 µg m^{-3}; SO_2=80 µg m^{-3} ***[101]***

The SPM and PM_{10}, maximum levels were observed in autumn, followed by summer and winter season. This is due to the ground level thermal inversion and fog conditions due to air pollution accumulation **[158]**. In respect to the Indian perspective, the fluctuation trends (winter > summer > rainy) were monitor and observed in this study, and similar are also reported in Agra, for $PM_{2.5}$ and PM_{10} **[92]**.

Seasonal changes in the mass concentration of major air pollutants can be expressed by monthly variations of air pollutant mass concentrations. Seasonal fluctuation in level is mainly due to meteorological factors (such as temperature, relative humidity, and wind speed), which affect the level of particulate matter and other pollutants in ambient air. Also, changes in source emissions power over time affect these variations. Besides the above, the

emission rate from various sources is also responsible for fluctuation in air pollutants concentration in the area.

4.2.3 Vertical variation in concentration of major air pollutants

Vertical variation of air pollutants has been studied in the Dudhichua industrial cum residential area. The sampling of air pollutants was carried out at two different heights, i.e., ground level (1m) and rooftop (15m). The study site was a residential area, either single storied, double–storied, or storied triple houses around the sampling site at Dudhichua. Monthly average air pollutant levels with heights at the residential area have graphically presented in **Fig 4.3**. The concentration of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 at 1 m height (Ground level) is ranging from 35.24–139.37 (78.70±30.05) μg m^{-3}, 59.15–256.35(181.87±59.22) μg m^{-3}, 215.38–591.93 (364.26±100.64) μg m^{-3}, 12.13–44.15 (27.17±10.20) μg m^{-3}, and 9.22–22.42 (15.55±3.52) μg m^{-3}, respectively, slightly higher than the concentrations at the 15 m higher height (three–story building). It may be concluded that $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 concentration at the height of ≈15 m are almost the same range, which occurs at ground level. The annual average concentrations of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 were decreased with increasing height with an average percentage value of 4.5±1.7%, 10±6.5%, 15±6.8%, 10.1±3.9%, and 8.3±3.3% in the Dudhichua industrial cum–residential area, respectively. The air pollutant concentrations in the area were very low during the rainy days, with an increase in height and maximum during the dry spell days. The peaks in **Fig. 4.3** can be identified with clear dry spell days and the valleys with the rainfall days.

The monthly variation of the ratio of the concentration of measured air pollutants was calculated at different heights and shown in **Fig. 4.4**. It may be seen from **Fig. 4.4** that the ratio of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 is varying from 0.94–0.99 with an average

0.95±0.02, 0.84–0.99 with an average 0.90±0.06, 0.80–0.98 with an average 0.85±0.07, 0.86–1.00 with an average 0.90±0.04, and 0.88–0.99 with an average 0.92±0.03, respectively.

However, the ratios were about 1.0 or >1.0 in the samples collected during rainy days, although the values were not significantly different in rainy seasons. The air pollutant concentration reported is based on 24 h sampling, with an average of a month. It is difficult to explain the effect of the day–to–day atmospheric disturbance and nocturnal effects of weather conditions. It is found that the vertical distribution of atmospheric pollutants in the open space is different from the houses of the residential area because the distribution of airflow area is a significant difference in above these conditions. In the early spring and on the day of the air, the atmospheric particle concentration is small in high altitude and becomes more substantial in the lower height for the atmosphere of the residential building. When the air gets stronger, atmospheric particles' distribution becomes smooth because the airflow around the location is thoroughly mixed. However, the reports were also similar to the observation **[116]**.

4.2.4 Monthly average variation in concentration of major air pollutants

The monthly average variation in particulate matter concentration, nitrogen dioxide, and sulfur dioxide are depicted in **Figs. 4.5–4.9**. In the case of $PM_{2.5}$, it may be observed from **Fig. 4.5** that a high concentration of $PM_{2.5}$ was observed mostly in the winter seasons (November, December, and January) at almost all sampling locations. The highest average concentration (166 μg m^{-3}) was recorded in December 2017 at NTPC Shaktinagar industrial cum–residential area (AQMS–02) out of four sampling sites. From 2016 to 2017, in two years, the highest concentrations were observed in the winter seasons. The lowest level (18 μg m^{-3}) was observed in August month (2016) at the Amlohri residential area (AQMS–04)

during the monsoon. The highest PM_{10} levels have continuously recorded in industrial cum–residential areas of Dudhichua (AQMS–03), and it has followed by NTPC Shaktinagar industrial cum–residential area (AQMS–02), Amlohri Residential area (AQMS–04) and industrial cum–residential areas of Bina (AQMS–01). All four sampling locations have located in industrial–cum–residential and traffic movement areas. The lowest average monthly SPM concentrations were measured (181 μg m^{-3}) in the AQMS–4 in August 2016. Monthly average SPM concentrations varied from 201 μg m^{-3} to 593 μg m^{-3} during two consecutive years (2016 & 2017). The highest level for the two years was recorded mostly in November, December, and January. In a monthly comparison, the particulate matter different sizes average with national air quality standard, and it is revealed that that particulate matter concentration level has been crossed the prescribed permissible limit **[101,102]**.

The average monthly highest concentration of nitrogen dioxide was measured in December 2017 (44 μg m^{-3}) at AQMS–01 and lowest in August 2016 (10 μg m^{-3}) at AQMS–04. The annual average concentration of nitrogen dioxide was varying form 22±9 μg m^{-3} to 28±10 μg m^{-3} at all air quality monitoring stations during two consecutive years (2016 & 2017). The average monthly trend of nitrogen dioxide is showing in **Fig. 4.8**. It may be observed from this **Fig.** that the highest concentrations were recorded in November, December, and January and lowest in July, August, and September at all four–sampling locations in the study area. In comparing monthly NO_2 averages with ambient air quality standards, it is observed that pollutant concentrations have been well within the prescribed permissible limit **[101]**. As far as SO_2 is concerned, monthly average levels varied from 7±2 μg m^{-3} to 22±3 μg m^{-3} in the sampling period at all four–sampling locations. The highest annual level of NO_2 has measured at 16±3 μg m^{-3} in the year 2017, and the lowest concentration 12±34 μg m^{-3} was recorded in the year 2016.

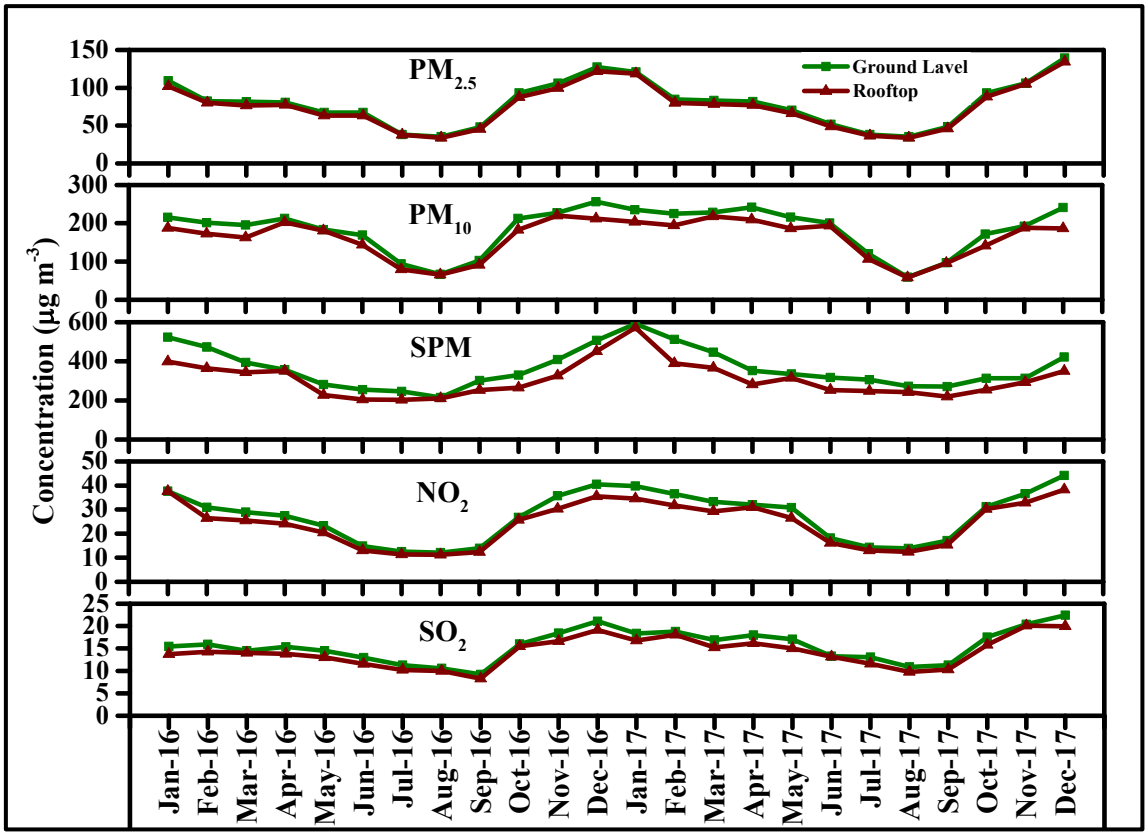

Fig. 4.3: Variation of monthly average concentration at Rooftop and Ground level of major air pollutants at AQMS–03

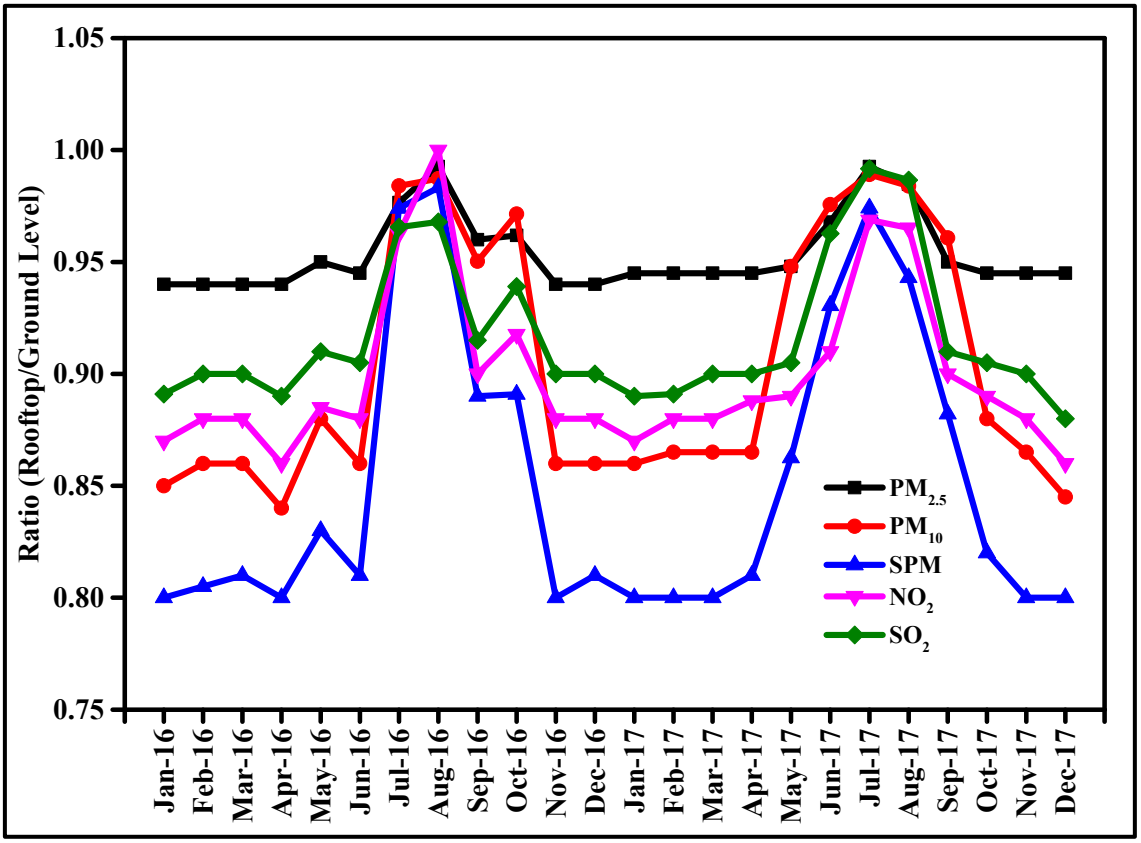

Fig. 4.4: Monthly average concentration variation ratio in Rooftop and Ground level of major air pollutants at AQMS–03

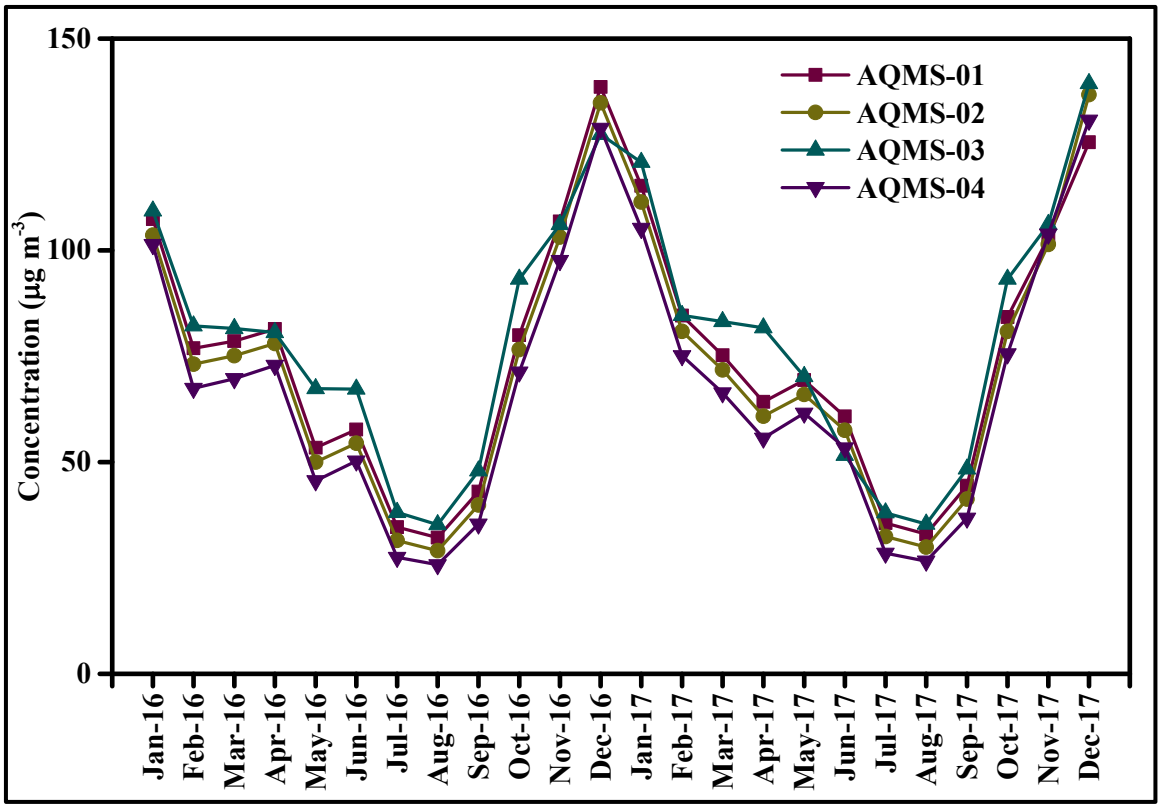

Fig. 4.5: Monthly Variations of $PM_{2.5}$ over the two consecutive years (2016 & 2017)

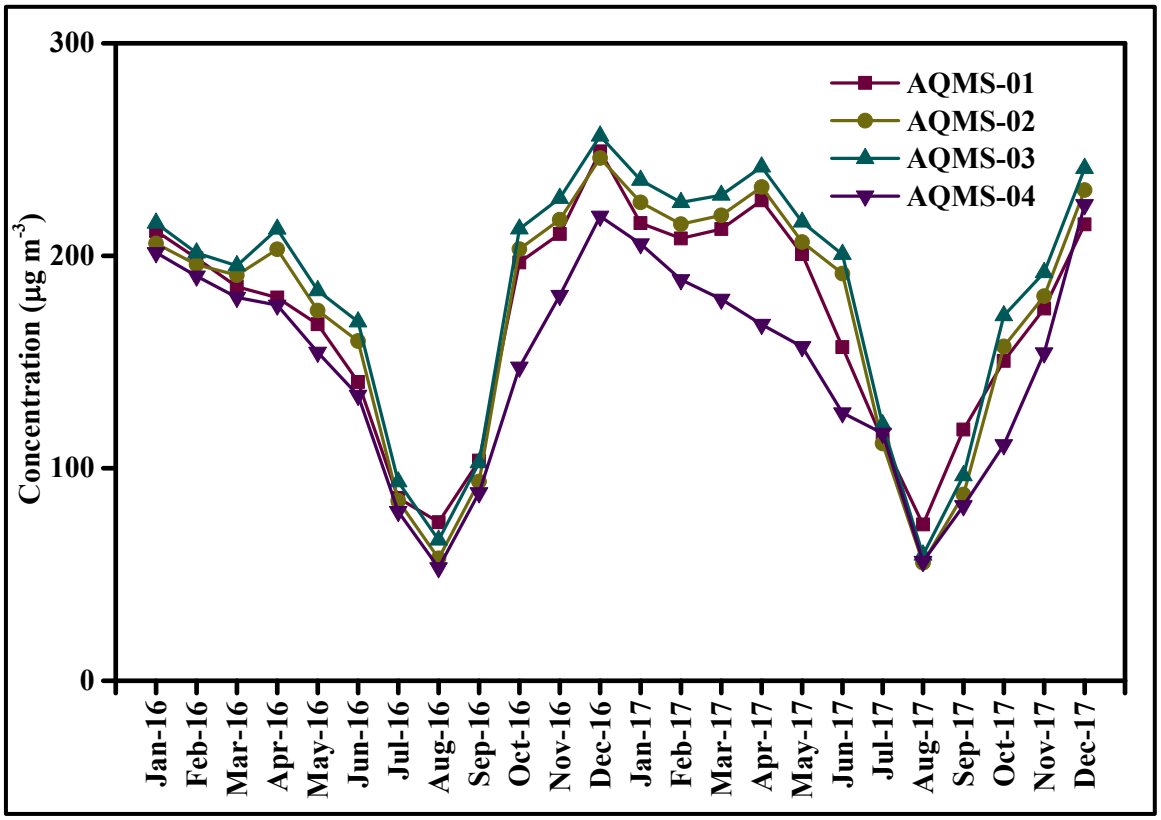

Fig. 4.6: Monthly Variations of PM_{10} over the two consecutive years (2016 & 2017)

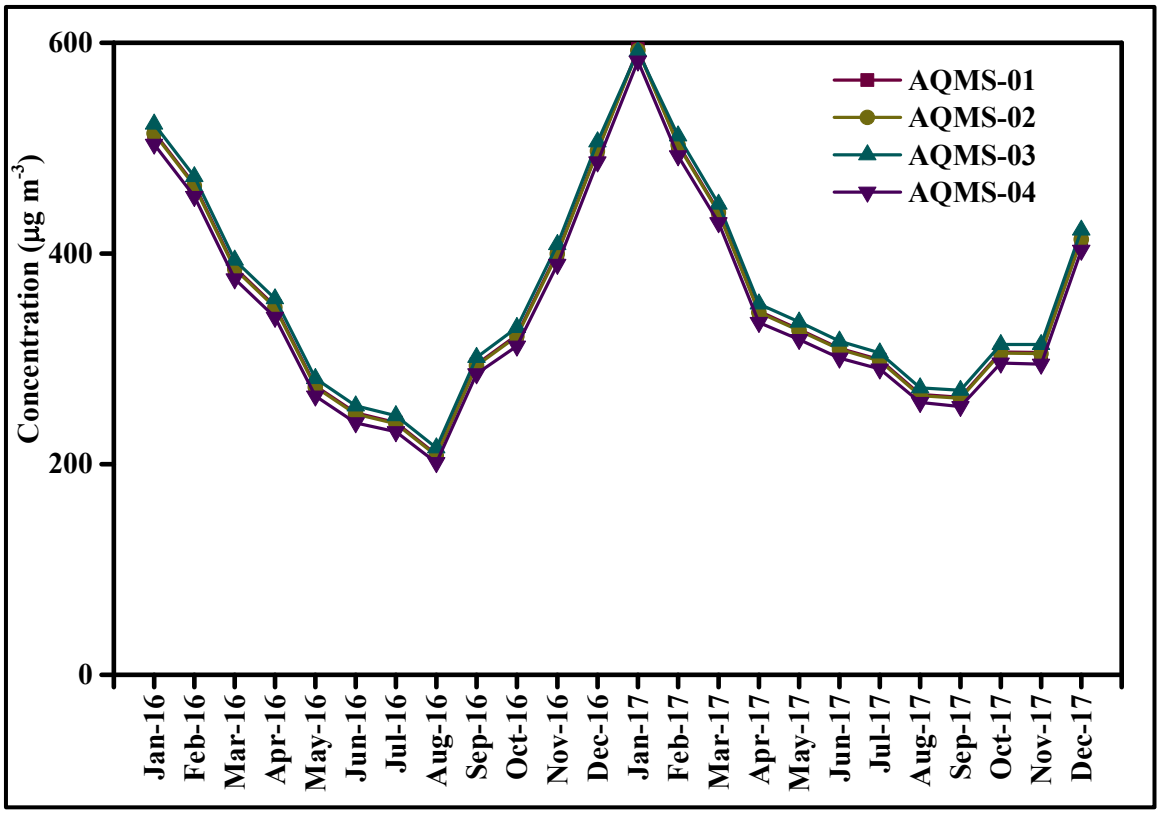

Fig. 4.7: Monthly Variations of SPM over the two consecutive years (2016 & 2017)

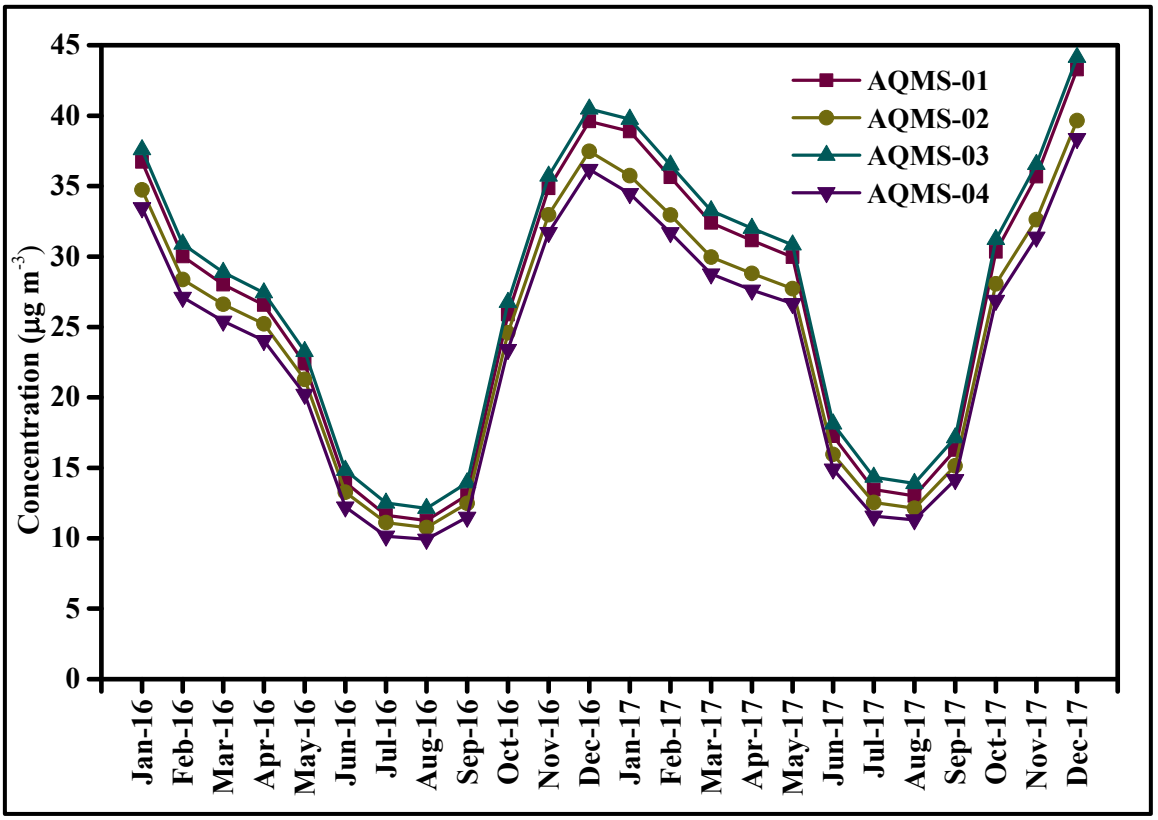

Fig. 4.8: Monthly Variations of NO_2 over the two consecutive years (2016 & 2017)

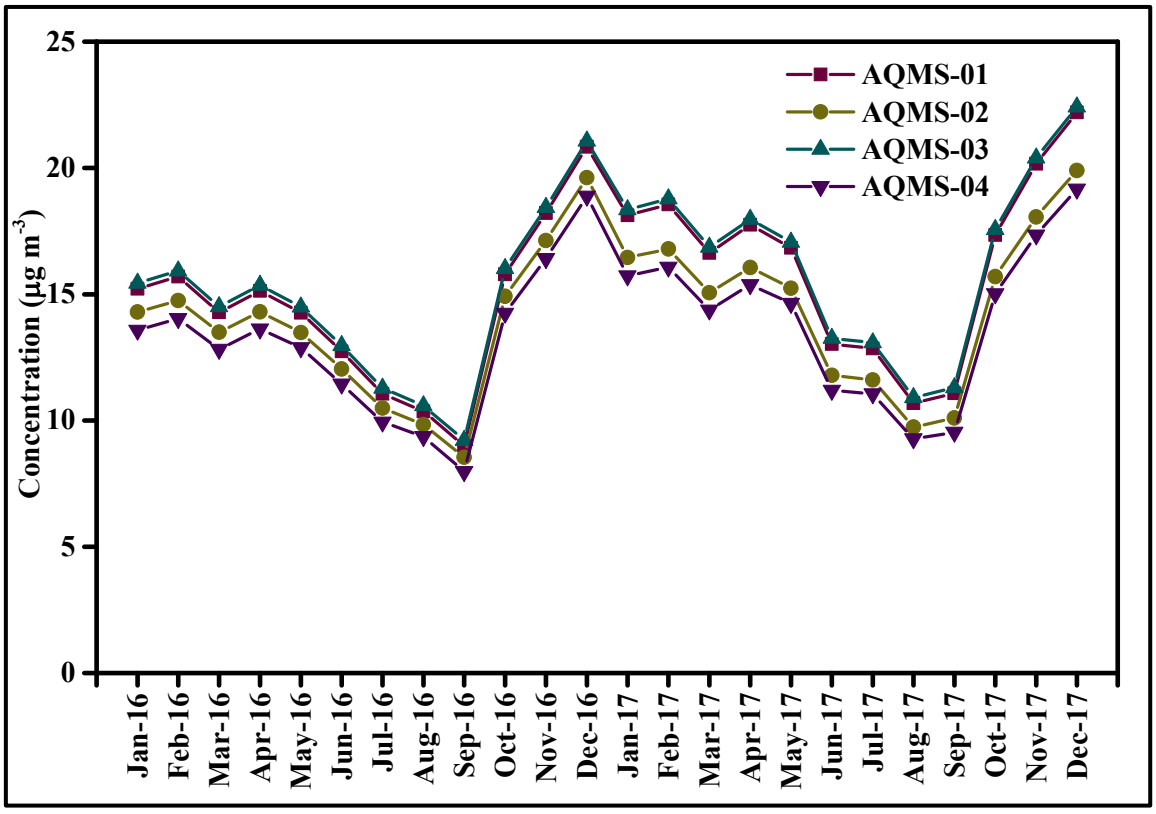

Fig. 4.9: Monthly Variations of SO_2 over the two consecutive years (2016 & 2017)

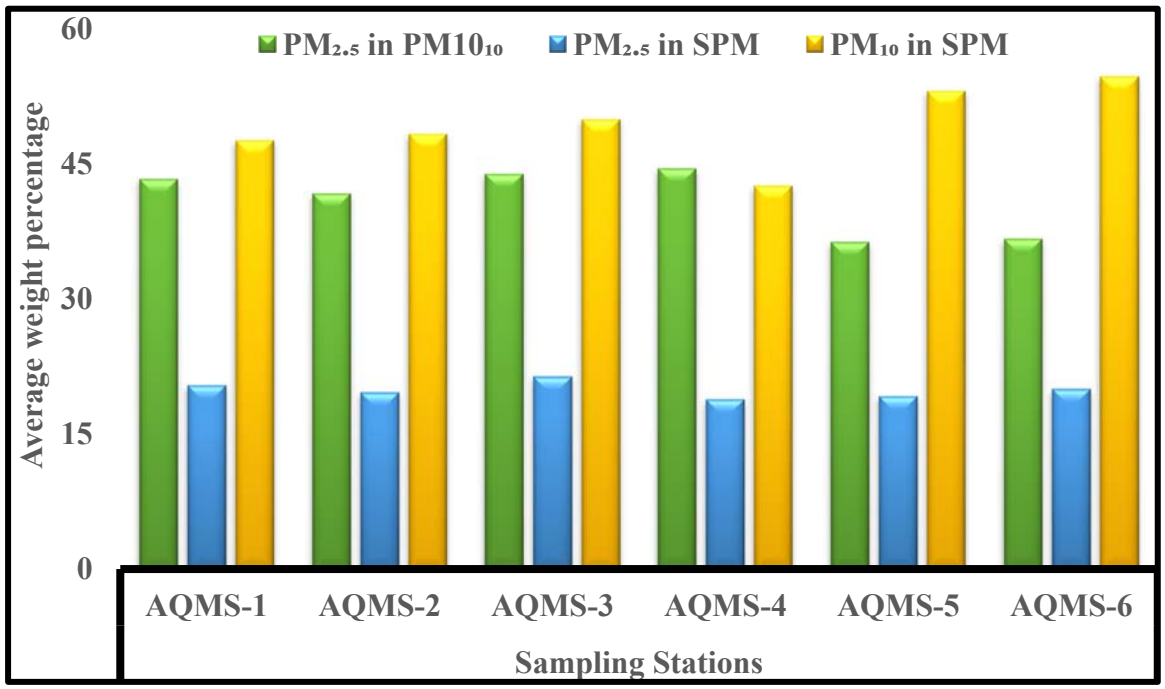

Fig. 4.10: Average weight percentage concentration of particulate matters in SPM

The average monthly fluctuation of sulfur dioxide is showing in **Fig. 4.9**. **Fig. 4.9** shows that the highest concentration was in November, December, and January and lowest in July, August, and September at all sampling locations in 2016 & 2017. It may be concluded that the SO_2 concentration has been well within the prescribed permissible limit (80 μg m^{-3}) **[101]**.

It has been realized that there may be some relation between $PM_{2.5}$ in total PM_{10} & SPM proceed by various activities. Keeping this idea in view, the average weight percentage of $PM_{2.5}$ in total PM_{10} & SPM was calculated and presented in **Fig. 4.10** in all four–monitoring stations. From **Fig. 4.10**, it is clear that $PM_{2.5}$ contributes to PM_{10} and SPM, varies from the average of 36%–45% and 19%–21%, respectively, and PM_{10} in SPM from average 48%–55% during two consecutive years (2016 & 2017). In Oct–17, the weight percentage % of $PM_{2.5}$ in PM_{10} has been maximum contribution 68%. Lowest 24% in Jul–17 and maximum contribution of $PM_{2.5}$ in SPM was 35% measured in Nov–17 and 9% lowest in Jul–17 in AQMS–04, respectively which means most of the particulates in PM_{10} is of fine particulate matter ($PM_{2.5}$). It was observed less in the rainy months during the study.

4.3 Frequency distribution of concentration of air pollutants

The frequency distribution of air pollutants concentration was also studied to know the number of sampling sites showing higher or lower concentration than the prescribed permissible limit **[101,102]**.

The frequency distribution of $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 concentration levels for the study periods of two consecutive years (2016 & 2017) were presented in **Figs. 4.11–4.15**. The daily $PM_{2.5}$, PM_{10}, SPM, NO_2, and SO_2 concentration levels in two years were divided into five ranges. The concentration of daily air pollutant value is compared with the Indian air quality reference values **[101,102]**.

In the distribution of $PM_{2.5}$ concentration, a peak is observed between 60 and 100 μg m^{-3} at all sampling stations. About 41% of $PM_{2.5}$ concentrations were below 60 μg m^{-3}, 49% in range of 60–100 μg m^{-3}, and 10% in range of 100–200 μg m^{-3}, around 70% of $PM_{2.5}$ concentrations exceeded the standard Indian value of 60 μg m^{-3} **[101] (Fig. 4.11)**.

In the PM_{10} levels, the peak was observed 100 to 200 μg m^{-3}, interval **(Fig. 4.12)**; 43% of PM_{10} levels were below 100 μg m^{-3}, and 57% of PM_{10} was above 100 μg m^{-3}. As far as SPM is concerned, the peak was observed 360 to 500 μg m^{-3}, interval **(Fig. 4.13)**; 35% of SPM concentrations were below 500 μg m^{-3}, and 18% of SPM was above 500 μg m^{-3}. However, 18% of SPM concentrations have been observed above the standard value of 500 μg m^{-3} **[102]**. In the NO_2 and SO_2 levels, the peak was 30 to 40 μg m^{-3}, and 14 to 18 μg m^{-3}, the interval in 38% and 45% **(Figs. 4.14 & 4.15)**, respectively.

The NO_2 and SO_2 concentrations were below the standard Indian value of 80 μg m^{-3} **[101]**. These values indicate the concentration level of nitrogen and sulfur dioxide of Singrauli coalfield, which is well within the prescribed permissible limit **[101]**.

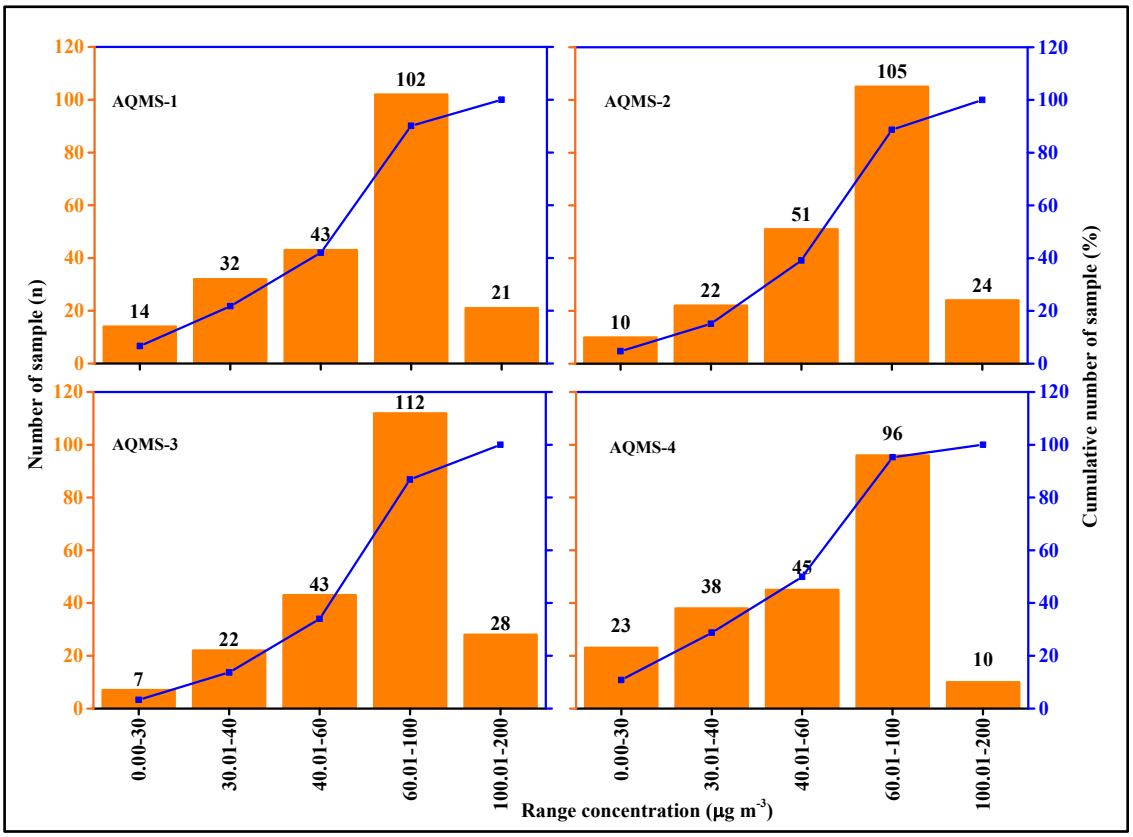

Fig. 4.11: Concentration of the frequency distribution of $PM_{2.5}$ during over the sampling period for two consecutive years (2016 & 2017)

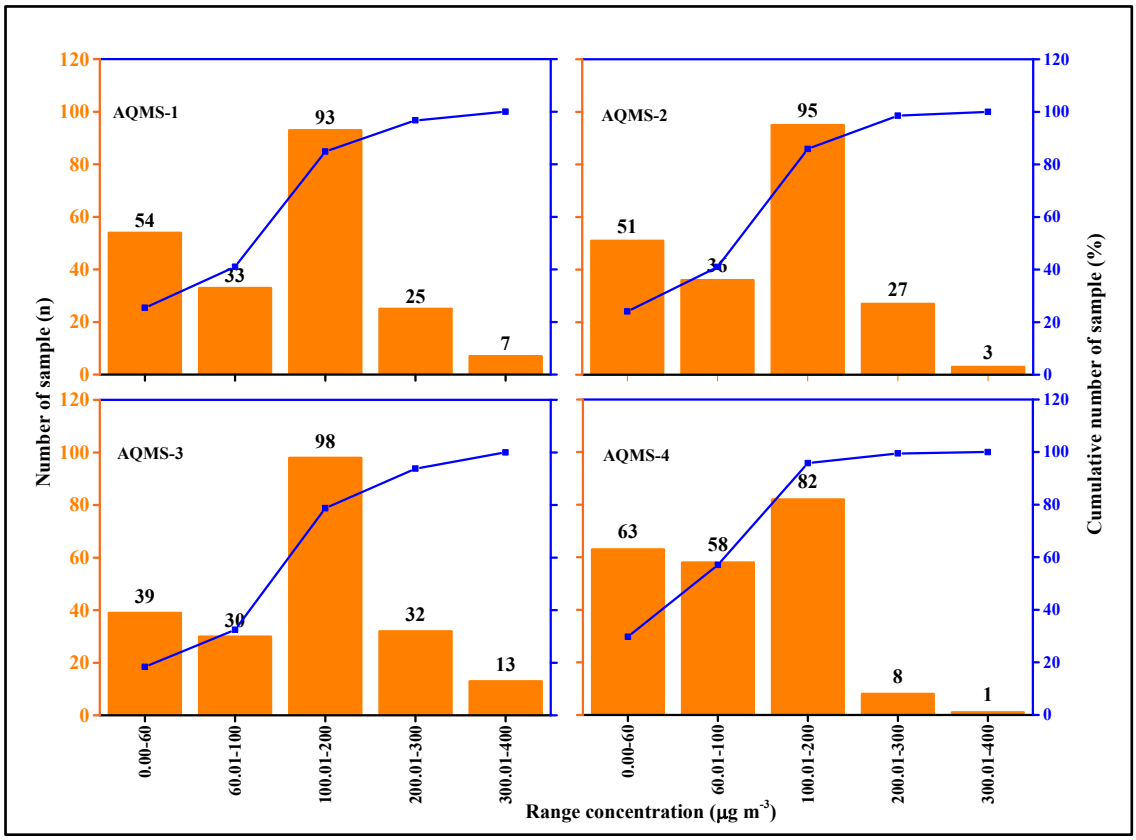

Fig. 4.12: Concentration of the frequency distribution of PM_{10} during over the sampling period for two consecutive years (2016 & 2017)

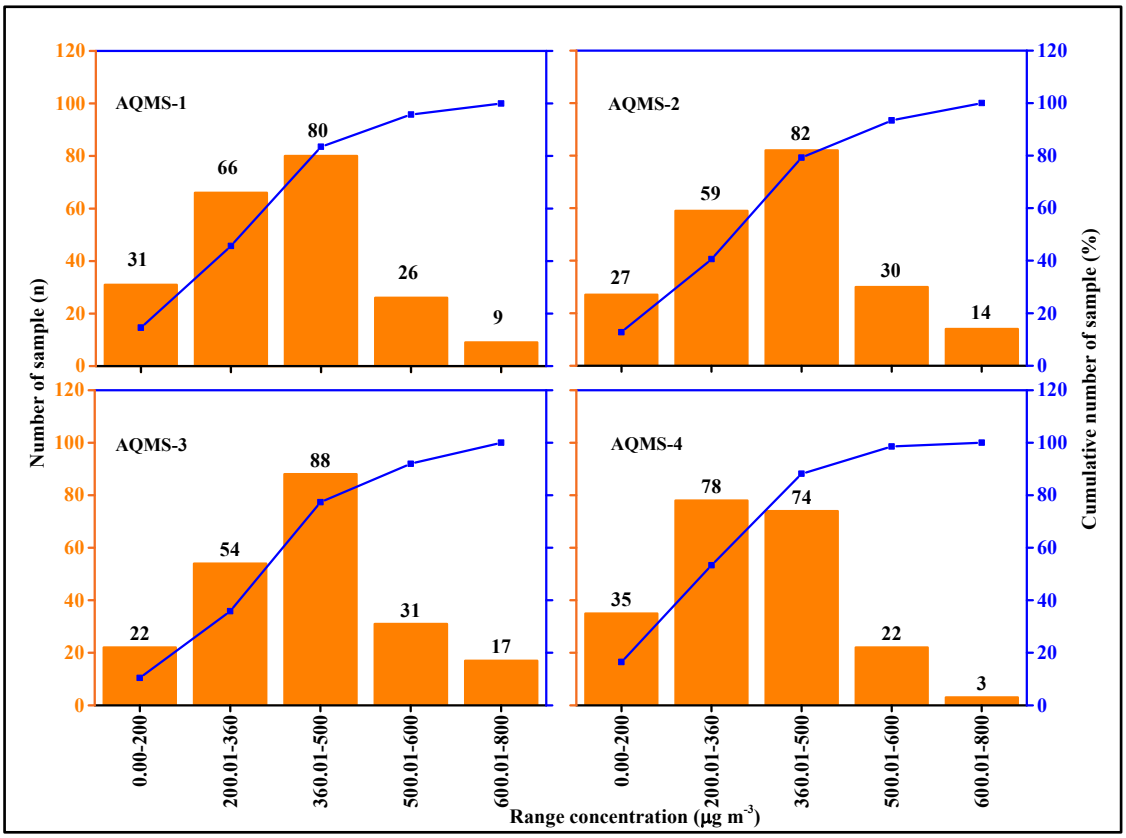

Fig. 4.13: Concentration of the frequency distribution of SPM during over the sampling period for two consecutive years (2016 & 2017)

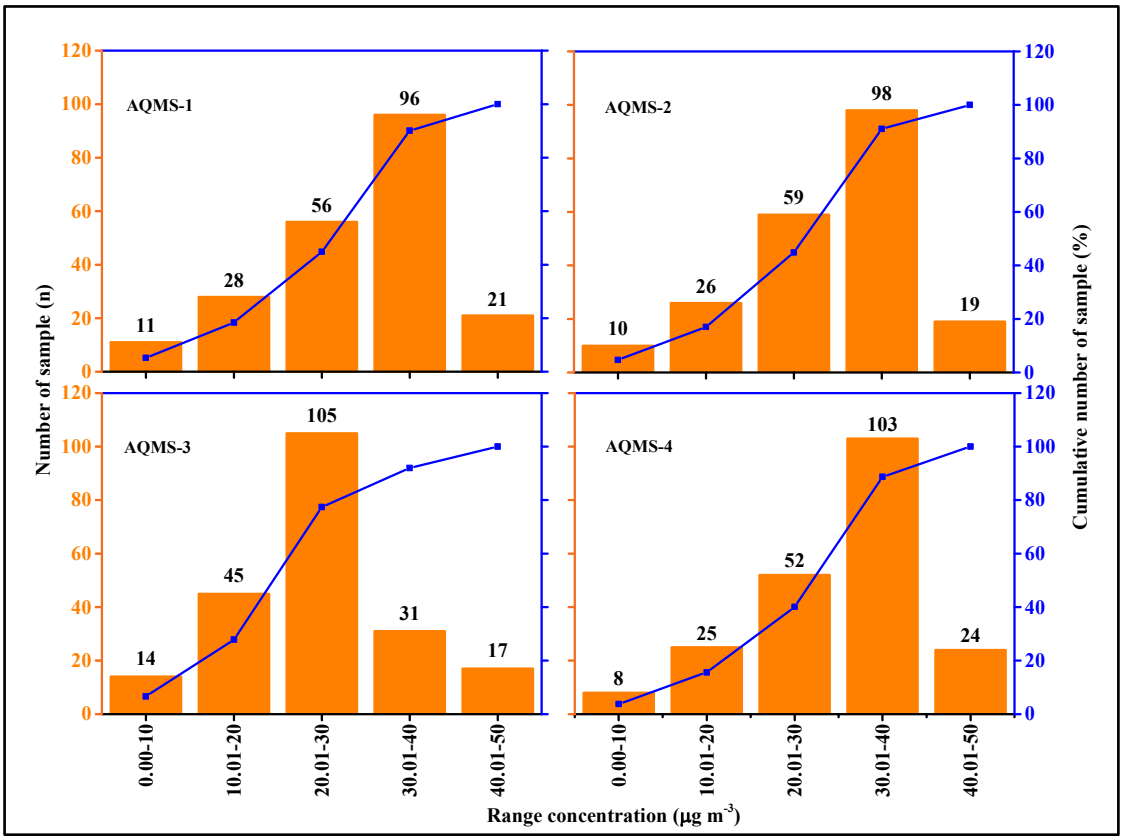

Fig. 4.14: Concentration of the frequency distribution of NO_2 during over the sampling period for two consecutive years (2016 & 2017)

4.4 Correlations among major air pollutants

The Pearson correlation coefficients, R was calculated among particulate matters, i.e., SPM, PM_{10}, and $PM_{2.5}$ and the gaseous pollutants, i.e., NO_2 and SO_2 at the monitoring sites **(Table 4.4)**. Particulate matters (SPM, PM_{10}, and $PM_{2.5}$) were highly correlated with NO_2 at over in the study area; R was in the range 0.45–0.85, reflecting their common origin. In general, the correlation coefficients were higher at the AQMS–03 than those in the industrial–cum residential area background, especially for PM_{10} due to the stronger influence of vehicle emissions. On the other hand, the correlation between suspended particulate matter and SO_2 was weaker, except for the monitoring sites.

However, PM_{10} and $PM_{2.5}$ were highly correlated with SO_2 at over in the study area. Finally, significant correlations have been found between PM and NO_2 (R = 0.4–0.8) related to primary emissions from combustion processes.

Table 4.4: Correlation among major air pollutants

	AQMS–01					AQMS–02				
	SPM	**PM_{10}**	**$PM_{2.5}$**	**NO_2**	**SO_2**	**SPM**	**PM_{10}**	**$PM_{2.5}$**	**NO_2**	**SO_2**
SPM	1.00					1.00				
PM_{10}	0.85	1.00				0.84	1.00			
$PM_{2.5}$	0.55	0.82	1.00			0.50	0.88	1.00		
NO_2	0.50	0.78	0.80	1.00		0.45	0.82	0.83	1.00	
SO_2	0.20	0.63	0.69	0.65	1.00	0.32	0.66	0.78	0.66	1.00
	AQMS–03					**AQMS–04**				
SPM	1.00					1.00				
PM_{10}	0.83	1.00				0.80	1.00			
$PM_{2.5}$	0.53	0.84	1.00			0.51	0.82	1.00		
NO_2	0.48	0.81	0.82	1.00		0.46	0.75	0.80	1.00	
SO_2	0.25	0.67	0.71	0.70	1.00	0.22	0.63	0.60	0.62	1.00
	AQMS–05					**AQMS–06**				
SPM	1.00					1.00				
PM_{10}	0.90	1.00				0.88	1.00			
$PM_{2.5}$	0.65	0.88	1.00			0.55	0.89	1.00		
NO_2	0.51	0.80	0.78	1.00		0.53	0.82	0.85	1.00	
SO_2	0.32	0.52	0.51	0.80	1.00	0.30	0.48	0.51	0.72	1.00

The critical value for the two–tailed test is 0.456 at 95% CI

4.5 Meteorological parameters and concentration of major air pollutants

It is observed from monitoring data that climate factors (wind speed, direction, temperature, humidity) plays an important role in suppressing or dispersing the air pollutants. Keeping these aspects in view, the meteorological parameters were also recorded along with air pollutants' monitoring.

Meteorology plays an essential role in the distribution of air pollutants in the ambient. There is a strong seasonality in meteorological variables that modulate air quality levels. **[92,144]**. Meteorological factors' significance inside the air pollution cycle's transport and diffusion level has been well identified. Meteorological elements consisting of wind speed, precipitation, and combining height all play essential roles in figuring out the pollutant levels for a given rate of pollutant emission **[159]**. The coming into of pollutants from the ground surface, their residence inside the atmosphere, and the formation of secondary pollutants are controlled now not most effective through the rate of emission of the reactants into the air from the source, however additionally by wind velocity, turbulence level, air temperature, and precipitation. Accordingly, it is often necessary to understand the physiological approach to the discovered concentration of pollutants at a given factor.

Rainfall is one reason for low particulate pollution inside the monsoon season as the contaminant is washed out by rain. Wet deposition with precipitation or wet removal is one of the predominant mechanisms for removing aerosols from the atmosphere **[160]**. Similarly, this particulate pollutant changes the precipitation pattern and spin down the hydrological cycle **[161]**. The monthly observation of meteorological parameters has given in **Table 4.5**. Air temperature ranged between 3°C and 46°C during two consecutive years (2016 & 2017). The minimum temperature, 3°C, was recorded for two consecutive years (2016 & 2017), and the maximum temperature, 46°C, was recorded in May–16 and April–17. The monthly average temperature varied from 14±4°C to 33±5°C. The lowest annual

average temperature, 25.2±1.1°C, was recorded in the year 2016, and the highest average yearly temperature, 26.1±1.2°C, was recorded in the year 2017.

The observed relative humidity varied between 5%–100% during two consecutive years (2016 & 2017). The annual average relative humidity, 41.1±3.2%, was observed highest in the year–16, and lowest average yearly relative humidity, 39.5±2.8% has found in the year–17. The monthly average of relative humidity varied from 23±13%–68±22% during the study period. The average monthly lowest relative humidity, 23±13, was noted in May–16 and April–17, and the average monthly highest humidity, 68±22%, was pointed out in December–16. Wind speed varied from 0.1 km h^{-1} to 20 km h^{-1} during 2016–17. The lowest wind speed has recorded in January 2017, which is 0.1 km h^{-1}, and the highest wind speed was recorded in June 2016, March and April 2017, which is 20 km h^{-1}. The monthly average of wind speed varied between 2.7±1.2 km h^{-1} to 8.2±3.4 km h^{-1}. The lowest annual average wind speed, 4.9±0.8 km h^{-1}, was recorded in 2016, and the highest average yearly wind speed, 5.8±0.7 km h^{-1}, has recorded in the year 2017.

The time series of particulate pollutants and meteorological variables are shown in **Figs. 4.16–4.18**. It may show the monthly variations of temperature, wind speed, relative humidity, $PM_{2.5}$, PM_{10}, and SPM concentration for the study area during two consecutive years. The rainy season winds control many pollutions in South and East Asian countries such as India and China. The rainy season winds, which come from the southwest during the rainy season, are characterized by heavy rains and winds. The monsoon collects moisture in the Indian Ocean and releases it into South and Southeast Asia. In contrast, during winter, the predominant wind direction is from the northeast and is characterized by a dry air mass, which produces almost no rain as air travels over continental lands.

Table 4.5: Monthly observation of meteorological parameters

Year	Month	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})		Wind direction w.r.t. N
		Range	Average	Range	Average	Range	Average	
2016	**Jan**	4–27	14±4	28–100	63±18	0.3–10	2.7±1.2	21.89
	Feb	9–31	17±5	21–95	45±18	0.4–12	4.4±1.3	21.59
	Mar	16–45	27±6	10–85	38±16	0.2–14	4.8±3.0	22.19
	Apr	22–41	31±6	6–56	26±12	0.3–18	7.1±2.7	53.49
	May	19–46	33±5	7–60	23±13	0.5–19	8.2±3.4	30.79
	Jun	17–45	31±5	6–58	34±12	0.7–20	5.9±2.8	33.79
	Jul	12–38	28±3	10–80	40±11	0.7–17	4.7±3.4	23.40
	Aug	13–38	30±3	12–75	40±13	0.8–16	5.6±2.8	49.68
	Sep	12–36	27±5	13–78	39±14	0.9–15	4.6±3.2	30.75
	Oct	10–31	26±4	15–70	39±14	0.7–14	3.5±2.0	35.13
	Nov	8–28	20±5	17–88	38±13	0.7–11	4.0±1.8	52.56
	Dec	4–28	15±6	20–100	68±22	0.2–9	3.0±2.0	51.38
2017	**Jan**	3–27	15±6	23–100	63±18	0.1–9	3.1±1.8	38.59
	Feb	8–33	20±5	11–83	42±18	0.2–18	5.0±3.4	37.95
	Mar	12–44	29±6	13–72	40±15	0.7–20	6.0±2.8	35.01
	Apr	17–46	32±5	5–68	23±14	0.8–20	6.0±3.2	44.47
	May	19–45	33±5	8–57	32±13	0.9–18	6.7±2.0	41.12
	Jun	18–45	32±6	7–70	39±12	0.8–16	8.0±1.8	50.97
	Jul	13–38	28±6	15–80	39±11	0.7–15	6.8±3.4	83.65
	Aug	13–39	27±3	18–78	32±13	0.8–14	8.0±2.8	124.08
	Sep	12–36	27±4	15–70	33±14	0.9–15	6.8±3.2	108.00
	Oct	12–34	25±4	14–88	30±10	0.9–14	6.8±2.0	128.15
	Nov	7–28	25±3	18–93	36±12	0.8–12	3.2±1.8	50.85
	Dec	3–28	17±3	22–100	65±18	0.9–10	3.2±2.4	126.34

± *Standard Deviation*

The highest PM_{10} and SPM concentrations were also affected due to wind speed. Wind affects turbulence near the ground, thus affecting the spread of pollutants released into the air. Turbulence (roughly up and downwind speed) is generated in part by airflow over rough ground. The higher the wind speed, the greater the turbulence, and therefore the greater the spread of pollutants present near the ground **[162]**. It was found that precipitation and wind speed causes a decrease particulate matter particles' level in the atmospheric atmosphere. It was also found that precipitation has a relatively high precipitation level with a decrease in particulate matter particle levels compared to other parameters. Due to rainfall, the soil becomes moist, thus limiting the possibility of particles coming out of the soil **[163,164]**.

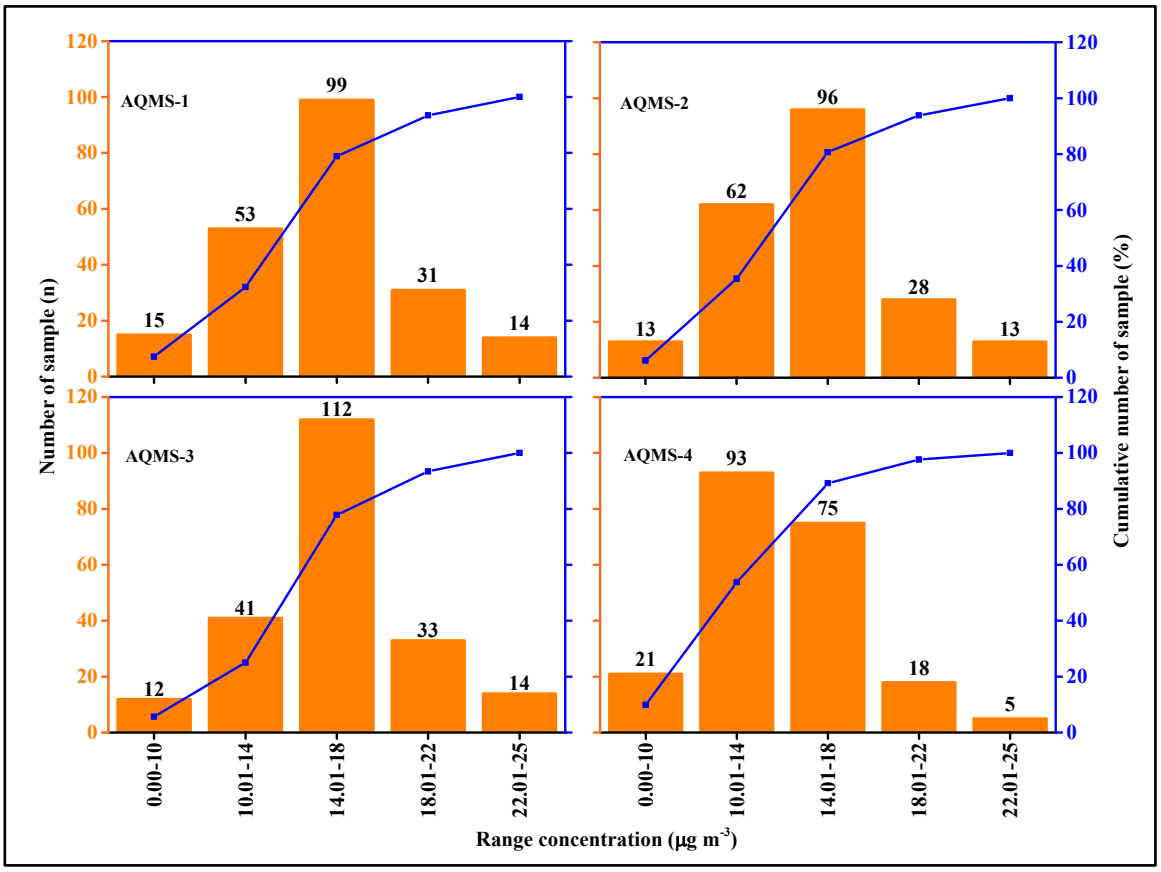

Fig. 4.15: Concentration of the frequency distribution of SO_2 during over the sampling period for two consecutive years (2016 & 2017)

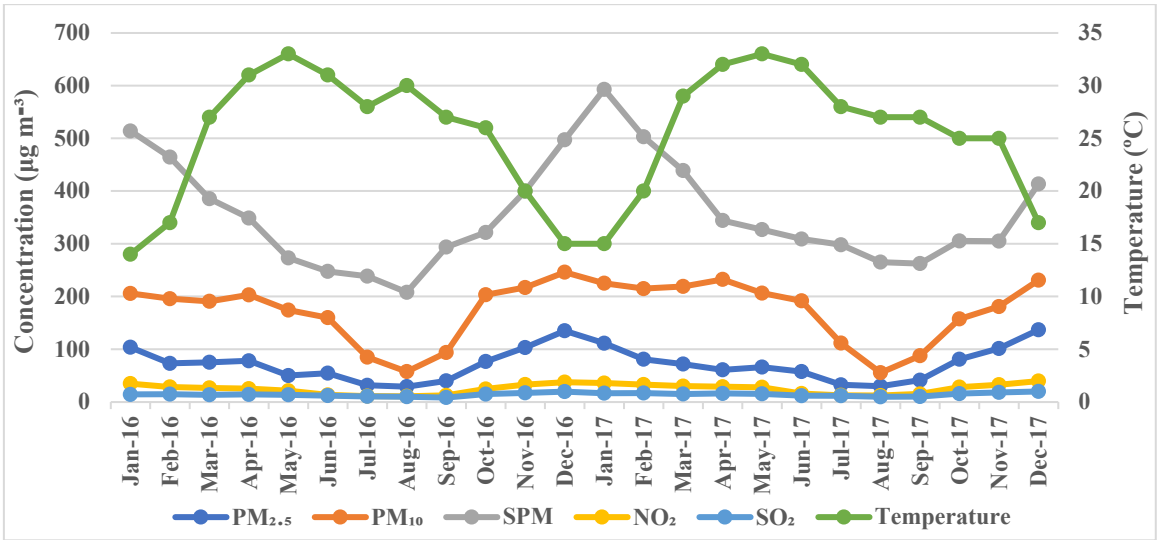

Fig. 4.16. Monthly variations of measured air pollutants and temperature of two consecutive years (2016 & 2017)

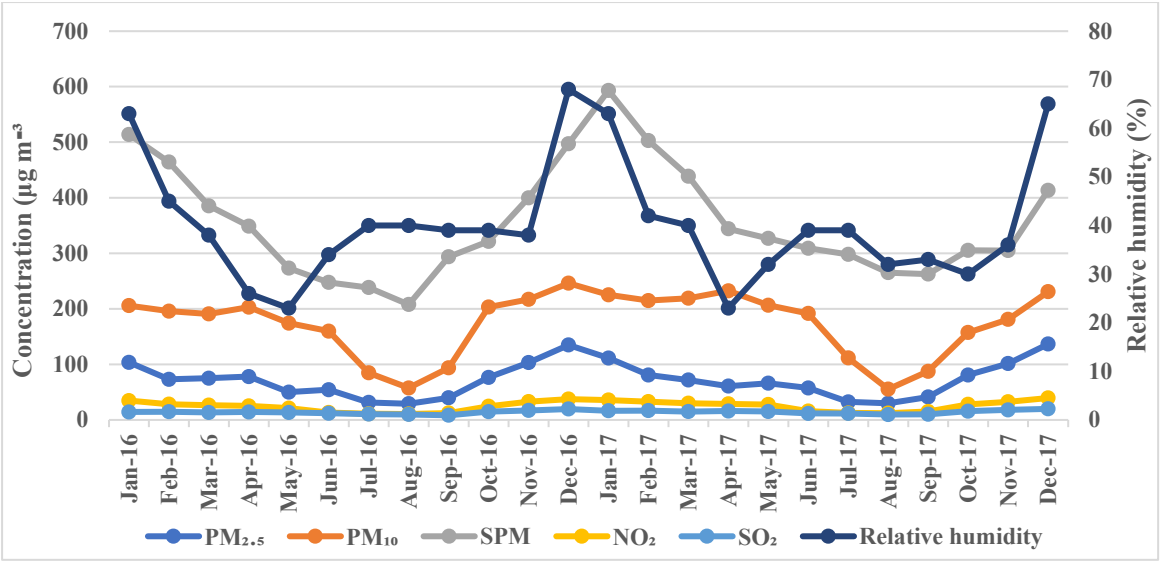

Fig. 4.17. Monthly variations of measured air pollutants and relative humidity of two consecutive years (2016 & 2017)

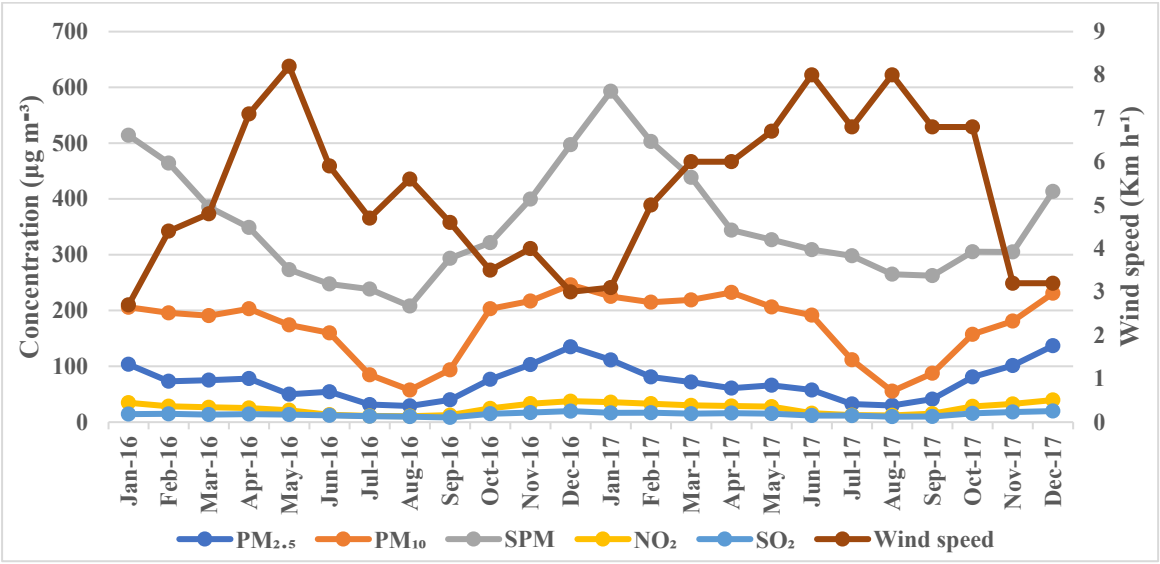

Fig. 4.18. Monthly variations of measured air pollutants and wind speed of two consecutive years (2016 & 2017)

The topography is also one of the parameters to be considered in air quality studies. The topography all around restricts the transport of pollution away from the industrial zone. When a weak background syntopic circulation is combined with valley air temperature inversion and surrounding organic blockade, it often results in the lack of dispersion of significant atmospheric pollutants away from industrial centers **[165,166]**. As far as the area's topography is concerned, the land is surrounded by a gently sloping beautiful area,

which is far from the city. But the height is very insignificant. This study area's flat topography experiences horizontally homogeneous airflow and steady–meteorological conditions, which do not allow the accumulation of pollutants.

4.6 Air pollution index

In this section, the air quality index (AQI) has been calculated and discussed. An air quality index is defined as a numerical rating that reflects the composite influence on the overall quality of several air quality parameters, which will advise public and urban planning **[156]**. AQI has focused on the health effects that polluted air can experience within a few hours or days of breathing. AQI varies from 0 to 500, and its health indicators are outlined in **Table 4.6 [167]**.

Table 4.6: AQI values and level of health concerns

Sl. No.	AQI value (Range)	air quality conditions	Color Code	Potential Health Effects
1	0–50	Good		Minimal impact
2	51–100	Satisfactory		Sensitive people suffer from breathing
3	101–200	Moderate		People are feeling restless with lungs, asthma and heart diseases
4	201–300	Poor		Most people suffer from breathing at prolonged exposure
5	301–400	Very Poor		Respiratory disease
6	401–500	Severe		It affects healthy people and seriously affects people with current diseases

The AQI is calculated using the following equation:

$$I_p = \left[\left(\frac{I_{HI} - I_{LO}}{B_{HI} - B_{LO}}\right) \times (C_p - B_{LO})\right] + I_{LO}$$

where, B_{HI} = Breakpoint concentration greater or equal to given concentration

B_{LO} = Breakpoint concentration smaller or equal to given concentration

I_{HI} = AQI value corresponding to B_{HI}

I_{LO} = AQI value corresponding to B_{LO}; subtract one from I_{LO}, if I_{LO} is greater than 50

Finally; $AQI = Max\ (I_p);\ (where, p = 1,2,\ldots,n;\ denotes\ n\ pollutants)$

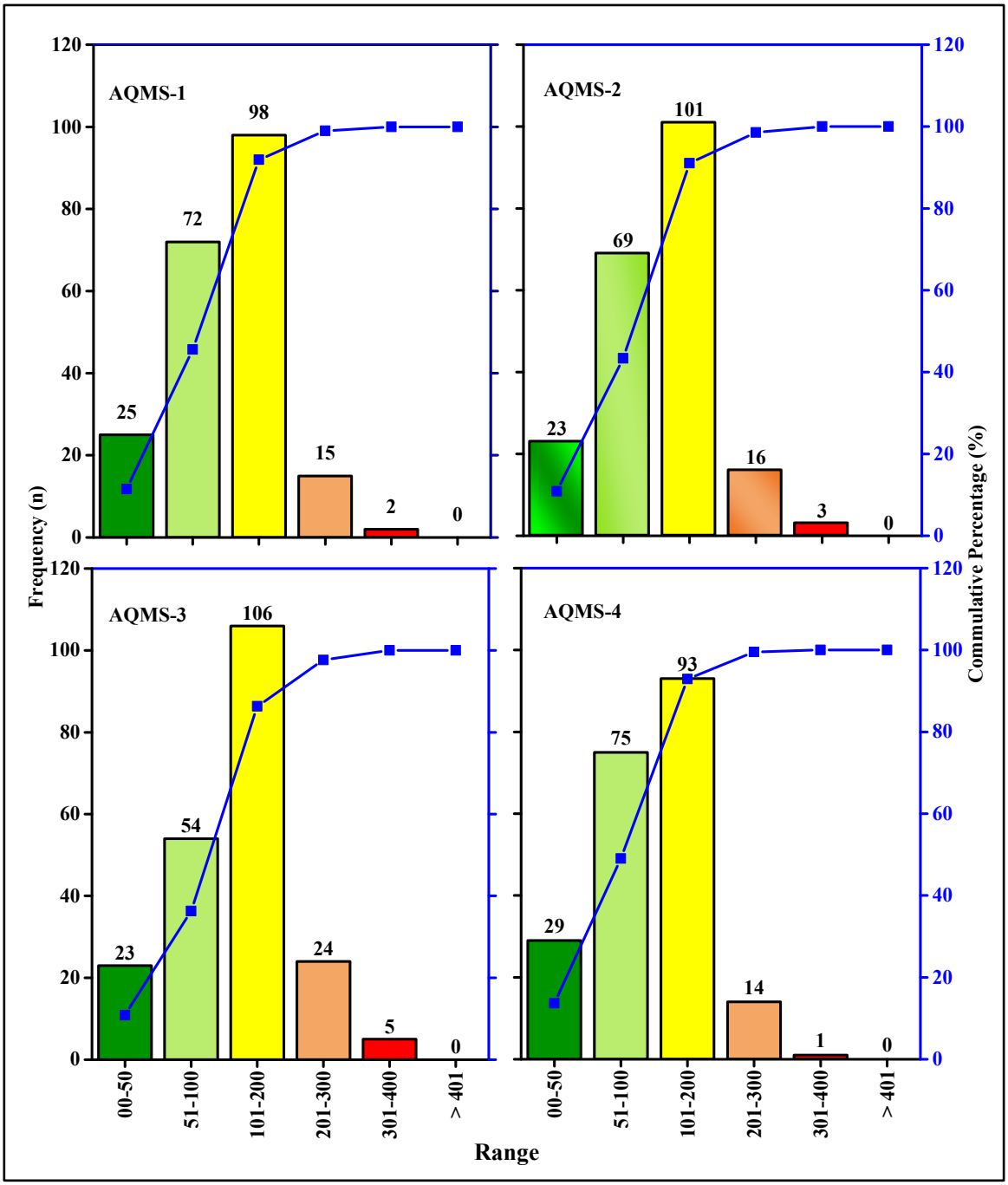

Fig. 4.19: Frequency distribution of air quality index during two consecutive years (2016 & 2017)

The higher AQI value and a higher level of air pollution will be more health concerns. The AQI value of 100 generally corresponds to the National Air Quality Standard, which is the level set for protecting public health in India. Less than 100 AQI values are usually considered satisfactory. When the value of AQI is above 100, then for some sensitive groups of people, the first air quality has deemed to be unhealthy, then for high AQI values for everyone **[157]**. The frequency distribution of the air quality index during the study area is shown in **Fig 4.19**. Air quality index values varied from 30 to 332 for the two consecutive years (2016 & 2017) in the area.

Higher AQI was estimated mostly in the winter season at some sites and in the winter season at some other sites. Low AQI values have been observed in the rainy season. The highest AQI values seen in the winter season can be attributed to weather conditions, less normal circulation, and more stable wind masses. Due to the velocity of rainfall and high air during the summer season, average air direction changes are also a significant cause of AQI. It helps in the wet depiction of rain pollutants. Changes in air velocity and the reversal of its trend increase the likelihood of the pollutants being removed from the sources and the weakness of pollutants concentration. It may be noted that the highest AQI value was seeing in mixed–use areas. The highest peak was observed in the value range of 101–200, which was observed 47±2% over the two consecutive years (2016 & 2017) in the study area. From these AQI estimates, it is clear that the particulate pollutants are emerging as critical pollutants for attention because they are degrading air quality in the study area with consequent effects on public health. Based on the rating scale **(Fig. 4.19)**, it is found that the atmospheric environment of Singrauli coalfield has polluted and fallen under moderate to poor condition. This indicates an urgent need for precise control of atmospheric

pollutants from anthropogenic sources, especially pollutant particles, to protect social property, along with human populations, flora, and fauna.

4.7 Conclusion

A field measurement was conducted to obtain the concentration of SPM, PM_{10}, $PM_{2.5}$, NO_2, and SO_2 around the Singrauli coalfield (Mining activities and thermal power plants). The highest annual average level was measured (81.3±38.9 μg m^{-3}) in the years 2017, and the lowest average yearly level was measured (66.4±37.3 μg m^{-3}) in the year 2016 for $PM_{2.5}$. The level of PM_{10} was varying from 178±77.0 μg m^{-3} to 230.3±38.2 μg m^{-3}. The highest level was observed (351.2 μg m^{-3}) and the lowest level (28.1 μg m^{-3}) in 2017. The twenty–four hours PM_{10} concentrations in the industrial cum–residential area were higher than the National Ambient Air Quality Standards of 100 μg m^{-3}, respectively.

The particulate matter of different sizes is a considerable amount in air of the Singrauli industrial complex. At few locations in the study area, the control measures may be deployed to reduce the concentration below the recommended permissible limit. High concentrations were observed in the winter seasons for major air pollutants (SPM, PM_{10}, $PM_{2.5}$, NO_2, and SO_2) in the area. In the winter season, the temperature is low, and the wind speed is usually moderate. Due to this situation, the planetary boundary layer's height decreases, so pollutants will not spread, and pollutants will accumulate in this season. During the rainy season, particulate pollutants are washed out of the atmosphere by precipitation. Wet deposition by precipitation or wet expulsion is one of the primary mechanisms to remove aerosols from the atmosphere.

Lower concentrations of pollutants have been observed during the monsoon season. This study will help in further research to understand aerosols behaviour in the Singrauli coalfield.

Air quality index values varying from 30 to 332, and the highest peak value ranged from 101–200, which percentage was found 47±2% over the two consecutive years (2016 & 2017) in the area. Based on the rating scale, it is found that the atmospheric environment in the study area has polluted and fallen under moderate to poor condition. Therefore, it can be concluded that adequate control measures and strict implementation of environmental regulations are urgently required

The study area is expanding rapidly with human and animal populations, vehicle traffic, industrialization. Hence, per capita energy consumption is increasing in the area. These developments are increasing atmospheric aerosol concentrations, which, in turn, are significantly growing ambient air pollution. Positively, these increases will adversely affect the climate and health and the personal and social wealth of the people living in the study area.