Bangladesh J. Environ. Sci., Vol. 42, 69-77, 2022 **@ BAED ISSN 1561-9206**

AIR QUALITY STATUS IN NARAYANGANJ INDUSTRIAL CITY OF BANGLADESH

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ABSTRACT

The study was conducted to observe the effects of seasonal variations (dry and wet) of air pollutant concentration in Narayanganj during November 2016 to October 2017. The highest particulate matter ($PM_{2.5}$ and PM_{10}) was found in January (237.04 and 397.56 µg/m^3) and lowest particulate matter ($PM_{2.5}$ and PM_{10}) was found in July (20.9 and 39.3 µg/m^3). Similarly, the maximum SO_2 and NO_2 concentration reached (22.5 and 108 ppb, respectively) in dry season (November to March) compared to wet season (1.06 and 25.5 ppb). The study reveals the strong seasonal variations of atmospheric ozone concentrations with dry season maximum (11.28 ppb) and wet season minimum (1.89 ppb) levels. The concentration of all air pollutants showed several times higher level in dry season than those of the wet season (April to October). The study determined the highest AQI value found 821 in January and lowest value found 13 in August.

Key words: Air pollutants, dry season, wet season, AQI, Bangladesh.

Introduction

Air pollution is becoming an urgent concern in South Asian countries such as Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka because of increasing urbanization and economic growth. In South Asia, airborne particulate matter (PM_{10} and $PM_{2.5}$) is a major concern because of its high ambient concentrations and documented impact on morbidity and premature mortality (Begum and Hopke, 2018). In recent years, the deterioration of air quality in urban areas has been caused by continuous industrial and commercial development, population growth and an increase in energy consumption (Banerjee *et al.*, 2011). Rapid economic growth, growing needs for goods and personal transportation have made Bangladesh one of the fastest growing in automobile sector and vehicular emission is also growing in parallel (CASE Project, 2011). The high influx of population to urban areas, increase in consumption patterns and unplanned urban and industrial development has led to the problem of air pollution (Gidde and Sonawane, 2012). According to the World Health Organization (WHO), approximately 3 million people die each year due to air pollution in the world. Narayanganj, a district town far 30 km south east fromf capital city of Bangladesh. Here, the river port is one of the oldest in Bangladesh. Rapid urbanization without considering the geological aspects has brought significant changes in the geo-environment of the Narayanganj city. However, air pollution becoming a major threat for the city dwellers due to various industries and traffic movement (Banglapedia, 2017). Therefore, the present study aims:(i) to determine the status of air pollutants ($PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3), (ii) to determine the influence of seasonal variations (pre-monsoon, monsoon, post-monsoon, winter) of air pollutants, and (iii) to examine air quality index (AQI) status of Narayanganj, Bangladesh.

Materials and Methods

Description of the study area and sampling sites: The study was conducted on Narayanganj, district lies between 23°33’ and 23°57’ north latitudes and between 90°26’ and 90°45’east longitudes. The current population of Narayanganj is estimated to be about 29, 48,217. The annual average temperature of the district varies maximum 36°C to minimum 12.7°C and the average annual rainfall is 2376 mm. Shitalakshya, Meghna, Old Brahmaputra, Buriganga, Balu and Dhaleshwari are the main rivers of Narayanganj district. The city has three distinct seasons: winter (November-February), dry with temperature 10° to 20°C; summer: the pre-monsoon season (March-June), some rain and hot with temperature reaching up to 40°C; and the monsoon (July-October), very wet with temperatures around 30°C (BBS, 2015; Banglapedia, 2017). A Continuous Air Monitoring Station (CAMS) was operated to measure criteria pollutants at the first floor of the guardhouse at 200 Bed Government Hospital in Khanpur, Narayanganj.

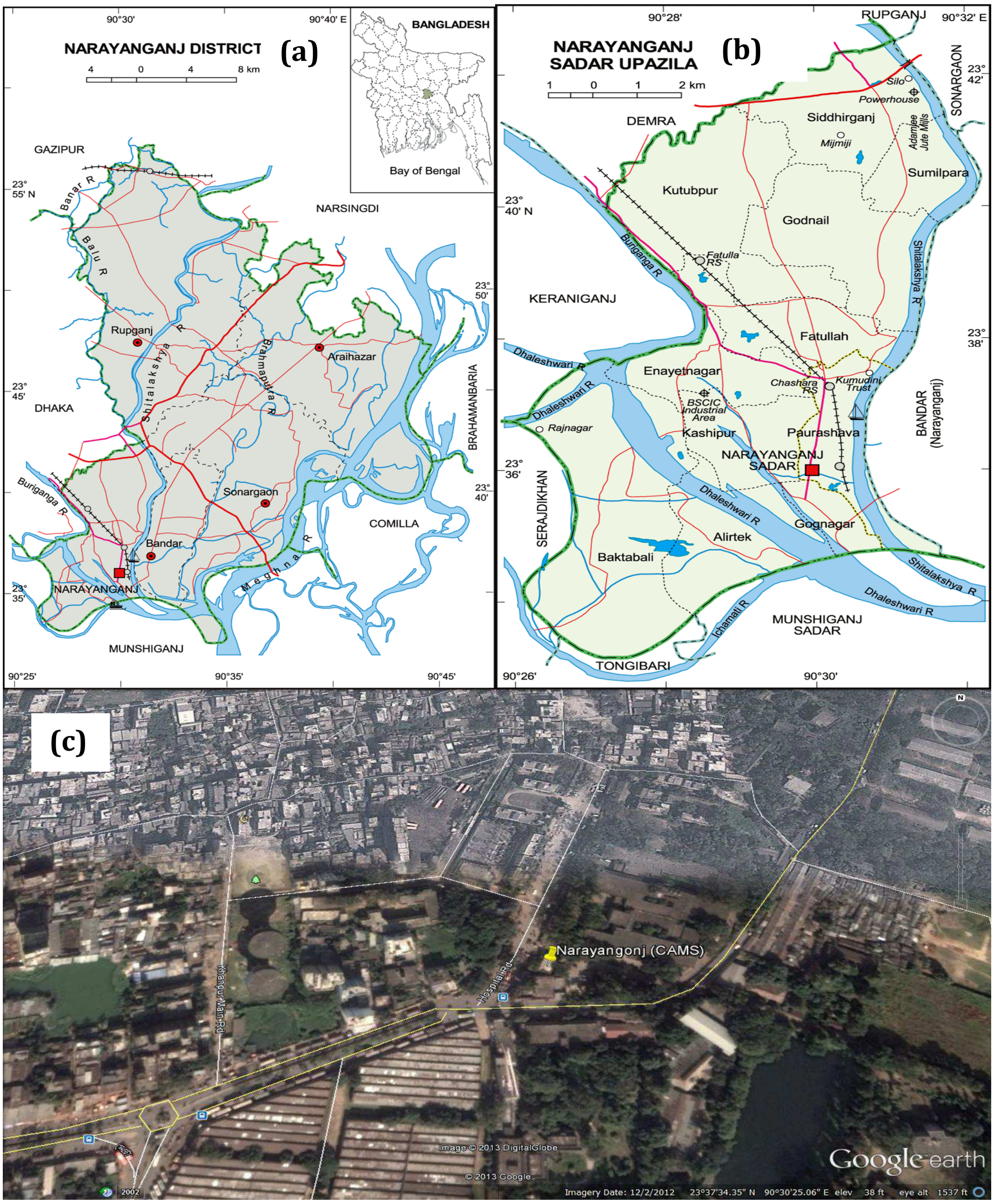

Fig. 1. Location map for the study area (a) Narayanganj District, (b) Narayanganj Sadar Upazila, (c) CAMS-05 Station (Narayanganj)

Different emission sources are located around the CAMS site, i.e. Diesel run water vessels movement just 200m south of the site, Chasara intersection is located at 1km west to the site and some industries located just 0.5km north side of CAMS. This site is characterized by different emission sources. The sampling inlet for gaseous and particulate matter was placed on the flat roof two storied building of the CAMS housing. The roof height was 7 m above the ground and the intake nozzle of the sampler was located 1.8 m above the roof. The site is about 5 meters away from the traffic artery with good natural ventilation.

Primary data collection: Primary data were collected through field observation, auto measurement gas analyzer and on laboratory work on clean air monitoring station (CAMS-5) during post-monsoon (October and November), winter (December to February), pre-monsoon (March to May), and monsoon (June to September) from October, 2016 to June, 2017. This location is also characterized as high rush-hour traffic for the reason that a large number of vehicles move around Narayanganj city. Air pollution data on PM_{10}, $PM_{2.5}$, NO_2, SO_2 and O_3 levels were collected from Narayanganj (CAMS-5). The Statistical Analysis Software (SAS) was used to determine significant levels of air pollution in Narayanganj city.

Secondary data collection: Apart from primary data collection secondary data were collected from authentic and related authorities and institutions, national and international journals, available books, related reports, thesis and newsletters, research papers, internet website, census and National encyclopedia of Bangladesh. Meteorological data were collected from Bangladesh Department of Environment and Bangladesh weather station.

Methods of analyzers: Gas analyzers were accessible at CAMS-5, include Sulfur dioxide (SO_2) analyzer, Nitrogen oxides (NO_x) analyzer, and Ozone (O_3) analyzer. They were nonstop computing the concentration SO_2, NO_2, and O_3 contemporary in the ambient air. These analyzers were used for continuous measurement of trace gases where O_3 was observed with a UV photometric analyzer (Teledyne Monitor Labs (TML), Inc., model 9810B); NO_2 using chemiluminescence analyzer (TML, model 9841B) and SO_2 were measured using a pulsed UV fluorescence analyzer (TML, model 9850B), respectively. The calibration procedures were perceptible as per National Institute of Standards and Technology (NIST) standard.

Data analysis and presentation: After receiving the air pollutant parameters laboratory test results, data were compiled, tabulated and analyzed through Microsoft Office Excel 13 software and SPSS (version 20.0). Correlation analysis was done to illustrate the interrelationships between the parameters.

Results and Discussion

Seasonal variation of ambient air quality in Narayanganj city: The seasonal variation of 5 (five) air pollutants ($PM_{2.5}$, PM_{10}, SO_2, NO_2 and O_3) in the study area are shown in Table 1. All of the pollutants, including gaseous and particulates, showed the highest concentration in winter season and lowest in monsoon season.

Table1. Seasonal variation of air pollutants in Narayanganj city

Season	$PM_{2.5}$ (µg /m^3)	PM_{10} (µg /m^3)	SO_2 (ppb)	NO_2 (ppb)	O_3 (ppb)
Post monsoon	86.7	213	4.4	50.8	5.04
Winter	208.3	367.9	14.3	79.7	8.05
Pre monsoon	54.8	169.7	8.02	33.5	7.2
Monsoon	30.2	71.9	1.4	25.8	2.3

Monthly average concentration of $PM_{2.5}$: Figure 2 shows the variations of $PM_{2.5}$ during post-monsoon (October and November), winter (December to February), pre-monsoon (March to May), and monsoon (June to September) at Narayanganj city. The highest value of $PM_{2.5}$ (237.04 µg/m^3) was found in January 2017, and the lowest value of $PM_{2.5}$ (20.9 µg/m^3) was measured in July 2017. The average concentration of $PM_{2.5}$ was 90.3 µg/m^3 which are six times higher than the annual Bangladeshi standard (15 µg/m^3) (CASE, 2013; Hossen and Hoque, 2016).

Monthly average concentration of PM_{10}: The highest value of PM_{10} (397.56 µg/m^3) was found in January 2017, and the lowest value (39.3 µg/m^3) was found in July 2017 (Fig. 3). Similar studies were conducted in Chittagong (Rouf *et al.*, 2011) and in Andhra Pradesh (Srinivas *et al.*, 2013), where the highest concentration found in January and lowest in July. The average annual pollutant level of PM_{10} was 188.6 µg/m^3 which exceeded 3.8 times from the annual standards (50 µg/m^3) for Bangladesh (CASE, 2013; Hossen and Hoque, 2016). The high PM_{10} in winter was occurred due to dry soil conditions, low relative humidity, scanty rainfall and low northwesterly prevailing winds (Begum *et al.*, 2010).

Monthly average concentration of SO_2: The SO_2 concentration of the study area shows increasing trends from October to February and decreasing from March to September (Fig. 4). During the observation, the highest concentration of SO_2 (22.5 ppb) found in winter season 2017 and the lowest concentration of SO_2 (1.06 ppb) in the monsoon season 2017. Similar studies were observed in Chittagong (Rouf *et al.*, 2011). The utmost peak was found in a wet season, coal-fired power plants and industry considering the primary source of pollutants contributing to these air quality problems (BP P.L.C., 2016). The average annual concentration level of SO_2 found 6.8 (ppb) which 4.5 times lower than the annual air quality standards (30.5 ppb) for Bangladesh (CASE, 2013; Hossen and Hoque, 2016).

Monthly average concentration of NO_2: During the observations, the highest concentration of NO_2 (108 ppb) was found in the winter season, and the lowest concentration of NO_2 (14.9 ppb) was measured in the monsoon season (Fig. 5). Similar studies were reported in Chittagong (Rouf *et al.*, 2011). The average annual concentration of NO_2 found 45.36 (ppb) which 1.2 times below the annual ambient air quality standards (53.2 ppb) for Bangladesh (Ahmmed *et al*. 2010; CASE, 2013; Hossen and Hoque, 2016). Maximum value of the NO_2 concentration levels reach higher in dry season compared to wet season. Emissions of NO_2 are produced primarily when fossil fuels are burned in motor vehicle engines, power plants, and industrial boilers. Mobile sources (including on-road and others) of NO_2 include emissions from aircraft, trains, ships, recreational boats, industrial and construction equipment, farm equipment, off-road recreational vehicles, and other equipment (Kgabi and Sehloho, 2012).

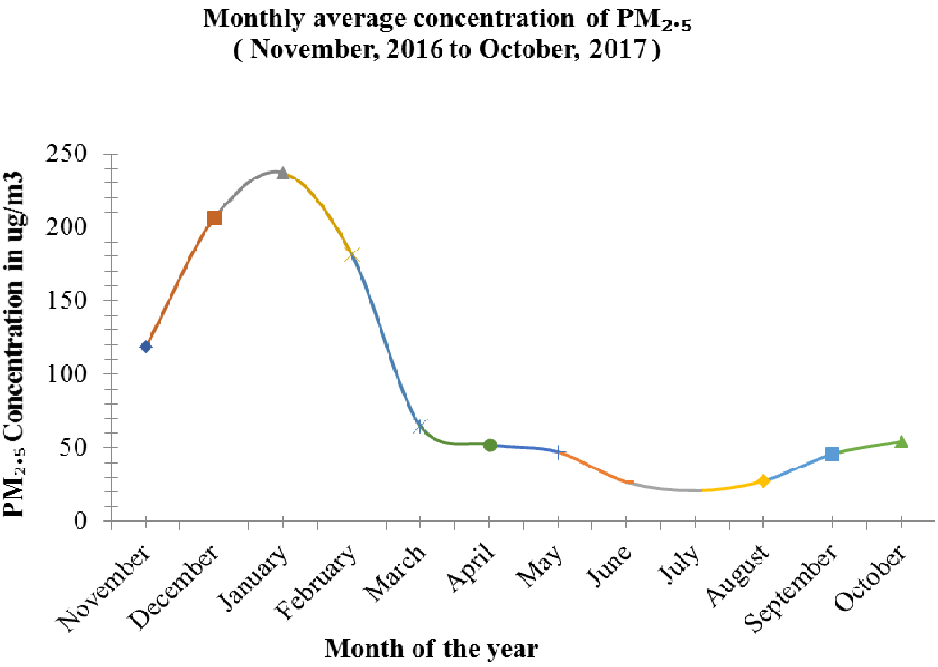

Fig. 2. Monthly average concentration of $PM_{2.5}$

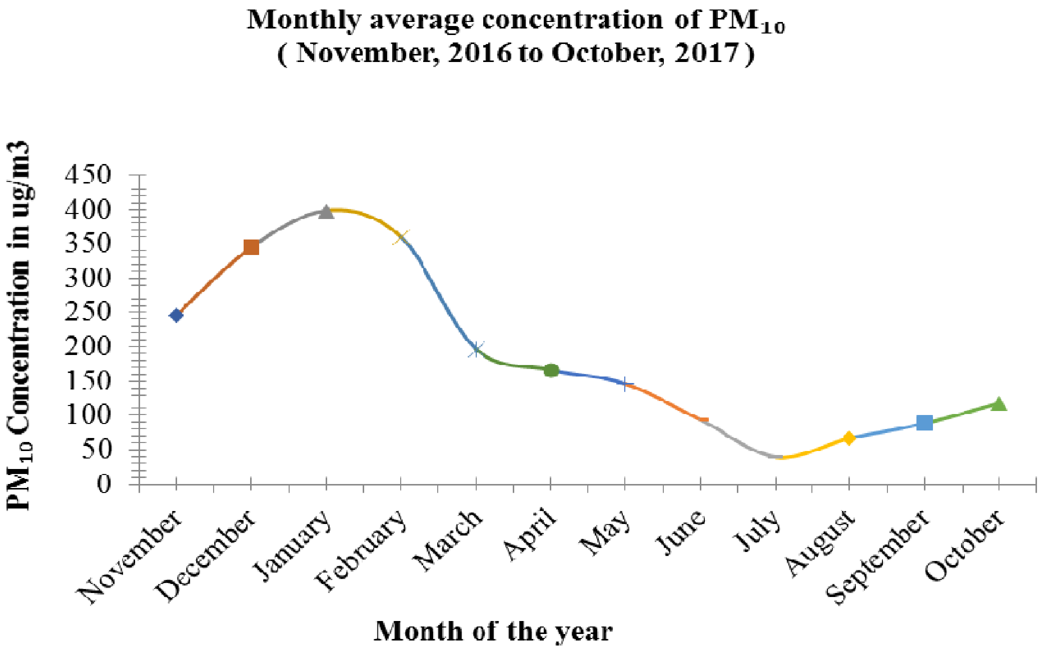

Fig. 3. Monthly average concentration of PM_{10}

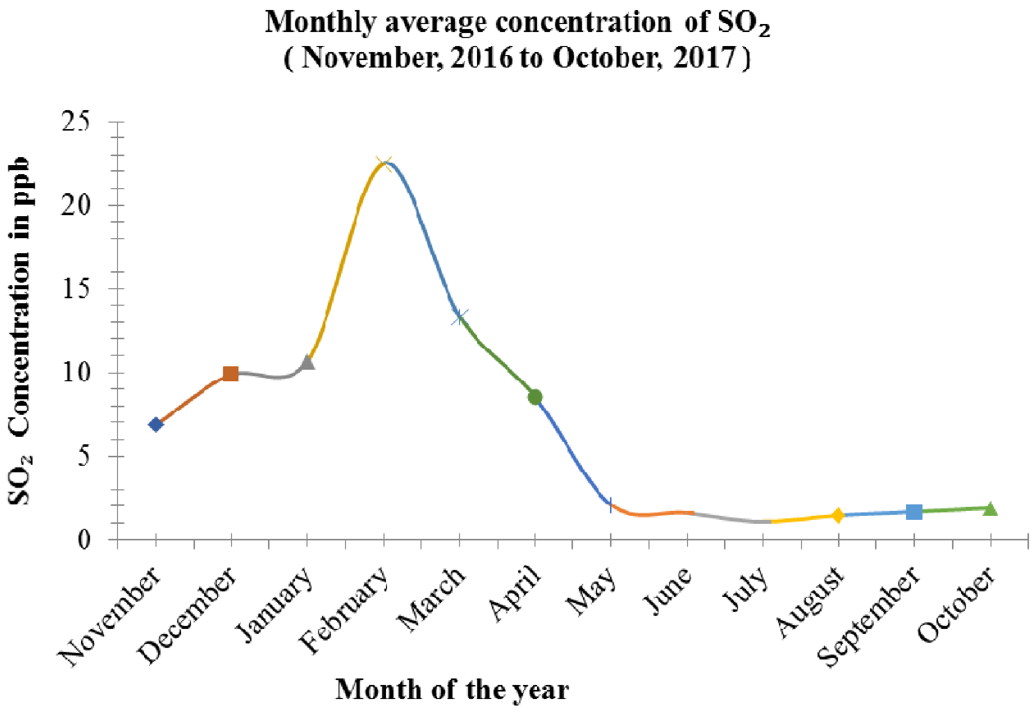

Fig. 4. Monthly average concentration of SO_2

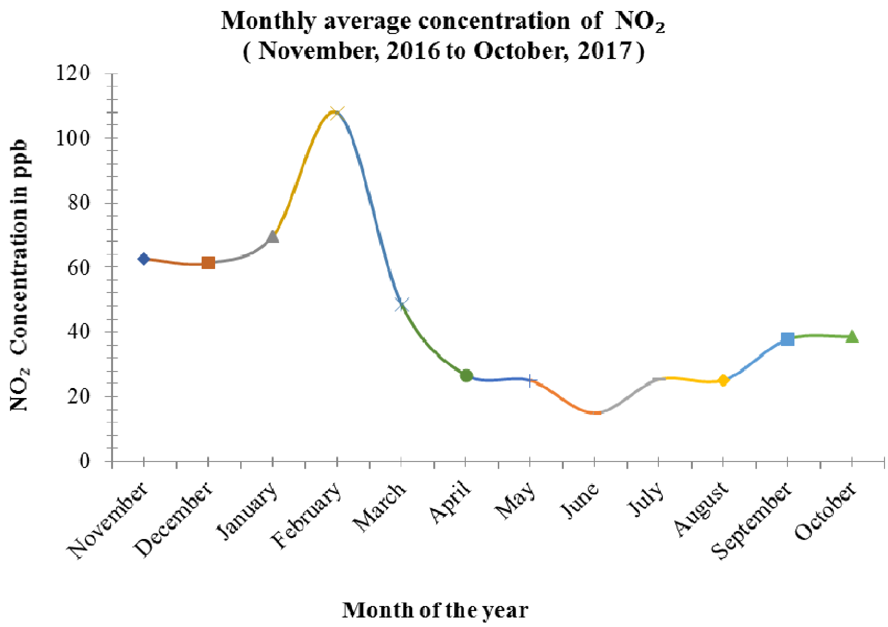

Fig. 5. Monthly average concentration of NO_2

Monthly average concentration of O_3: As shown in Fig. 6, the highest concentration of O_3 (11.28 ppb) was found in the winter season, and the lowest concentration of O_3 (1.89 ppb) was measured in the monsoon season. Similarly, the O3 concentration shows higher values in winter and lower values in monsoon (Mukta *et al.*, 2010). After the highest peak of O_3 concentration of the study area shows the decreasing trends in March to September.

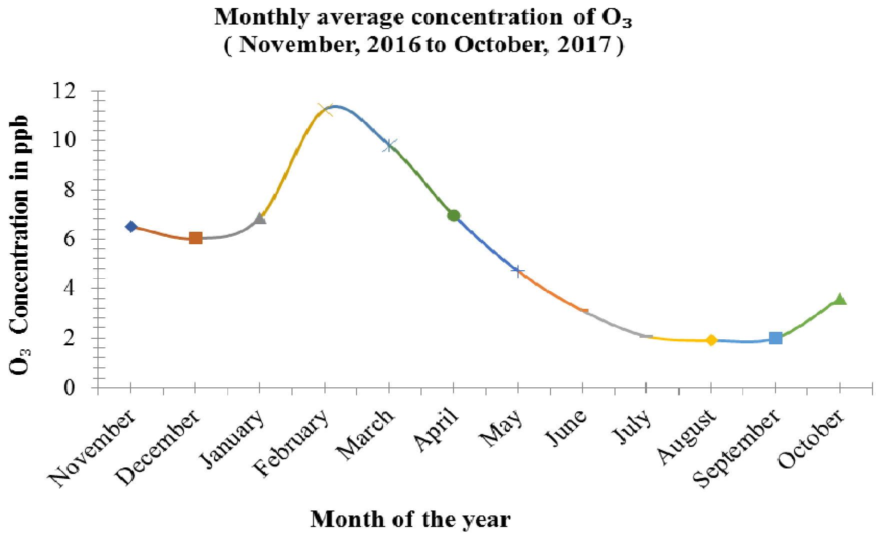

Fig. 6. Monthly average concentration of O_3

Correlation between meteorological factors and air pollutant: The results of the study indicate that there was a strong and significant correlation between ozone and NO_2 emission in the study area. The correlation value of ozone and NO_2 was found as $r^2 = 0.57$, which is shown in Fig. 7(a).

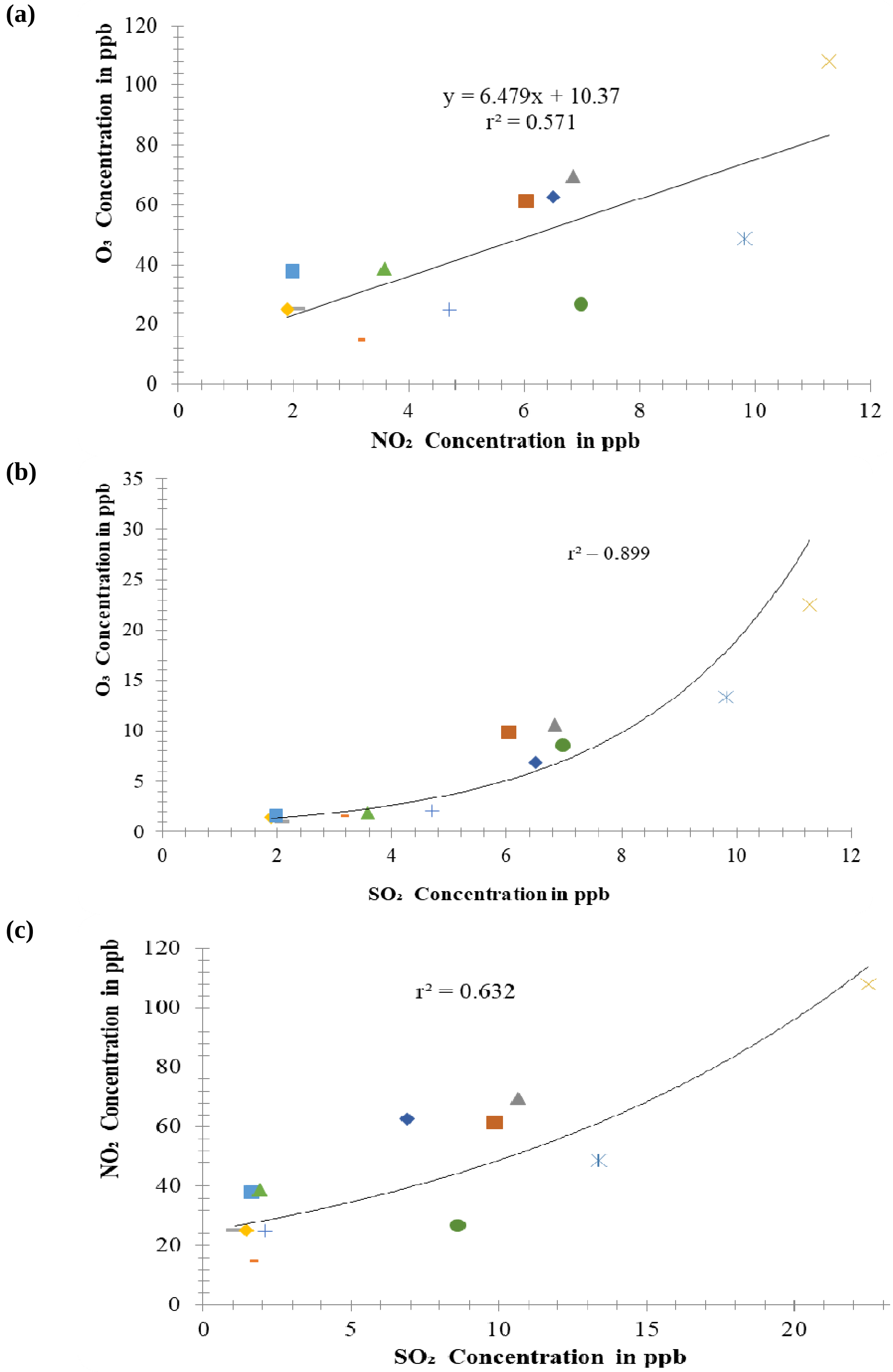

Fig. 7. Correlation between air pollutant (a: Correlation between O_3 and NO_2; b: Correlation between O_3 and SO_2; c: Correlation between SO_2 and NO_2

The results designated that ozone was strongly correlated with NO_2 emission and this indicates that as NO_2 emission increase formation of ozone also increase which means NO_2 emission is an important precursor of atmospheric ozone concentration. Fig. 7(b) shows the Correlation between O_3 and SO_2. There was also a strong correlation between ozone and SO_2 emission. The correlation value of ozone and SO_2 was found as $r^2 = 0.899$, which is shown in Fig. 7(b). The results of the study point out that ozone was positively correlated with SO_2 emission and this means that as SO_2 emission increase formation of ozone. Fig. 7(c) shows the Correlation between SO_2 and NO_2, whereas a strong positive correlation between SO_2 and NO_2 emission found by this study. The correlation value of SO_2 and SO_2 was found as $r^2 = 0.632$. This trend indicates that SO_2 concentration increases NO_2 concentration and both of SO_2 and NO_2 produce from similar pathways of photochemical oxidation of VOC, industrial emission and fossil fuel burning.

Status of AQI variation in Narayanganj: Monthly Air quality index, which was calculated at Narayanganj stations of CAMS-5 shown in Table 2. Monthly AQI of Narayanganj station varies 13 to 821 respectively during study period from November, 2016 to October, 2017.Whereas average AQI value in dry season found about 298 and 110 which that in wet season. Monthly summary of calculated AQI values based on data from different CAMS Narayanganj showed that during dry season most of the day's air quality was either very unhealthy or extremely unhealthy categories or few caution, moderate and unhealthy categories as well. In all cases most frequent responsible pollutant was $PM_{2.5}$. In absence of $PM_{2.5}$ sometimes found responsible pollutant PM_{10}. AQI Categories in wet season monthly summary of calculated AQI values based on data from CAMS Narayanganj showed that during wet season most of the day's air quality was either Moderate or good categories as well. In all cases most frequent responsible pollutant was $PM_{2.5}$. In absence of $PM_{2.5}$ sometimes found responsible pollutant PM_{10}.

Table 2. AQI Status in Narayanganj (November, 2016 to October, 2017)

Season	Month	AQI Values			
		Maximum	Minimum	Average	Seasonal
Dry	November, 2016	403	59	231	298
	December, 2016	469	93	281	
	January, 2017	821	169	495	
	February, 2017	435	145	290	
	March, 2017	298	92	195	
Wet	April, 2017	257	62	160	110
	May, 2017	253	75	164	
	June, 2017	168	29	99	
	July, 2017	121	21	71	
	August, 2017	100	13	57	
	September, 2017	174	25	100	
	October, 2017	218	25	122	

Conclusion

The study found that during the dry season, due to lower average temperatures, wind speeds, and precipitation, pollutant dispersion and washout reduces, and consequently pollution concentration levels rise. The research also showed a high positive association was found between ozone and NO_2 emissions, specifying that NO_2 emissions are an important precursor of ozone. Particle pollutants in both fractions ($PM_{2.5}$ and PM_{10}) normally have a higher burden, especially during the dry season when participation rates and wind speeds are low. Because of scavenging of particles by moderate rainfall, particulate matter concentrations in the wet season are moderately lower than in the dry season. As a result, particulate matter pollution must be controlled in order to improve air quality.

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