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Air Quality Index and its Possible Impact on Human Health in Industrial area Gajraula, U.P.

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Abstract: *Over the last decades the development of Gajraula as an industrial area has elevated the risk of atmospheric pollution. Thus to know the quality of air, AQI was evaluated and for the purpose PM_{10}, $PM_{2.5}$, SO_2 and NO_2 was monitored over a period of monsoon (July to September 2014) and winter season (November to January 2015) at three different Sites i.e. Raunaq Automotive (S1), Indra Chowk (S2) and Town Basti (S3). Results are based on AQI calculator recently launched by CPCB MoEF, New Delhi. The experimental results of air quality index (AQI) obtained from different Sites are 137 at S1, 144 at S2 and 95 at S3 in monsoon and 197 at S1, 268 at S2 and 131 at S3 in winter season. The highest AQI value was obtained from experimental result at Site S2 in winter season while lowest at Site S3 in monsoon season. Elevated concentration of all the pollutants at Site S2 may be due to anthropogenic activities i.e. industrial growth, vehicular density and other developmental works in this area. There are relatively stronger inter- pollutant correlation at the sites and results also suggest that a large number of industrial developments induces high correlation of $PM_{2.5}$, PM_{10}, NO_2 and SO_2 at S1 and S2 sites. Human beings are more affected as evidenced in increases in daily hospital admissions in different departments' i.e. Cardiac, Respiratory, Skin and Eye of Gajraula Government Hospital.*

Keywords: Air quality index, Anthropogenic activities, Health effect.

Introduction

Air quality has deteriorated in most large cities in India, a situation driven by industrialization, population growth and increased vehicle use (Lepeule *et al*., 2012). Ambient air quality is a matter of great concern for good health and sustainability of any city can be assessed through Ambient Air Quality monitoring data which is done or being done since two decades in Gajraula (Aydin *et al.*, 2014; Giles *et al*., 2014).

As Gajraula is an industrial area various chemicals are being emitted into the air mainly from the industrial activities effecting the environment and vegetation (Kumar *et al*., 2015). In spite of the introduction of cleaner technologies in industries, energy production and transport, air pollution remains a major health risk. Thus here is a need for timely information about simple change in Pollution levels in industrial/urban area and to maintain the desired level of air quality. Air quality indices are used for local and regional air quality management in metro cities of the world (Gulia *et al*., 2015). The AQI (Air Quality Index) is a single number which represents the air pollution level caused by various pollutants. It shows us how clean or polluted our air is focuses on health effects (Dong *et al*., 2012; Kesavachandran *et al*., 2013). Recently air quality index (AQI) is launched by prime minister of India and are given in report of central pollution control board (CPCB, 2015).

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An analysis of the annual and seasonal trends of air quality index of urban and industrial area (Deshmukh *et al*., 2012a; Deshmukh *et al.,* 2012b) using multi-instrument approach and air quality indexing (Subrahmanyam and Murty, 2009). A novel air pollutant index based on the relative risk of daily mortality associated with short - term exposure to common air pollutants (Carincross et al., 2007).

Industrial pollution is deteriorating the environment day by day and combined effect of air pollution (aerosol/particulate matter and toxic gases) may induce greater variability in different season of the year thereby reducing the rainfall (Azmi *et al*., 2010; He *et al*., 2012; Mahima *et al*., 2013; Pal *et al*., 2014., Ediagbonya *et al*., 2014).

Like other industrial cities Gajraula is also threatened by industrial and vehicular pollutants. The basic objective of the present work is, therefore, to carry out a systematic and scientific investigation to assess the degree of air pollution by evaluating air quality index and its impact on human health. Present study examines the quality contribution of local emission sources contributing the aerosol mass which is an important factor in the development of effective strategies for the control of aerosol associated problem in this industrial area.

Materials and Methods

Site Selection: A network of three air monitoring and sampling stations, covered the whole city were operated during the period of one year i.e. July 2014 to January 2015. The study area was classified into three zones- Industrial area, high density residential area and low density residential area (agriculture area). The geographical location of the sites is described below.

Raunaq Automotive (S1): It is a Automotive Industry and the site is established on the roof of the building of this Industry located near NH-24. The largest chemical factory Jubilant Life Sciences Ltd. is located near this Site. The movement of traffic on the road is very frequent throughout the day and night.

Indra Chowk (S2): It is a residential area having commercial activities. A large number of shops and workshops are situated near this site and the distance of Gajraula railway station is 500 meters. This site is receiving more pollution than Raunaq automotives from the emissions of main industries such as Teva and Jublient life sciences is situated near this Site. The movement of the traffic is highly congested and slow due to high density of vehicles, railway crossing and encroachment on both sides of the road.

Town Basti (S3): This site is located in southern part of the city and around 2 Km away from the Railway station. It is low density residential and agriculture based area, almost free from pollution.

Air quality index (AQI) was calculated by the concentration of major air quality parameters i.e. Respirable suspended particulate matter (PM_{10}), Fine particulate matter ($PM_{2.5}$), Sulfur dioxide (SO_2) and Nitrogen dioxide (NO_2).

PM_{10} samples were collected with the help of Raspirable Dust samplers APM-460NL (Envirotech, New Delhi) at rate of six samples per week on Whatman glass fiber filter paper with air flow rate of 1-1.5 m^3/min. The difference in initial and final weights of the filter paper gave the total quantity of PM_{10} collected over the period of 8 hours. The values of PM_{10} were reported in μgm^{-3}.

Gravimetric method was also used for measuring the mass concentration of $PM_{2.5}$. The instrument employed for this purpose is Fine Particulate Sampler (FPS, Model: APM-550, Envirotech, New Delhi,). The $PM_{2.5}$ fraction escaping from the impactor is collected on a teflon membrane filter (Whatman paper of 47 mm dia). Dividing the difference between initial and final weights of the Teflon membrane filter by the total volume of air sampled gives the mass concentration for $PM_{2.5}$.

SO_2 was analyzed by employing the West and Gaeke method (1956) on a Systronic Spectrophotometer at a wavelength of 560 nm using Sodium-tetra chloromercurate (Na_2HgCl_4) as absorbing reagent.

NO_2 was also analyzed by employing the Jacob and Hochheiser modified method (1958) on the above spectrophotometer at a wavelength of 540 nm. Solution of Sodium Hydroxide and Sodium Arsenite (NaOH, $NaAsO_2$) is used as absorbing reagent.

Air quality index values (AQI) were calculated with the help of AQI calculator on CPCB website.

Quality Control

The quality control, during the investigation, filter paper numbering, pre conditioning, weighing, handling, monitoring, the post weighing and recording was the thrust. For maintaining the quality control all instrument used during monitoring such as balance, Respirable dust sampler (RDS), fine particulate sampler (FPS), Gas leakage checker spectrophotometer were calibrated on regular interval and recorded. The instruments performance check, data validation, temperature, humidity control and standard monitoring protocol were followed at all stages. The complete analytical procedures were provided by central pollution control board, Delhi. As a part of QA/QC, calibration charts (Absorbance vs SO_2/NO_2 content) were prepared once in every month using certified reference material. Absorbing solution in amber colour bottle and fresh solution were prepared once in every week. The outlier values have been removed during the validation of data and recording.

Results and Discussion

The air quality data of selected parameters PM_{10}, $PM_{2.5}$, SO_2 and NO_2 from different sites of Gajraula city have been summarized in Table 1 and the monthly average of particulate pollutant were higher than the permissible limits (for 24-hour average) of 100μgm^{-3} and 60μgm^{-3} for PM_{10} and $PM_{2.5}$ respectively whereas gaseous pollutants were found lower than the standard values 80μgm^{-3} for the industrial, commercial and residential areas given by CPCB 2009.

The experimental results show that the seasonal average concentrations of PM_{10} in three different areas in Gajraula city i.e. Raunaq Automotive (Industrial area, S1), Indra Chowk (Commercial area, S2) and Town Basti (Residential area, S3) were reported as 189.33 μgm^{-3}, 204.33 μgm^{-3} and 145.67 μgm^{-3} in winter and 155.67 μgm^{-3}, 166.67 μgm^{-3} and 95.67 μgm^{-3} in monsoon season respectively. In all the investigated areas the highest concentration of PM_{10} was recorded at S2 (221 μgm^{-3}) in the month of January and lowest concentration was recorded at S3 (90 μgm^{-3}) in the month of July (Table 1). The average of all three sites exceeded the CPCB National Air Quality Standards. During the most critical season i.e. winter, the exceedance was found to be 100% for S2 whereas 89% for S1 and 45% at S3.

The detailed result for $PM_{2.5}$ at three selected sites shows that the seasonal average concentrations were found as 89.00μgm^{-3}, 110.33 μgm^{-3} and 63.00 μgm^{-3} at S1, S2 and S3 in winter season and 37.67μgm^{-3}, 49.00μgm^{-3} and 26.33 μgm^{-3} in monsoon season respectively. The highest concentration of $PM_{2.5}$ was recorded at S2 (117μgm^{-3}) in the month of January and lowest concentration at S3 (22 μgm^{-3}) in the month of July. At S1 and S2 it was found 50% and 80% higher than the prescribe limit respectively in winter season, whereas below the standard at all the sites in monsoon season (Table 1).

The seasonal variation of SO_2 concentration at different sites were found as 25.67 μgm^{-3} (S2), 21.33 μgm^{-3} (S1) and 14.67 μgm^{-3} (S3) in the winter season while 21.33 μgm^{-3} (S2), 16.33 μgm^{-3} (S1) and 6.67 μgm^{-3} (S3) in the monsoon season. Among the three investigated areas, the monthly average concentration of SO_2 was maximum (33μgm^{-3}) at S2 in the month of

January and minimum (5 µgm^{-3}) at S3 in the month of July. The result of SO_2 at different location of Gajraula city were further compared with national ambient air quality standard (Table-2). NO_2 concentration was reported maximum (45µgm^{-3}) at S2 in the month of January and minimum (15µgm^{-3}) at Site S3 in the month of July (Table-1). Monthly average of NO_2 concentration were reported below the prescribed limit of National Ambient Air Quality Standard. The maximum seasonal average concentration of NO_2 was observed in the winter season at Site S2 (38.67 µgm^{-3}) and minimum at Site S3 (18.67 µgm^{-3}) in monsoon season.

The correlation between atmospheric pollutants at all stations are shown in Table 2. A positive significant correlation ($p<0.01$), ($r = 0.975$) and ($r = 0.989$) were found at S1 and S2 between SO_2 and NO_2 respectively whereas strong positive correlation ($p<0.01$), ($r = 0.928$) and ($r = 0.998$) were recorded between PM10 and $PM_{2.5}$ at S1 and S3 respectively. This correlation pattern indicates that there were the same sources of atmospheric pollutants recorded in S1 and S2. Indra Chowk (S2) itself, is located in a congested, urban and industrial area which would lead to the existence of atmospheric pollutants from various sources in comparison to S1 which is more influenced by the movement of motor vehicles.

The monthly average air quality index ascertained the actual value of air quality category of each Site in Gajraula city (Table 3). AQI calculation helps in better understanding of air quality status. Seasonal air quality at three locations is more, well elaborated based on Air quality index (AQI) calculations, using the mass concentration data with corresponding various pollutant values viz. PM_{10} , $PM_{2.5}$, SO_2 and NO_2 (Beig *et al*., 2010). According to National AQI calculator, recently given by CPCB (2015), during winter season at S1 and S3 the air quality was found to be moderate but poor at S2 in winter season whereas in monsoon season it was found satisfactory at S3 and moderate at remaining sites (CPCB, 2015). As per the EPA AQI air quality was found very unhealthy at S2, unhealthy at S1 and unhealthy

Table 3 Comparisons of AQI of Gajraula with CPCB AQI and EPA AQI

SITE	SEASON	AQI VALUE	CPCB AQI*		EPA AQI**	
			CATEGORY	color	CATEGORY	color
RAUNAQ AUTOMO-TIVE	WINTER	197	Moderate	Yellow (101–200)	Unhealthy	Red (150–200)
	MONSOON	137	Moderate	Yellow (101–200)	Unhealthy for Sensitive Groups	Orange (101–150)
INDRA CHOWK	WINTER	268	poor	Orange (200–300)	Very Un-healthy	Purple (251–300)
	MONSOON	144	Moderate	Yellow (101–200)	Unhealthy	Orange (101–150)
TOWN BASTI	WINTER	131	Moderate	Yellow (101–200)	Unhealthy	Orange (101–150)
	MONSOON	95	Satisfactory	Light Green (51–100)	Moderate	Yellow (50–100)

*CPCB Health Statements for AQI Categories is good(0-50), satisfactory(51–100), moderate(101–200), poor(201-300), very poor(301-400), severe(401–500) (CPCB 2015).
**The EPA air quality index of ambient air for health impact parameter as good(0-50), moderate(51-100), unhealthy for sensitive groups(101–150), unhealthy(151–200), very unhealthy(201-300), hazardous(301-500) (EPA calculator 2015).

for sensitive groups at S3 in winter season. In monsoon season S1 and S2 falls in unhealthy for sensitive groups and moderate at S3 (Table 3). This is mainly due to the seasonal variation with meteorological parameters such as wind speed, wind direction as well as influence of temperature i.e. temperature inversion which significantly marked during winter besides localized sources of emission (Guttikunda and Gurjar, 2012).

Emission from paved roads and background concentration from industrial and semi-industrial areas of the city also contribute the particulate pollution. Cooking in houses, School and commercial establishments and refuse incineration in houses and public places and municipal incineration in open grounds may also contribute to the total pollutant load as well as the atmospheric particulate matter concentrations in an Indian city (Jain and Palwa, 2015). The city road and NH-24 which is dusty in nature, is not removed periodically all over the city, hence, all these factors cumulatively contribute to the PM_{10} concentrations in the range of 90μgm^{-3} to 211 μgm^{-3} in the city.

Even though the RSPM pollution activity were wide spread all over the city, it was noticed that during the period of experiment, that Raunaq Automotive (S1) endured the highest traffic densities among the sampling stations. The highest average concentration of PM_{10} (221μgm^{-3}), $PM_{2.5}$ (117 μgm^{-3}), NO_2 (45 μgm^{-3}) and SO_2 (33 μgm^{-3}) and NO_2 (65.84 μgm^{-3}) were recorded at Indra chowk (S2) in the winter season might be attributed to the pollution from chemical industries and automobiles both.

Indra Chowk (S2) which is commercial area, is extremely congested during the day time resulting the slow movement of vehicles long waits at the signals and a large number of vehicles are running on the roads everyday. In addition, traffic – derived aerosol particles were emitted into the atmosphere due to abrasion processes of automobiles components such as the brake or tire wear (Guney *et al*., 2010; Balakrishnan *et al*., 2013). Due to high level commercial activities the AQI value (268) is categorized under poor air pollution and rather very unhealthy conditions at this Site.

The lower concentration of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 were recorded at Town Basti (S3), which could be considered rather a clean area having the lowest traffic density among the three sampling stations. The Traffic survey results show that at this Site, a least number of automobiles are plying and most of the vehicles operated in this area are gasoline–powered light–duty vehicles, which emitted almost negligible amount of particulates (Horaginami and Ravichandran, 2010; Guttikunda *et al*., 2013). It was also noted that among the commercial establishments, only a few are related to combustion activities as the number of sources was substantially less, the calculated source strengths of particulate matter as well as the recorded AQI value (95) was also found to be low and categorized in slightly air pollution category.

According to a report on air pollution and health given by TERI (Jain and Palwa, 2015) among seventeen cities of U.P. state the maximum concentration of PM_{10} was recorded in Ghaziabad (248 μgm^{-3}) and minimum in Unnao (98 μgm^{-3}) whereas Gajraula comes on 10th position having concentration of 158 μgm^{-3} (Fig.1). In Gajraula, health problems are of main concern. percentage distribution of respiratory disease were found maximum and it may be due to air pollution as evidenced in the paper presented in Sofia, Bulgaria (Source: Proceedings) (Fig. 2). The disease-wise percentage distribution of deaths attributable to ambient particulate matter pollution in India given in Figure 3. There are many studies across the world and also in India to prove that outdoor and indoor air pollution is a serious environmental risk factor that causes or aggravates acute and chronic diseases (Ghosh and Mukherjee, 2010; Guttikunda *et al*., 2014; Pope *et al*., 2015).

The increases in the atmospheric pollutant with this rate have created a threat for long-range

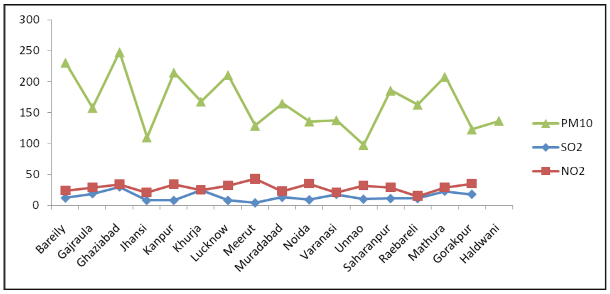

Fig. 1 Ambient Air Quality data in different cities in India for the year 2012 (Source: CPCB 2014).

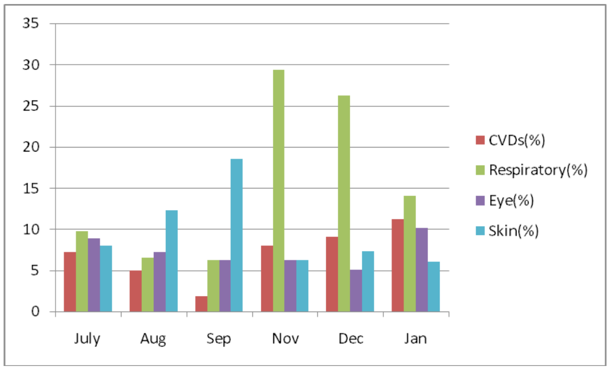

Fig. 2 Percentage distribution of hospital admitions of various diseases in Gajraula.

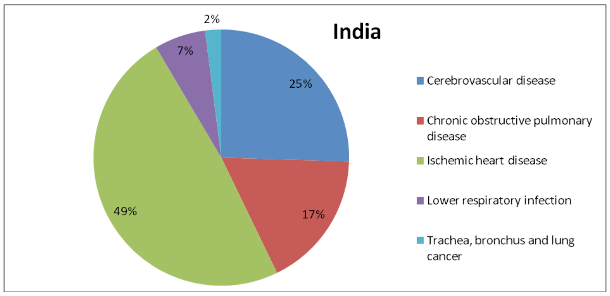

Fig. 3 Percentage distribution of deaths from ambient PM pollution in India Lim et al, (2012)

adverse effects on the plants, public health and social wellbeing of Gajraula city (Kumar *et al*., 2015). This earlier studies pertaining to major toxic pollutants shows an upward trend during the years. Thus the measurement of Air Quality Index helps in informing the public about air pollution levels in a particular area and in comparing air pollution levels in different urban areas. It may be used for development of a system for avoidance or management of a severe episode of air pollution and evaluate changes in air quality over periods of several years or more.

Therefore, the strict implementation of adequate abatement measures are necessary for the present and the sustainable future of Gajraula Industrial area residents (urban/factory).

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