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Short communication

Pre-monsoon and Post-monsoon Analysis of Air Pollutant PM_{10} in Air: A Case Study of Bareilly district, Uttar Pradesh, India

SACHIN AGARWAL AND BOYINA RUPINI*

Environmental Sciences, SOITS, IGNOU, New Delhi
E-mail: sachin23agarwal@gmail.com, brupini@ignou.ac.in
***Corresponding author**

ABSTRACT

In the past five years air quality has deteriorated and is alarming for the entire urban areas throughout the world. The present study focused on the evidence-based analysis of pre monsoon and post monsoon status of air pollution, PM_{10} in specific in Bareilly. The urban air database released by GreenPeace reported that Bareilly was among the seven most air polluted cities of Uttar Pradesh, India, where PM_{10} was almost four times the annual standard of 60 $\mu g/m^3$ averaging 226 $\mu g/m^3$ for the year 2015 and 2016. Post Monsoon and pre monsoon monitoring of seasonal trend of suspended particulate matter was done from September 2019 to August 2020 from three monitoring stations. During the pre-monsoon analysis, after 25th March 2020, there is a sharp fall in the PM_{10} concentration at all. During end of March 2020 and April 2020 there was a sharp cut in vehicular emissions and no construction site was under operation due to lockdown imposed to combat outbreak of COVID-19. During the post monsoon analysis of $PM_{10,}$ Station A reported maximum peak of 333 $\mu g/m^3$ during the month of November 2019. The fireworks during Diwali festival 2019 could have contributed to this hike in PM_{10} concentration. In December 2019 all stations A, B, and C recorded PM_{10} values above 200 $\mu g/m^3$. In this study the details of PM_{10} from three monitoring stations have been analysed, interpreted and reported.

Keywords: Air pollution, Pre-monsoon, Post-monsoon, Bareilly, PM_{10}, Vehicular emissions, Lockdown, NAAQS.

INTRODUCTION

Air Pollution is now one of the serious problems in the world especially in urban areas of developing countries due to the rapid growth of population, increase in number of vehicles and industrialization. In India urban air quality in megacities getting deteriorated day by day due to increase in industrialization and urbanization (Dubey et al. 2010). Continuous rise of population along with the lack of suitable measures for air pollution control means that there is a great potential that conditions may worsen in future in Indian cities.

The rapid urban growth is also associated with transportation sector and road networks which support various vehicular movements on roads (NEERI 2008). In urban areas, air pollution is affected mainly due to construction of buildings, traffic composition and meteorological conditions (Weichenthal et al. 2014). Motor vehicle traffic has been regarded as the primary cause of air pollution in the urban areas and account for 60 to 70% of this found in the urban environment. Emissions from vehicular exhaust are associated with a number of chronic and acute health problems (Crouse et al. 2010). Studies proved that diseases like cancer, heart attack and asthma are associated with NOx, SO_2 and PM emissions from vehicular exhaust (Parent et al. 2011). There is a significant increase in cardiovascular diseases, from 0.5 to 1.5%, for every 5~6 $\mu g/m^3$ increase in $PM_{2.5}$ (Gold et al. 2000). Goyal et al. (2010) have reported 17 and 28 % of total NOx and PM, respectively, contributed by vehicular emissions. This was almost equal to the combined sources such as industry, power plants and domestic sectors in Delhi, India. The heavy traffic, thickly populated areas, jams, poor driving patterns, improper town planning and congested and encroached roads have severe impact on the environment in urban areas (Gurjar et al. 2009). The dominant air pollutants in India could be sulphur dioxide, nitrogen di-oxide, Suspended Particulate

Matter and Respirable Suspended Particulate Matter. All these pollutants may pose harmful effect on human health such as cardio-vascular and respiratory disease, neurological impairments, increased risk of preterm birth and even mortality and morbidity. It has been found and reported that around ten million people from India lost their lives due to air pollution alone. Urban air pollution is of significant importance, as in 2014 more than half of the World's population lived in cities and a further growth to 66% by 2050 is forecasted (UN 2015). In a report, Aircalypso II, published by Greenpeace in 2018 the city Bareilly was reported among the seven most air polluted cities of Uttar Pradesh where PM_{10} was almost four times the annual standard of 60 $\mu g/m^3$ averaging 226 $\mu g/m^3$, respectively, for the years 2015 and 2016. In the past five years the level of PM_{10} has increased to three times. This could be very alarming for children, senior citizens and asthma patients. Lack of industrialization in Bareilly city indicates that vehicular emissions and inappropriate construction activity could be the primary sources of air pollution. Lack of comfortable mass transport compel people to use their own transport, as a result more combustion of fuel takes place leading to high level of pollutants such as SO_2, NO_x. Aberration of automobile parts including metal and vehicle parts are equally responsible in increasing $PM_{2.5}$. Burning of fire crackers at the time of festivals also increases the concentration of suspended particulate matter in the atmosphere. For the last three year it has been found that Bareilly city has been affected by a layer of smog after Diwali festival causing serious health impacts. Traffic congestion due to narrow roads makes the situation worse. The present research focused on pre monsoon and post monsoon monitoring of seasonal trend of air pollutant PM_{10} in Bareilly city of Uttar Pradesh in India was done and analyzed for a period of twelve months from September 2019 to August 2020 from three monitoring stations covering approximately 11 km.

MATERIAL AND METHODS

The methodology used to study seasonal and annual trends of PM_{10} of Bareilly district for Pre monsoon and post monsoon analysis from three air monitoring stations is done as per the guidelines of Central Pollution Control Board of India CPCB. Three monitoring stations were selected on the basis of traffic frequency and construction sites. Respirable Dust Sampler with Gas analyzer were installed at three stations namely A, B and C within 11 km of the city (Fig. 1). Station A is situated at Petrol Pump, near Rampur Garden Bareilly in the heart of the Bareilly city which has the maximum vehicular frequency of 70-80 vehicles per 5 minutes and is supposed to heavy traffic site due high commercial activities. Station B, which is supposed to be medium traffic site is located in the residential area at D.D Puram, Bareilly, has the average vehicular frequency of 50-60 vehicles per 5 minutes. Station B is residential cum commercial site. Station C is near IVRI, Izzatnagar, Bareilly which has low vehicular frequency of 20-30 vehicles per 5 minutes is a residential site. Monitoring from these stations was done in accordance with CPCB guidelines. From these three air monitoring stations sampling was done every 8 hourly using respirable dust sampler as per the guidelines of CPCB. Glasswool filter paper GF1 is used and is changed every eight hours. Analysis was done twice a week in three sessions of eight hours each; 6:00 a.m. to 2:00 p.m., 2:00 p.m. to 10:00 p.m. and 10:00 p.m. to 6:00 a.m.

Figure 1. Satellite image of air monitoring stations A, B and C at Bareilly, Uttar Pradesh, India

Cyclotone flow Technique

In order to measure Suspended Particulate Matter Respirable Dust Sampler Envirotech make APM460DXNL is used. Air from the surrounding is drawn through a size-selective inlet and through a glass wool filter paper having size 20.3 x 25.4 cm (8 x 10 inches) at a flow rate which is typically 0.9 – 1.4 m^3/min free flow. PM particles having aerodynamic diameters lower than the cut-point of the inlet is collected by the filter. Prior to sampling, the Glass wool filter paper used for the analysis is kept in a digitally controlled oven at 45^0C for 24 hours. Particles of size 10 microns are collected on glass wool filter Paper. After eight hours of sampling the filter paper is carefully collected and kept in a labeled zip-lock pouch. The mass of these particles is determined by the difference in filter weights prior to and after sampling is done. The concentration of suspended particulate within the designated size range is calculated by dividing the load gain of the filter by the quantity of air sampled. Its principal is based on Cyclone flow technique for determining the PM_{10} level.

Calculation of PM_{10}

Concentration of PM_{10} in air can be calculated from the following equations

$$C(PM_{10}\ \mu g/m^3) = \frac{(W_f - W_i)\times 10^6}{V} \quad \text{.....(1)}$$

$$V = Q \times T \text{.....(2)}$$

Where,

C (PM_{10}) = Concentration of PM_{10} µg/m^3

W_f = Pre-weight of filter in g

W_i = Post-weight of filter in g

10^6 = Conversion of g to µg

V = Volume of air sampled m^3

Q = Average flow rate in m^3/minute

T = Total sampling time in minute

RESULTS AND DISCUSSION

In order to study the seasonal trend of air pollutants PM_{10} the analysis is done on pre-monsoon and post-monsoon basis. Post monsoon analysis was done from September 2019 to February 2020 whereas pre-monsoon and monsoon analysis was done from March 2020 to August 2020.

Post Monsoon Analysis

During the post monsoon analysis, all the three monitoring stations showed high level of PM_{10} which was a matter to worry as station C assumed to be control site with respect to air pollution due to less vehicular frequency and excessive greenery. The least value of PM_{10} was recorded as 153 µg/m^3 in the month of January 2020 at Station C which was still well above the NAAQS monthly limit of 80 µg/m^3. It is evident that station A (Coco Pump, Civil lines, Bareilly) recorded the maximum value of PM_{10} for all months during post monsoon season (Fig. 2). PM_{10} concentration at Station B was between the trends for station A and C. The trend line for station C, (IVRI, Bareilly) showed least PM_{10} concentration among the three stations. Station A reported a maximum peak of 333 µg/m^3 during the month of November 2019. The fireworks during Diwali festival (27th October, 2019) could have contributed to this hike in PM_{10} concentration. In the month of December 2019 all station A, B and C recorded PM_{10} values above 200 µg/m^3.This could be due to excessive open fossil burning as in December 2019 the average minimum temperature of the city fell to 11^0C.

Temperature inversion phenomenon could be a factor for producing smog, trapping the pollutants produced by vehicular, burning of open fires and aberration from automobiles. Furthermore, the hydrocarbons and nitrogen oxides present in these trapped pollutants are converted into harmful ozone by sunlight, which reduces air quality. These gases remain suspended within the inversion layer and result in a long-term impact on the global climate.

Pre-Monsoon Analysis

The Pre monsoon analysis was done from the month of March 2020. Due to the outbreak of novel coronavirus COVID19, lockdown was imposed in the entire country from 25th March 2020 onwards. Figure 3 shows the pre monsoon analysis for PM_{10} concentration. After lockdown (25th March 2020) there is a sharp fall in the PM10 concentration at all stations A, B and C. All commercial, industrial and

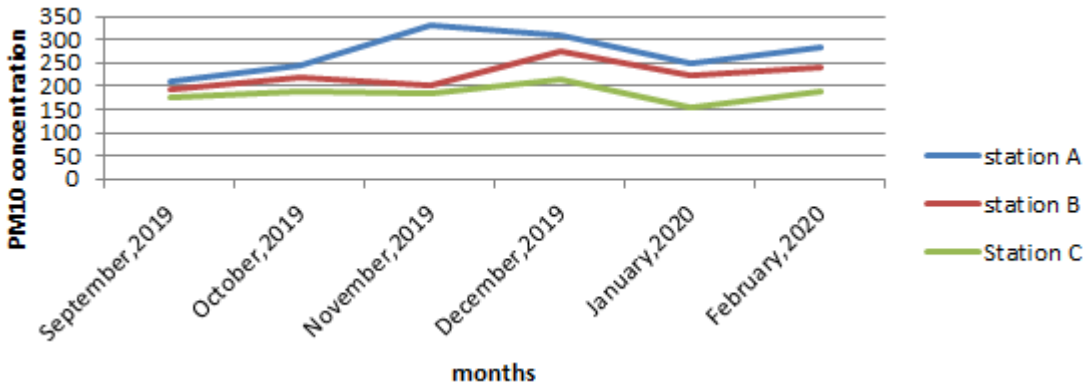

Figure 2. PM_{10} concentration for the Post monsoon season during September 2019 to February 2020 at Station A, B and C. All concentrations are in µg/m^3

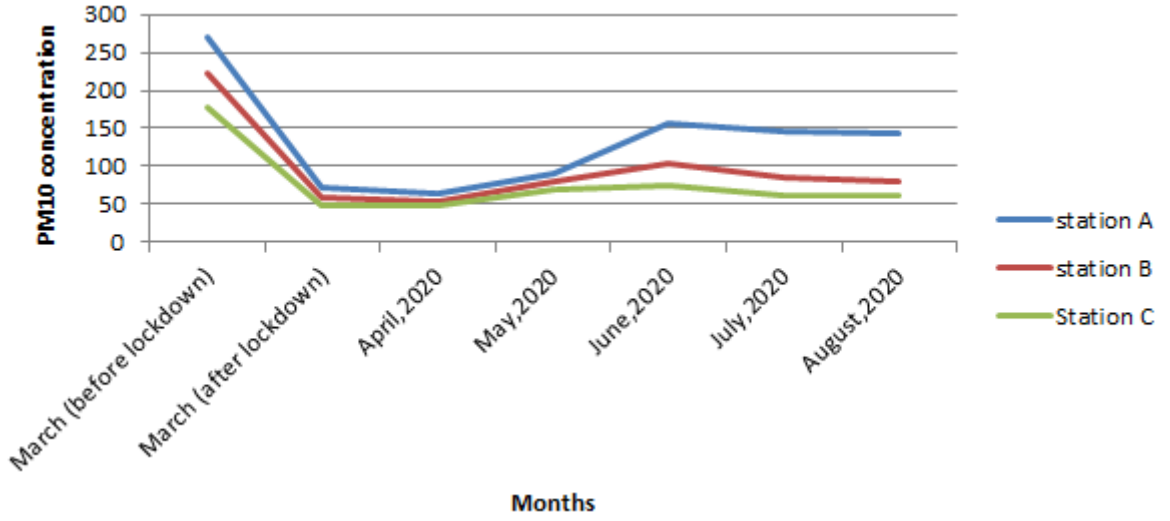

Figure 3. PM_{10} concentration for the Pre monsoon season during March 2020 to August 2020 at Station A, B and C. All concentrations are in µg/m^3

institutional activities were suspended since 25th March 2020 due to spread of novel corona virus COVID19 with the exception of supplies of essential goods such as groceries and medicine, as a result, the movement of vehicles was very low and vehicular emissions were supposed to drop down significantly. The lockdown situation continued till mid of May 2020 and then lockdown was lifted depending on the number of cases in a particular locality. From the month of June 2020 commercial activities were restored in the city with all precautions as instructed by the state and central government. The construction work which was suspended during the lockdown phase was steadily initiated. Thus, vehicular emissions, non-exhaust emissions and construction work were suspended from end of March 2020 till May 2020. On 10th May, after a heavy rainfall the mountain peaks of Nainital, Uttarakhand (130 km from Bareilly) were clearly visible from Station C. The consumption of diesel and petrol has also decreased significantly during the month of April (Table 1) which has also contributed to improvement in the air quality.

Figure 4 represent the PM_{10} collection over glass-wool filter paper after sampling in August, 2020 from air monitoring station A, B and C, respectively. It is evident from the filter darkness that station A reported maximum level of PM_{10} and station C reported the minimum level of PM_{10}.

The annual trend of PM_{10} concentration from September 2019 to August 2020 were recorded and analysed. During the twelve months of analysis maximum PM_{10} level is observed in the month of November 2019 and minimum in April 2020. Air

Table 1. Monthly sales of diesel and petrol (in kilolitres) of three fuel pump P1, P2 and P3, respectively, during January 2020 to June 2020 in the vicinity of Study area.

Month	P1 Diesel	P1 Petrol	P2 Diesel	P2 Petrol	P3Diesel	P3Petrol
Jan 2020	303	349	69	171	66	174
Feb2020	283	345	72	192	81	183
Mar2020	248	301	51	141	39	129
Apr2020	153	139	21	51	21	51
May2020	203	181	42	102	36	66
June 2020	275	311	75	153	45	123

A B C

Figure 3. PM_{10} collection over filter paper at Station A, B and C, respectively, in the month of August 2020. Darker shades represent high concentration of PM_{10}

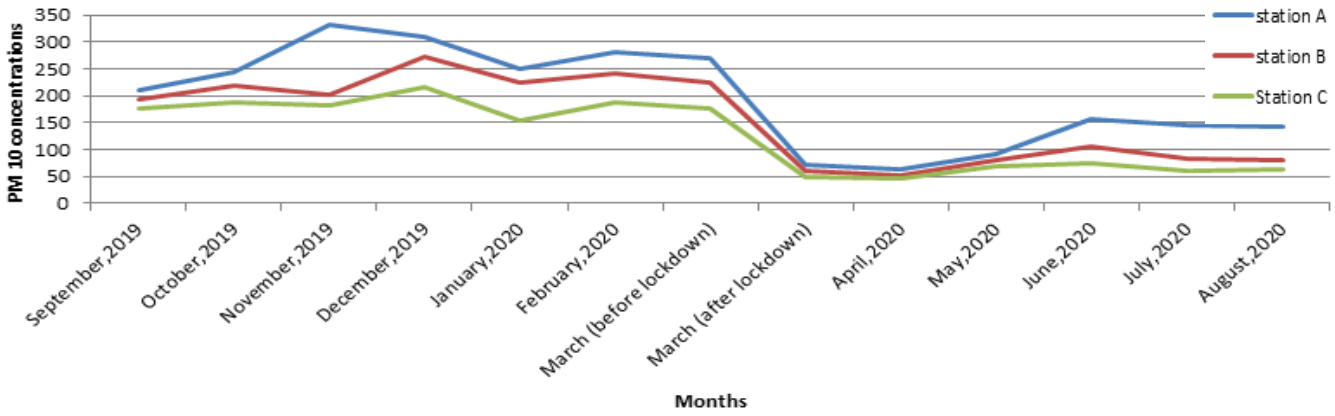

Figure 4. Annual trend of PM_{10} concentration from September 2019 to August 2020 at Station A, B and C. All concentrations are measured in $\mu g/m^3$

pollutant during winter season (Fig. 5) was more concentrated near the earth surface and less dispersed as compared to summers. Morning walker, asthmatic patients should avoid outdoor walk during winter season especially at the time of fog when the suspended particulate matter is trapped in air. During the monsoon season, the suspended particulate matter gets precipitated with rain and the air quality was found to be better.

The results clearly indicate that during the lockdown period due to pandemic COVID-19 there was a sharp cut in the concentration of air pollutants in Bareilly city and all stations reported the air pollutants concentration within the permissible

limits. This could be due to low vehicular emissions, suspended construction work and restricted use of commercial DG sets. This was further confirmed from the data collected from three petrol pumps (Table 1) regarding the sale of diesel and petrol fuel in the vicinity of the monitoring stations from January 2020 to June 2020.

It was evident that the fuel sale shows a decreasing trend (Table 1) in the month of March 2020 and least in April 2020 when the Bareilly city was under lockdown due to the out-break of coronavirus pandemic and a gradual rise in the fuel sale was observed from May 2020 onwards. The sale of diesel at Coco Pump, DD Puram and Dhruv Pump during the month of April 2020 has decreased by 38, 58 and 46%, respectively, as compared to the sale in the month of March whereas the sale of petrol has crashed during the month of April 2020 at Coco Pump, DD Puram and Dhruv Pump by 53, 63 and 60%, respectively.

CONCLUSIONS

From the analysis of the air pollutant PM_{10} over a period of twelve months from three monitoring locations depending on the traffic frequency in the vicinity of 11 km, it can be concluded that the concentration of air pollutants in Bareilly city was alarming during the post monsoon season particularly in the month of November 2019 to December 2019 and the PM level dropped down significantly during the lockdown period especially in the end of March 2020 and April 2020 and showed gradual increasing trends from May 2020 onwards as the city stepped in to unlock phase. Bareilly city do not have too much of industrialization and hence air pollution largely depends on vehicular exhaust emissions which is evident from the sale of diesel and petrol fuel reported from the fuel pumps in the study area. As expected, the Station A being a commercial and heavy traffic site showed higher concentration of PM_{10} but station C also recorded PM_{10} values exceeding the NAAQS limits in spite of ecofriendly environment. This could be due to the ongoing construction of a flyover just adjacent to IVRI Bareilly. Thus, it can be concluded that the possible cause of air pollutant in the city Bareilly could be vehicular emissions, re-suspended road dust or incomplete construction works. The study carried out for air pollutant analysis is from a limited number of stations covering only an area of 11 km. On increasing the number of monitoring locations better estimate of air quality can be done. Currently, limited attention and concern is given to air pollution in spite that millions die due to air pollution all over the world.

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REFERENCES

Crouse, D.L., Goldberg, M.S., Ross, N.A., Chen, H. and Labrèche, F. 2010. Postmenopausal breast cancer is associated with exposure to traffic-related air pollution in Montreal, Canada: A case-control study. Environmental Health Perspectives, 118 (11), 1578–1583.

Dubey, B., Pal, A.K. and Singh, G. 2013. Assessment of Vehicular Pollution in Dhanbad City Using CALINE 4 Model, International Journal of Geology, Earth and Environmental Sciences, 3,156–164.

Gold, D.R., Litonjua, A., Schwartz, J., Lovett, E., Larson, A., Nearing, B., Allen, G., Verrier, M., Cherry, R. and Verrier, R. 2000. Ambient pollution and heart rate variability. Circulation, 101, 1267–1273.

Goyal, P., Jaiswal, N., Kumar, A., Dadoo, J.K. and Dwarakanath, M. 2010. Air quality impact assessment of NOx and PM due to diesel vehicles in Delhi. Transportation Research Part D, 15, 298–303.

Gurjar, B.R., Butler, T.M., Lawrence, M.G. and Lelieveld, J. 2008. Evaluation of emissions and air quality in megacities. Atmospheric Environment, 42, 1593–1606.

NEERI. 2008. Air quality monitoring, emission inventory and source apportionment studies for Delhi. NEERI, Nagpur. [https://www.mpcb.gov.in]

Parent, M.E., Goldberg, M.S., Crouse, D.L., Ross, N.A., Chen, H., Valois, M.F. and Liautaud, A. 2013. Traffic-related air pollution and prostate cancer risk: a case-control study in Montreal, Canada. Occupational and Environmental Medicine, 70(7): 511–518.

Weichenthal, S., Farrell, W., Goldberg, M., Joseph, L. and Hatzopoulou, M. 2014. Characterizing the impact of traffic and the built environment on near-road ultrafine particle and black carbon concentrations. Environmental Research, 132: 305–310.

United Nations. 2015. World Urbanization Prospects: The 2014 Revision, Department of Economic and Social Affairs, Population Division. (ST/ESA/SER.A/366). https://population.un.org/ wup/Publications/Files/WUP2014-Report.pdf.

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