A comparative studies PAHs associated with Particulate Matter at a Residential and a Commercial Site in Delhi

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Abstract

Polycyclic Aromatic Hydrocarbons (PAHs) associated with particulate matter especially with PM2.5 have concerning attention due to their carcinogenic nature. In this study characterization of SPM bound PAHs has been done for a year, from July 2012 to June 2013 at two selected locations (JNU and CP) in Delhi which are considered to be a representative indicator of a particular regional behavior. Samplings were collected by using filter paper such as Polytetrafluoroethylene (PTFE) on 24-hrs based. The Total PAHs (TPAHs) concentration in particulate phase PAHs varied from 72.98 to 140.88 ng/m3 at both sites. CP experienced a higher concentration of TPAHs in comparison to JNU, which may be due to more petrol and diesel-driven vehicles plying in this area, due to its commercial nature. At both sites, the maximum concentration of PAHs was found to be dibenzo (a, h) anthracene with 38.25 ng/m3 at CP among the PAHs respectively, while at JNU the observed value for benzo(a) anthracene was 23.85 ng/m3. Such a high concentration could be mainly attributed to primary emission from the vehicular exhaust. The TPAHs concentration in the particulate phase was observed to be lower in the monsoon in comparison to the winter and the summer seasons.

Keywords: PAHs, particulate matter, petrol, diesel-driven, photo-degradation.

Introduction

The rapid increase in urbanization, industrialization, and vehicles has led toair pollution, which is considered as one of the serious environmental problems that adversely affects life on the earth. Air pollutants that are of principal concern are suspended Particulate matter ($PM_{10\mu m}$& $PM_{2.5\mu m}$), Nitrogen oxides (NO_X), Sulphur oxides (SO_x), Carbon monoxide (CO), Volatile organic compounds (VOC_S), Polycyclic Aromatic Hydrocarbons (PAHs), Peroxyacetyl nitrate (PAN) and Ground-level ozone (O_3) (1,2,3). Among these pollutants, PAHs are of great concerned due to their carcinogenic and mutagenic properties (4, 5, 6). PAHs are emitted into the atmosphere by incomplete combustion of fossil fuels. PAHs associated with fine particulate matter ($PM_{2.5}$, aerodynamic diameter ≤ 2.5 μm), are responsible forfatal cancer and cardio-pulmonary disease.

PAHs containing five to seven rings have a more adverse impact on human health (Harvey, 1997; Boehm et al., 2002). In particular,the PAH, Benzo (a) pyrene [B(a)P] including Benzo (a) anthracene, and Dibenzo (a,h) anthraceneare considered ascarcinogens (7, 8). It has been found that they have a significant impact on reproduction as well as on the immune system (6).Several studies have shown that the concentration of PAHs in the atmosphere varies seasonally and spatially, especially across the different regions (9,10, 1112,13, 14)

The present work attempts to study seasonal and spatial variation in the concentration of particulate-bound PAHs in the ambient air of Delhi. The air samples have been collected from two sites representing different human activities.

[2] METHODOLOGY

[2.1] Study Area:

In the present work, Delhi has been taken as the area of study. Since the concentration of air pollutants have increased here many times due to rapidexpansion in population, automobiles, and industries,the possibility of a higher concentration of PAHs exists in the atmosphere over this region.

The largest no of vehicles (a major contributor to PAHs)in comparison to any other cities of India are plying in Delhi.Its trend of annual growth has been depicted in Fig 1.

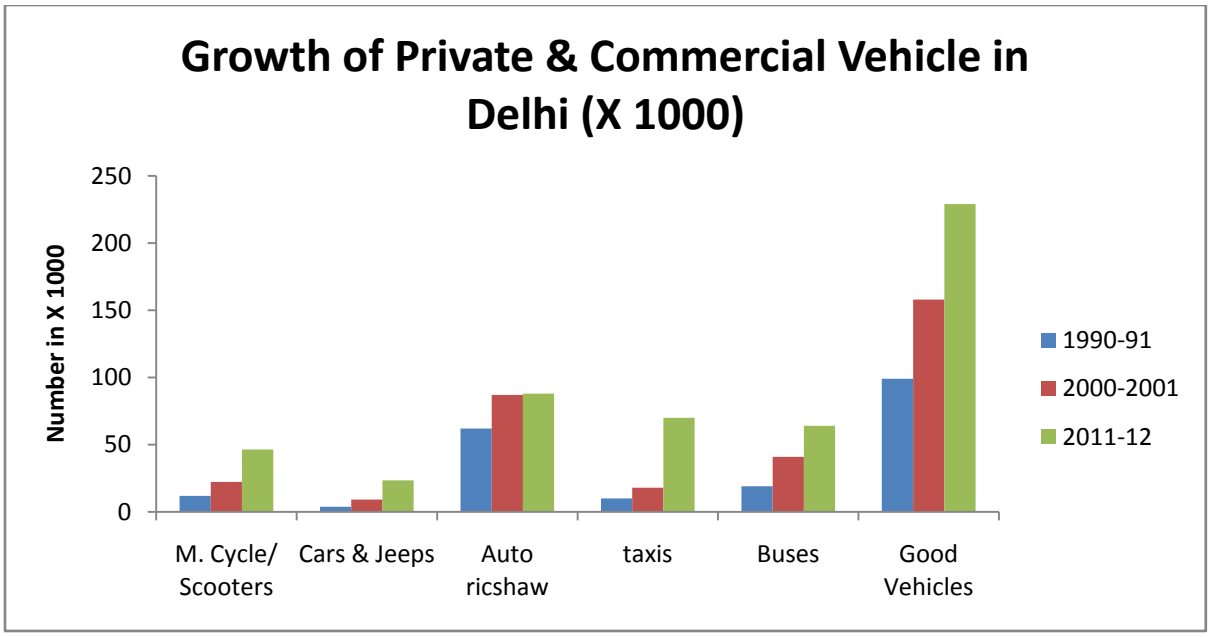

Fig1: registered no. of the vehicle in Delhi transport

Source: Transport Department, GNCT of Delhi.

[2.1.1] Sampling Location

In order to get a representative idea of the pollutant level, air sampling was done at two selected points (JNU and CP) which are considered to be a representative indicator of a particular regional behaviour. Jawaharlal Nehru University (JNU), represents the residential area, and the other at Connaught Palace (CP) represents the commercial area.

Sampling Procedure:

Sampling was carried out for a year, fromJuly 2012 toJune 2013, so as to cover all three seasons (summer, monsoon, and winter). Sampling was carried out at the same location for all three seasons. In each season, 30 samples were collected using filter paper such as Polytetrafluoroethylene (PTFE),out of which 82 samples were quantified for PAHs. The analysis of PAHs was doneon 24-hrs based method ofthe National Institute of Occupational Safety and Health (NIOSH method 5515).

Results and Discussion

Total Annual Particulate PAHs Concentration at Different Sites

Total PAHs (TPAHs), the sum of the concentration of 16 detected PAHs have been calculated for both sites.The annual Concentration of TPAHs in the $PM_{2.5}$ fraction at both thesites was found to range from 72.98ng/m^3 to 140.88ng/m^3, which is higher than the reported value for European countries (15), South America (16), the USA (18), and the UK (18). CP experienced a higher concentration of TPAHs in comparison to JNU, which may be due to more petrol and diesel-driven vehicles plying in this area due to its commercial nature. The TPAHconcentration was observed to be lower in monsoon in comparison tothe winter and the summer seasons. The lower PAHconcentrations in monsoon are likely due to the washout effects and, to a lesser extent, due to photo-degradation of PAHs (19).

Quantification of Particulate PAHs at JNU site:

The concentration of the analyzed PAHs is shown in Fig 2. It is observed from the diagram that the concentration of the PAHs having higher molecular weight is higher in comparison to the PAHs of lower molecular weight. The TPAHs at JNU were found to be 72.98 ng/m^3. The observed value was found to be lower than a previous study reported in JNU during the years 2002-2003 (20). The observed lower value of PAHs may due to the replacement of Diesel/gasoline-driven vehicles with CNG-driven vehicles. khillare et al (2008) have the same observation.

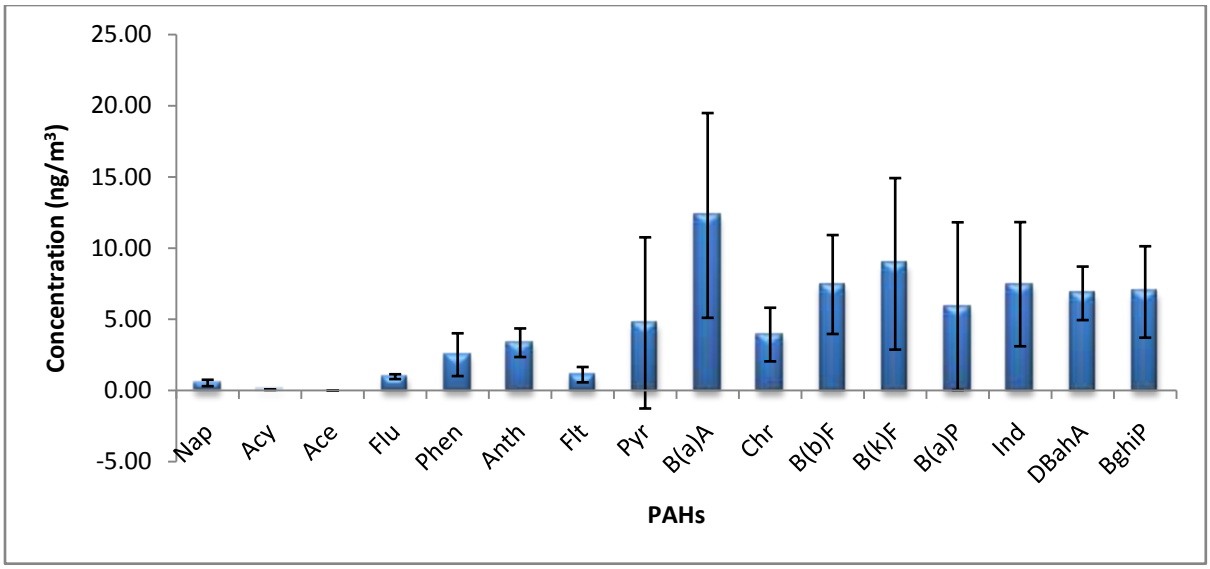

Fig 2: The annual mean Concentration of PAHs at the JNU site.

The seasonal average concentrations of PAHs were observed to be higherduring the winter season in comparison to the monsoon season. More solid fuel combustion in the winter period may also be an added reason for the higher concentration of PAHs. The meteorological conditions prevailing in the winter season may also be a reason because they are less conducive for the dilution of the air pollutants. The average trend of major PAHs during all seasons was found to be in the following order: Benzo (a) anthracene>benzo (k) florentine>endo (1,2,3-CD) pyrene>dibenzo (a, h) anthraceneat JNU. The concentration of lower molecular PAHs (Nap, Acy, and Flu) had less value (<1 ng/m^3), whereas acenaphthene was not detectable among the PAHs on particulate matter. It might be noted that Benzo (a) anthracene had the highest concentration (23.85ng/m^3) among the particulate PAHs during the winter season, whereas acenaphthylene had the lowest concentration (0.01 ng/m^3) at the JNU site during monsoon. The mean concentration of Benzo (a) anthracene (12.30 ± 7.14ng/m^3) was found to be the maximum, whereas acenaphthylene (0.06 ± 0.02 ng/m^3) was the minimum among particulate PAHs during all the three seasons.

Quantification of Particulate PAHs at Connaught Place site:

The meanconcentration with a standard deviation of particulate PAHs has been presented in Fig. 3. The annual TPAHswerecalculated to be 140.88 ng/m^{3}at CP.Benzo[a] anthracene was reported the highest concentration (29.38 ng/m^3) during the winter season, whereas acenaphthylene was the lowest concentration (0.03ng/m^3) during the summer. The higher concentration was noted which might be due to the prevailing meteorological conditions. The annual average concentrationPAHs was observed to be 8.89 ng/m^3, whereas the highest and the lowest averageconcentrations were found to be 22.16 ng/m^3 (Benzo (k) fluoranthene) and 0.06 ng/m^3 (acenaphthylene) among the PAHs.

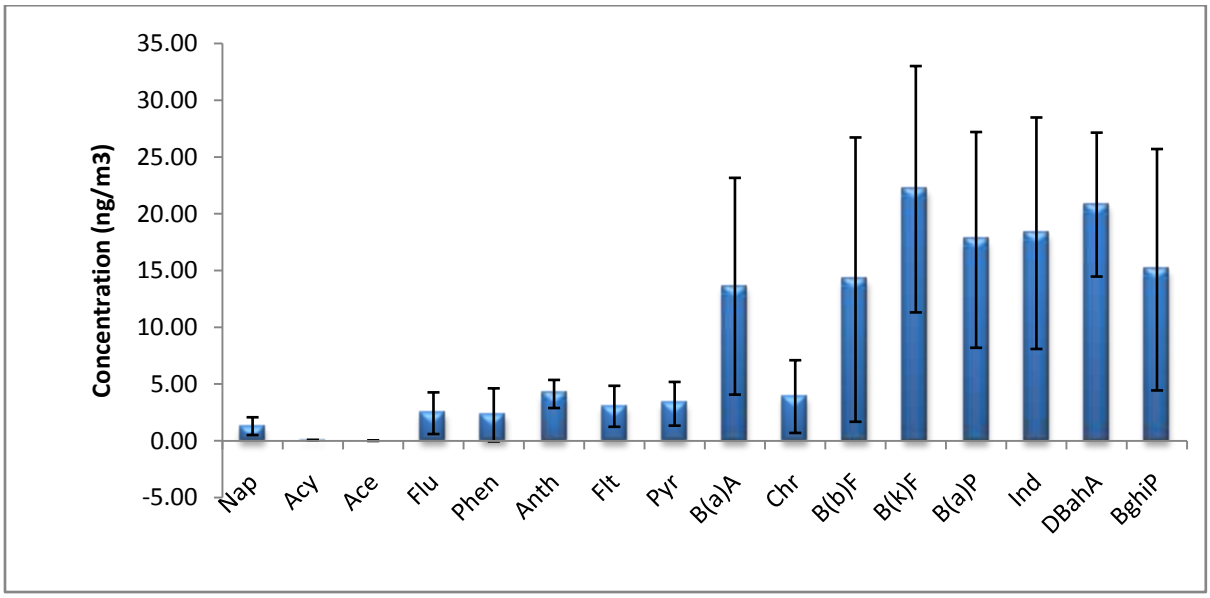

Fig. 3: The annual mean Concentration of particulate PAHs at the CP site

The average trend of particulate PAHs was followed in order as:benzo (k) fluoranthene>dibenzo [a,h] anthracene>endo (1,2,3-cd) pyrene>benzo [a] pyrene.Benzo (k) fluorantheneaccountedfor the highest 16% of total PAHs. The contribution of higher molecular weight accounted for more than 65%, whereas lower molecular weight accounted for less than 11% of total PAHs.

Comparison of Individual species of Particulate phase PAH

the TPAHs in Indian cities werereported 10–50 times higher in comparison to those reported internationally and ranged from 23 to 190 ng/m^3 (21, 22, 23, 24,25, 26). Several

studies claimed that higherconcentrationsof PAH having higher molecular weight areassociated withthe particulate phase PAHs, namely B(a)P (30%), Pye (20%), DBahA (15%), and IndP (15%)(11,12,14).

The average trends of major PAHs found in the present study were Benzo (a) anthracene>benzo (k) fluoranthene>endo (1,2,3-cd) pyrene>dibenzo (a,h) anthracene at the residential site of JNU.It might be noted that Benzo (a) anthracene hadthe highest mean concentration among the particulate PAHs at JNU (8.90 ± 60.3 ng/m^3), whereas benzo(k) fluoranthene (22.16 ± 10.84 ng/m^3) at CP.At both sites, the maximum concentration of PAHs was found to be dibenzo (a,h) anthracene with 38.25 ng/m^3 at CP among the PAHs respectively, while at JNU the observed value for benzo(a) anthracene was 23.85 ng/m^3. Such a high concentration could be mainly attributed to primary emission from the vehicular exhaust.

Conclusion

Polycyclic aromatic hydrocarbons (PAHs) in the particulate phase were measured at two different sites a residential (JNU), and a commercial site (Connaught Place) in the ambient atmosphere during the period April 2012 to March 2013. In the current study, a total of 16 PAHs for the particulate phase were identified and analyzed by GS/ GS-MS instrument. The present study investigated that higher molecular weight PAHs were primarily associated with the particulate phase, especially $PM_{2.5}$. The TPAHs concentrationin particulate phase PAHs varied from72.98to 140.88ng/m^3at both sites. CP experienced a higher concentration of TPAHs in comparison to JNU, which may bedue to more petrol and diesel driven vehicles plying in this area, due to its commercial nature. The TPAHs concentrationin the particulate phase was observed to be lower in the monsoon in comparison to the winter and the summer seasons. The lower PAHconcentrations in monsoon are likely due to the monsoonal rains, whereas in the summer witnessed thephoto-degradation and dispersion of PAHs. More solid fuel combustion in the winter period may also be a reason for the higher concentration of PAHs, along with the meteorological conditions prevailing in the

winter season. Further, the current study needs for investigating of physio-chemical properties of PAHs along with gaseous PAHs in the ambient air of the Delhi region.

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