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Aerosolized polycyclic aromatic hydrocarbon (PAH) concentrations during monsoon season at a semi arid region of India: A case study

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Abstract
Air pollution is responsible for nearly seven million deaths around the globe every year. Nine out of ten human beings currently breathe air that exceeds the WHO's guideline limits for pollutants, with those living in low- and middle-income countries suffering the most. We breathe tiny particles called aerosols, which can damage lung tissue and lead to lung diseases. There are many sources of aerosol particles in our atmosphere, some are natural sources, such as mineral dust and sea spray. Other sources such as urban smog and vehicle exhaust are caused by human activities. Major sources of aerosols include urban/industrial emissions, smoke from biomass burning and secondary formation from gaseous aerosol precursors, sea salt and dust. Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal, crude oil, and gasoline. They result from burning coal, oil, gas, wood, garbage, and tobacco. PAHs can bind to or from small particles in the air. Airborne particulate matter from four different locations from Agra city was collected using respirable dust samplers during the 2006 monsoon season and was then extracted with dichloromethane using an automated Soxhlet Extraction System (Soxtherm®). The extracts were analyzed for 17 target Polycyclic Aromatic Hydrocarbons (PAHs). The total PAH (TPAH) concentrations were 61.09, 22.24, 20.81 and 5.21 ng m^{-3} at industrial, residential, roadside, and agricultural sites, respectively. The combined mean concentration of TPAH was 27.54 ng m^{-3} for all sites. The industrial site had the highest TPAH concentration followed in order by the residential, roadside and agricultural sites. Indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene and benzo(b)fluoranthene were the predominant compounds found in the samples collected from all of the sites.

Keywords: Particulate PAHs, Monsoon, Semi-arid, Spatial variation

Introduction

Polycyclic aromatic Hydrocarbons (PAHs) are chemicals containing two or more benzene rings in a linear, angular or cluster arrangement. They contain only Carbon and Hydrogen. PAH are usually generated under inefficient combustion conditions, such as insufficient oxygen [1,2] by primary natural sources which are forest fires and volcanic activity, but most of the PAHs released into the environment arise from anthropogenic sources such as burning of fossil fuels, petroleum refinery, industrial processes, as a constituent of coal tar and motor vehicle exhaust [3]. Airborne particulate matter derives from a wide variety of sources. Probably the major sources within most urban areas of developed countries are road traffic emissions, resuspension of soils and road dust [4,5]. Sources of PAHs in urban atmosphere include automobiles, refineries and diesel generators. Automobile exhaust gases contain many non-polar PAHs such as benzo(a)pyrene, benzo(a)anthracene and benzo(b)fluoranthene which are associated with diseases such as cancer, asthma, and hay fever [6,7]. The lighter PAH (2-3 rings), are mostly found in the gas phase while the heavier ones are mainly associated with airborne particles. Heavier PAH (with more than three rings) are rapidly attached to existing particles, usually soot particles, by adsorption or condensation upon cooling of fuel gas [8,9]. It is well established that some PAHs have carcinogenic, mutagenic and immunotoxic effects on animals and can occur in low concentration in many parts of the environment. In many circumstances the environmental occurrence of PAHs has been associated with adverse effects on public health [10]. It is believed that there is no *"Threshold"* or "*Safe*" level for the mutagenic compounds, hence exposure to these PAHs at any level provide the risk of toxic effects [11].

This present study ascertained PAH concentration and trends in atmospheric PM_{10} at Agra during monsoon season, a semi-arid region of India, and identified sources based on variations in PAH profiles and land use among the sites. The concentration determined for individual PAH will help Planners, Scientists, and Administrators to draw strategies to reduce PAH exposure to the people living in this area.

Methodology

Regional site description

Agra, the city of Taj (27º10'N78º02'E) is located in the North Central part of India having 1,271,000 of total population [12]. It is bounded by the arid Thar Desert of Rajasthan on two-third part of its Periphery. Monsoon season comprises of four months *i.e.* from July to October. In monsoon season, the temperature and relative humidity ranges from 14.5°C to 38.2°C and 35.6%-96.2% respectively. The down ward wind is east and south-south-west and its speed ranges from 0.2 m s^{-1} to 6.9 m s^{-1} in monsoon [13]. Four locations, representing industrial, residential, roadside and agricultural areas, were selected for study. St. John's College was selected as a representative roadside area. It is situated in the heart of Agra city, by the side of a road that carries a maximum traffic density of about 100,000 vehicles per day, resulting in the emission of smoke and total suspended particulate matter from engine exhaust [3].

Nunhai (TransYamuna) was selected as an industrial zone because large numbers of diesel generator manufacturing plants, iron processing and tanning industries are located in this area. Dayalbagh, to the north, is exclusively agricultural. Kamla Nagar was considered representative of a residential area.

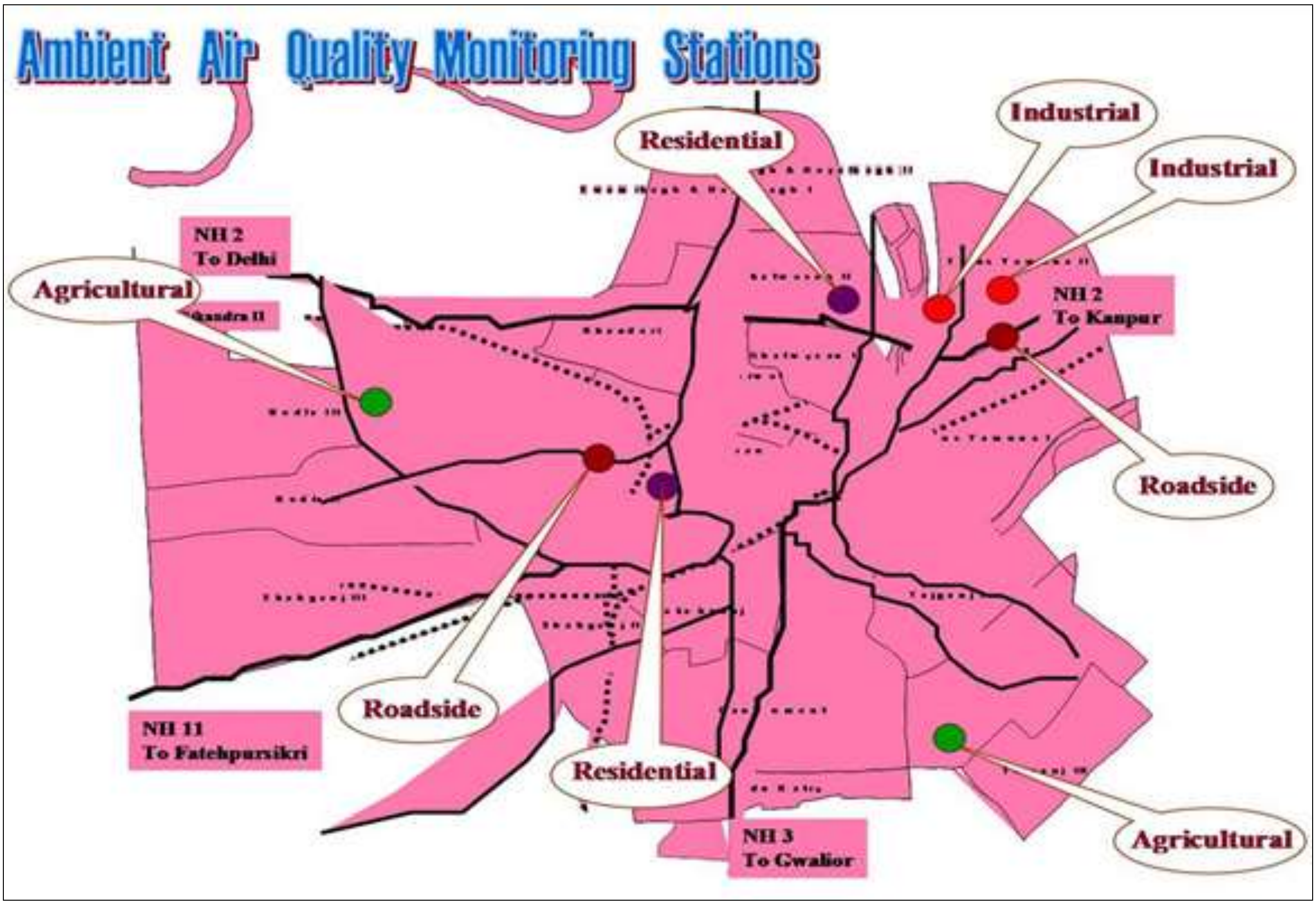

Fig 1: Map of Agra showing sampling sites

Sampling & Analysis

Air sampling stations were set up in the four previously described locations during monsoon season (Jul. 2005 to Oct. 2006). Each station was monitored 24 hours for ambient air quality twice a week in a scheduled manner. Particulate Matter (PM_{10}) in air were collected on 20.3 x 25.4 cm^2 glass fiber filter paper (EPM-2000) using respirable dust samplers (RSPM Envirotech Sampler RDS, 460 DX, New Delhi, India) at the rate of 1.0 cubic meter per minute (m^3/min). The air suction rate was verified every week using calibrated rotameters with an accuracy of ±1%. Lot blanks and TSP filter paper samples were kept in desiccators overnight and were weighed on a microbalance accurate to 0.1 milligrams (mg). Samples were stored in a cool, dark place until analysis. Samples and blanks were extracted with 140 milliliters (mL) methylene chloride by Soxtherm®. Blank spike/blank spike duplicate (BS/BSD) samples (spiked with PAH spiking solution) were extracted using clean fibreglass thimbles. The gas chromatograph (GC) oven was temperature programmed to separate the method analytes on a fused silica column, which were then detected with a mass spectrometer (MS) [14, 15, 16].

Results and Discussion

The average TPAH concentrations measured in ambient air at the various sites are presented in Figure 2. The TPAH concentrations were 61.09, 22.24, 20.81 and 5.21 ng m^{-3} at industrial, residential, roadside, and agricultural sites, respectively. The combined mean concentration of TPAH was 27.54 ng m^{-3} for all sites. The industrial site had the highest TPAH concentration followed by the residential, roadside and agricultural sites. These results also indicate that PAH concentrations are strongly linked to land use. Figure 3 shows the relative contribution of 2-, 3-, 4-, 5-, and 6-ring PAHs in the atmosphere at the locations investigated in this study. The average TPAH percentage based on the number of rings were 0.46% (2-ring), 3.02% (3-ring), 25.72% (4-ring), 38.48% (5- ring), and 32.31% (6-ring). The major contributors to TPAH in the Agra region were 5-ring and 6-ring PAHs (48.48% and 32.31% of the TPAH respectively).

The concentration trends of the major PAH found in present study are illustrated in Figure 4, which were: benzo (g, h, i)perylene > indeno(123-cd)pyrene > benzo(b)fluoranthene > benzo(a)pyrene at the industrial site;

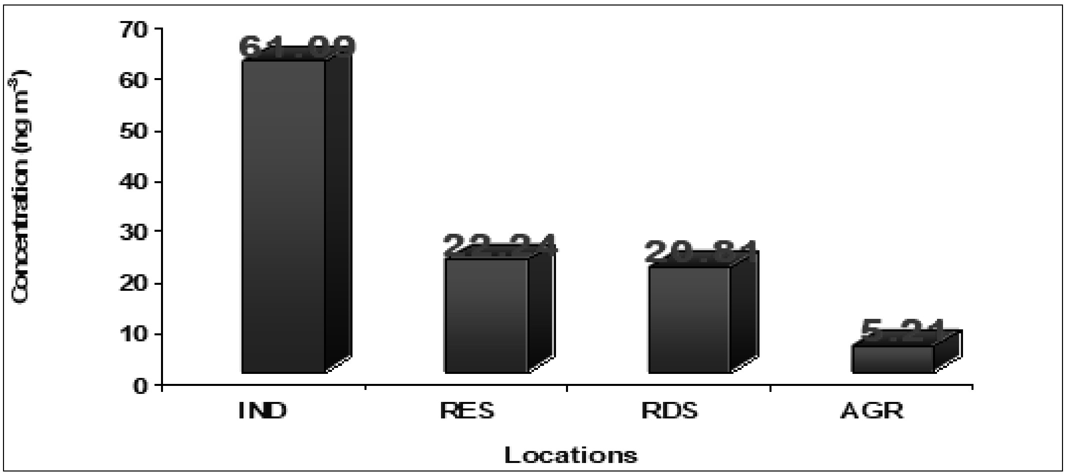

Fig 2: TPAH concentrations in ambient air at Agra during monsoon

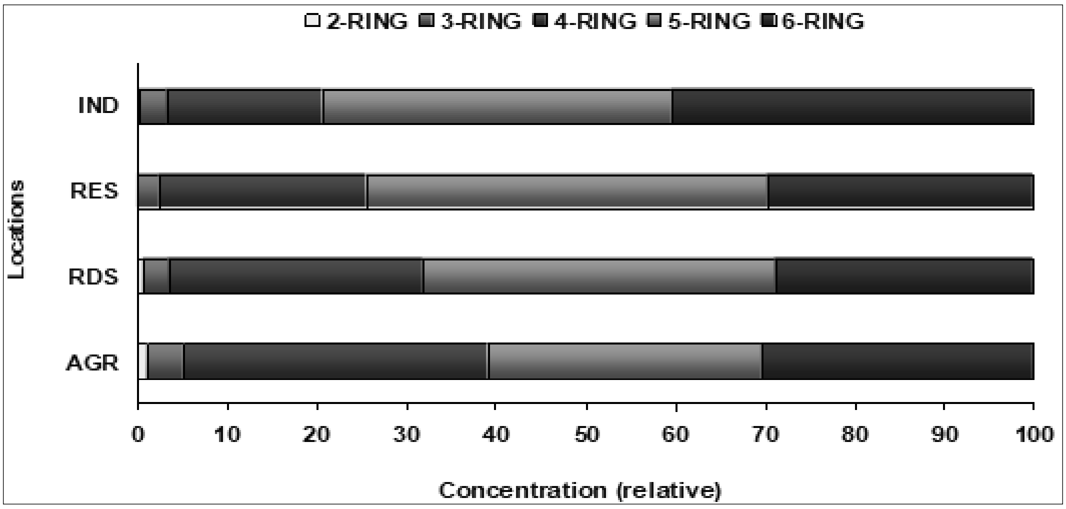

Fig 3: Distribution of PAHs based on benzene ring at Agra during monsoon

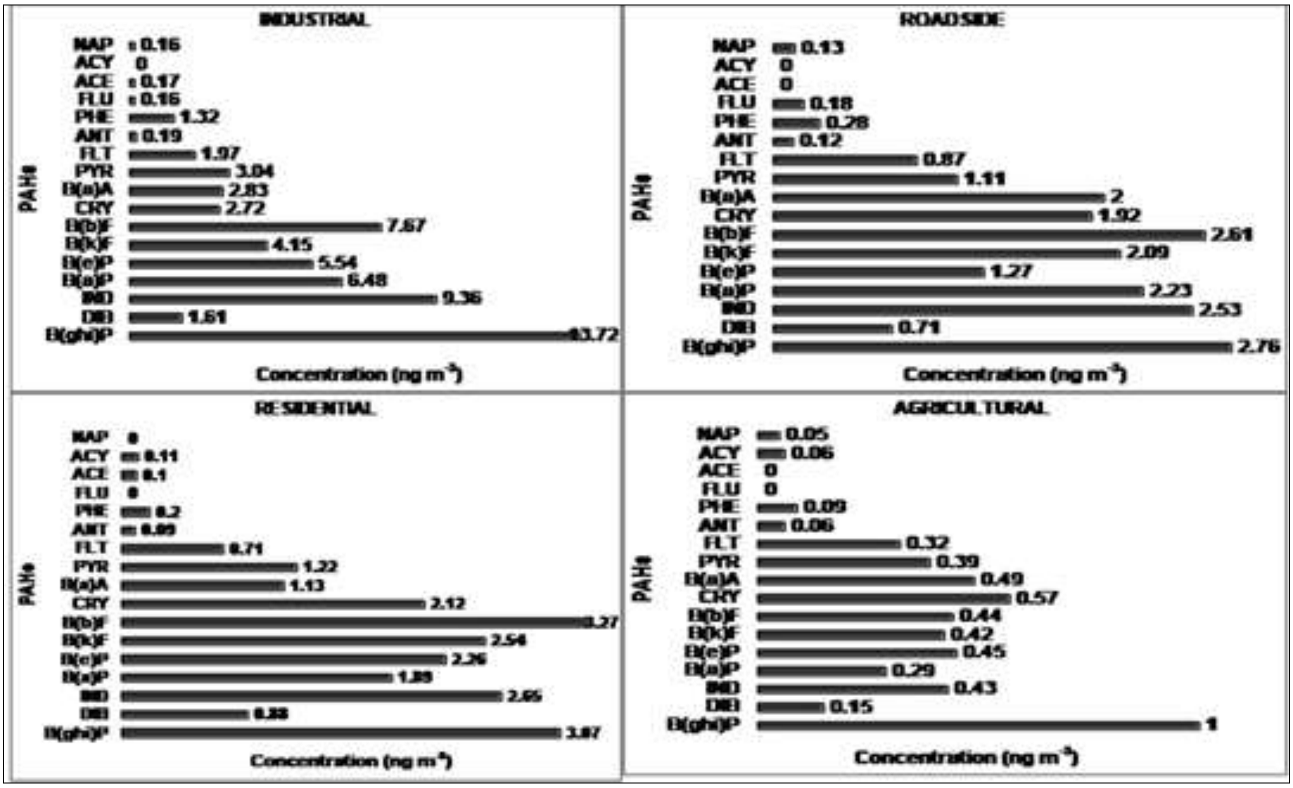

Fig 4: Trends of individual concentrations of PAHs (ngm^{-3}) during monsoon

benzo(b)fluoranthene > benzo(g,h,i)perylene > indeno(123-cd)pyrene > benzo(k)fluoranthene at the residential site; benzo(g,h,i)perylene > benzo(b)fluoranthene > indeno(123-cd)pyrene > benzo(a)pyrene at the roadside site: and benzo(g,h,i)perylene > chrysene > benzo(a)anthracene > benzo(e)pyrene at the agricultural site.

Benzo(b)fluoranthene were the predominant compounds except agricultural site. The atmospheric pollution load is high and because of the down ward wind, pollutants may be transported to the different areas mainly from an oil refinery situated in Mathura (50 kms from the centre of Agra City).

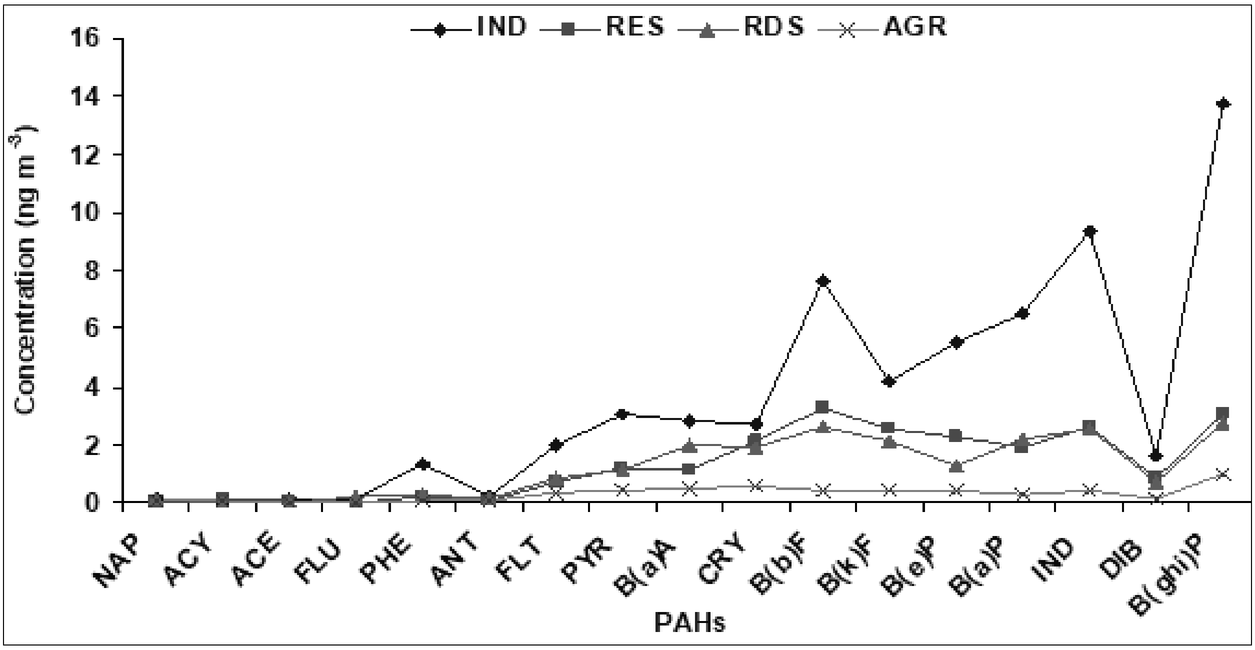

Fig 5: Spatial variation in the concentration of individual PAHs in monsoon

Figure 5 shows the variation in the concentration of PAHs depending on different locations. It is clear from the figure that much variation is found in industrial and agricultural sites whereas the residential as well as roadside sites have almost similar concentration of PAHs.

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References

1. Sorensen J. Polycyclic Aromatic Hydrocarbons (PAHs): Comparison of ambient air concentrations of vehicular exhaust and local emissions from roofing asphalt/tar operations. Atmospheric Environment,1994:14:983-1011.
2. Nam JJ, Song BH, Lee SH, Smith A. Distribution of Polycyclic Aromatic Hydrocarbons (PAHs) in agricultural soils in south Korea. *Chemosphere*,2003:50:1281-1289.
3. Masih A, Taneja A. Polycyclic Aromatic Hydrocarbons (PAHs) concentrations and related carcinogenic potencies in soil at a semi-arid region of India. *Chemosphere*,2006:65:449-456.
4. APEG. "Source apportionment of airborne particulate matter in the UK". Airborne particles expert group, DETR, London. 1999.
5. Harrison RM, Tilling R, Jarvis K. A study of trace metals and polycyclic aromatic hydrocarbons in the roadside environment. Atmospheric Environment,2003:37:2391-2402.
6. Oda J, Nomura S. Mobile sources of atmospheric PAHs in a roadway tunnel. Atmospheric Environment,2001:35:4819-4857.
7. Masih A, Saini R, Taneja A. Concentrations, Sources and Exposure Profiles of Polycyclic Aromatic Hydrocarbons (PAHs) in Particulate Matter (PM 10) in the North Central Part of India" Environmental Monitoring and Assessment,2010:163:421-431.
8. Kamens R, Odum J, Fan Z-H. Some observations on time to equilibrium for semi volatile Polycylic aromatic hydrocarbons. Environmental Science and Technology,1995:29:43-50.
9. Masih A, Masih J, Taneja A. Study of air–soil exchange of polycyclic aromatic hydrocarbons (PAHs) in the north-central part of India – a semi arid region – Journal of Environmental Monitoring, (RSC) DOI: 10.1039/c1em10567a 14,2012:(1):172-180.
10. Grimmer GG. (Ed) "Environmental Carcinogens: PAHs Chemistry, Occurrence, Biochemistry, Carcinogenicity". CRC Press, Inc., Boca Raton, FL. 1983.
11. Masih A, Saini R, Taneja A. Inhalation and carcinogenic exposure profiles of atmospheric polycyclic aromatic hydrocarbons at a semi-arid region of India. International Journal of Research in Engineering and Science,2022:10(10):341-349.

12. National Solid Waste Association of India. 2004. www.nswai.com
13. CPCB. http://wwwcpcb.nic.intas.htm (assessed January 22), 2006
14. EPA Region III. Table of Risk-Based Concentrations. Published by the US Environmental Protection Agency on the Internet at: http://www.epa.gov/reg3hwmd/risk/human/rbc/rbc0406.pdf 2006.
15. NIOSH. Manual of analytical methods, US, Department of Health and Human Services publication,1-3,1988:94-113. Publication No.
16. REAC. Analysis of PAHs in Air by GC/MS, 2002: SOP No. 1817, 1-31.