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STUDIES ON BTEX IN AMBIENT AIR OF AGRA

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ABSTRACT

In this study, the concentration of benzene, toluene, ethylbenzene and xylene were measured in ambient air of Agra, Uttar Pradesh , India at five locations. Samples were collected by using Respo Rae 3000 Ultra VOC Monitor having PID with 9.8 eV discharge lamp. It is a real time measurement of BTEX. It was observed that the toluene has the highest concentration species, followed by benzene, ethylbenzene and xylene. Maximum concentration of BTEX were reported in winter season and the lowest concentrations of BTEX were reported in summer season. Refueling pump stations and vehicular exhaust emission as well as usage of petrochemical products are the dominant sources of BTEX were observed.

Key words: photo-ionization, pre-concentration, fatigue, solvent usage, FID (Flame Ionization Detector).

I. INTRODUCTION

With the recent introduction of the problems associated with the air pollution in the whole world, this triggered our interest in investigating the presences of BTEX in ambient air of Agra. The term BTEX is regarded as benzene toluene, ethylbenzene and xylene collectively. Several megacities of the world are facing serious air quality problems as a results of increase in urbanization and industrialization, as well as population [1]. There has been a continuous increase in levels of pollutants (VOCs) and environmental emanating from these pollutants particularly from the second half of the last century [2]. VOCs, mainly BTEX play an important role in the chemistry of atmosphere such as their role in the formation of photochemical smog and their associated oxidants, degrading air quality and threatening both human health and ecosystem is alarming [3,4]. Several studies have shown that VOCs enter the human bloodstream through the following means; inhalation, ingestion and through the skin. The short term adverse health effects of BTEX include conjunctive irritation, nose irritation, throat discomfort, headache, sleeplessness, allergic skin reaction, nausea, fatique and dizziness. While the long term health effects of BTEX include loss of coordination, leukemia, anaemia, cancer and damage to liver, kidney and central nervous system(CNS) [5,6,7]. In addition, BTEX have long been object of study in occupational epidemiology, hence, the health effects of these compounds among highly exposed population are well known. The health effects, those caused by chronic exposure to benzene, which are considered to have more serious consequences than the exposure to other compounds such as toluene, ethylbenzene and xylene. In this context, there is a scientific evidences that benzene exposure is one of the risk for leukemia [8] and other types of cancers [9] and that it has immune-toxic effects.

Several studies have shown that more of the BTEX were released in the ambient air during the dry season, this may also be attributed to a greater industrial activities such as solvent usage, petrochemical processes, storage and distribution of chemicals, combustion processes, vehicular exhaust and petroleum products emissions, emissions from waste dump and evaporative sources such as from dry cleaning shops, refrigerator and air

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conditioner workshops, fuel filling stations and hawkers of cloths, footwears, cosmetics etc [11]. While in wet season, BTEX levels are low due to dilution of the atmospheric air. In this context, the presence of heavy traffic, gas stations, refueling pump stations and petrochemical plants in the vicinity are the main determinants of the levels of BTEX pollutants [12,13]. Several researchers have attempted VOCs monitoring studies over different parts of the world considering BTEX increasing importance in environmental issues[14].

In this context, the spatial and temporal distribution of VOCs concentration in Apapa industrial area was found to be dependent mainly on industrial activities such as industrial solvent usage, petrochemical processes, storage and distribution of chemicals, combustion processes, vehicular/petroleum products emission and meterological factor such as wind speed, direction of wind, humidity, rainfall and temperature [11]. Weekdays – weekends variations of total volatile organic compounds (TVOCs) in atmosphere of Benin city, Southern Nigeria was determined [15]. Meteorological conditions and photochemical activities cause diurnal, seasonal and annual variations of VOCs concentration [16]. Outdoor, indoor and personal distribution of BTEX in pregnant women from two areas of Spain was studied and found that in comparision with other studies, sample population's exposure to BTEX compounds was not excessively high[17]. Indoor and outdoor air concentrations of BTEX and NO_2 was measured and observed that in a setting of moderate climate like Germany, the variability of BTEX and NO_2 concentrations over time id high [18]. Measurements and correlations of MTBE and BTEX in traffic tunnels was estimated and pointed out that notanly the high ratios in all tunnels reflect a fresh air parcel in the tunnels due to enclosed/half-enclosed environment[19]. Occupational exposure of gasoline station workers to BTEX compounds in Bangkok, Thailand was reported and showed that exposure to BTEX compounds would increase the risk of cancer in gasoline station workers. Exposure to benzene and toluene may cause fatigue [20]. Patterns of VOCs and BTEX concentrations in ambient air around industrial sources in Daegu, Korea was studied and indicated by the significant differences observed between daytime and nighttime BTEX [21].

Therefore, monitoring of BTEX in urban area has become important issue. With this view, the present study aims to report the ambient levels of BTEX measured at Agra at different locations.

II. METHODOLOGY

Several methods have employed to determine the concentrations of BTEX in ambient air, depend on the presence of air pollutants. These methods are active and passive sampling. In active sampling method, first the samples were collected by sampling tube filled with coconut shell charcoal at a height of 1.5m – 2.0m, by using the sampling pump at the flow rate of 30– 60ml/minute. Then the absorbed BTEX were desorbed with carbondisulphide and kept for ultrasonication for 30 minutes. Finally, the solution analysed using gas chromatography (GC) fitted with flame ionization detector (FID). While in passive sampling method, the sampling tube were exposed in air with the help of hood and then followed the active sampling method [22,23].

In the present study, the study area is Agra, which is located at latitude of 27^0 10' N and longitude of 78^0 05' E with an altitude of 169m above the sea level in the semiarid zone of India. Agra has a continental type of climate characterized by extreme dryness in summer and cold winters with calm periods. The study period was devided into four seasons on the basis of rainfall, namely summer (March-June), mansoon (July -August), Post monsoon (September - October) and winter season (November-February).

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Five different sites were selected namely, Avas Vikas colony (residential), Sadar Market (Commercial), Foundary Nagar (Industrial), St. John's crossing (traffic intersections) and Hariparwat (refueling pump station) respectively. In this study, the ambient air samples were collected during the period of November 2008 to October 2009 at five locations in Agra , Uttar Pradesh, India. A real time measurements of benzene, toluene. ethylbenzene and xylene (BTEX), ambient air concentrations were performed by using Respo Rea 3000 Ultra VOC Monitor, which is a programmable compound specific photoionization detector (PID), designed to provide instantaneous monitoring of BTEX. The PID has a 9.8 eV gas discharge lamp. Before using the VOC Monitor, it was first calibrated with isobutylene gas level in usual fashion to read in isobutylene equivalent. After calibration process, monitor now ready to use. Thus we collected samples and obtained the reading which manually multiplied by the correction factor (CF) to obtain the concentration of BTEX. The sample size for the pre-concentration step was four hours in a month at all the selected locations in Agra. The obtained data on BTEX were statistically analysed and compared with other studies performed in India and other countries of the world.

III. RESULTS AND DISCUSSIONS

Through this study, the levels of BTEX from five locations in Agra has been obtained. The average concentrations of BTEX measured in Agra by means of VOC monitor, during November 2008 to October 2009 are summarized in Table 1. Highest concentrations of BTEX were observed at Hariparwat (Refueling pump station) and followed by Foundary Nagar (Industrial), St. John's crossing (Traffic Intersection), Sadar Market (Commercial) and Avas Vikas colony (Residential) locations respectively. This showed that refueling pump stations, petrochemical processes and products, vehicular exhaust emissions, anthropogenic activities are the main sources of the BTEX in ambient air. In overall study, the total BTEX concentrations measured in Agra was 238.3 µg/m^3 at all the locations during November 2008 to October 2009. The results indicate the following BTEX composition: 25.4 % of benzene, 54.8 % of toluene, 12.1 % of ethylbenzene and 7.7 % 0f xylene respectively. Toluene constitutes highest percentage composition, followed by benzene, ethylbenzene and xylene respectively. From the table-1, it was evident that the highest concentration of benzene was observed at Hariparwat refueling pump station location and the lowest concentration was observed at Avas Vikas colony (Residential). Similar patterns were shown by other species such as toluene, ethylbenzene and xylene.

Table 1. Composition of Btex in Agra at Different Sites (µg/M^3)

S.no.	Sites	Benzene	Toluene	Ethylbenzone	Xylene	Total BTEX
1.	Avas Vikas colony (Residential)	5.7	16.2	2.7	1.7	26.3
2.	Sadar Market (Commercial)	8.1	9.3	3.8	2.4	23.6
3.	Foundary Nagar (Industrial)	17.8	34.1	8.7	5.4	66.0
4.	St.John's Crossing (Traffic Intersection)	9.7	11.4	4.4	2.8	28.3
5.	Hariparwat (Refueling Pump Station)	19.2	59.8	9.3	5.8	94.1
	Total	60.5	130.8	28.9	18.1	238.3

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Figure 1-5,summarizes the trends of the monthly mean concentrations of BTEX measured in Agra. At all the locations, the annual mean concentrations were : 5.7, 8.1, 17.8, 9.7 and 19.2 µg/m^3 for benzene, 16.2, 9.3, 34.1, 11.4 and 59.8 µg/m^3 for toluene, 2.7, 3.8, 8.7, 4.4, and 9.3 µg/m^3 for ethylbenzene and 1.7, 2.4, 5.4, 2.8 and 5.8 µg/m^3 for xylene respectively. Toluene concentrations were 1.5 to 3 times higher than benzene concentrations. Similarly, toluene concentrations were 5 to 7 times higher than ethylbenzene concentrations and 6 to 9 times higher than the concentrations of xylene respectively. Therefore, at each locations, the concentrations of toluene were highest and followed by the benzene, ethylbenzene and xylene respectively. The concentrations of BTEX decreases during the summer, monsoon and post-monsoon periods and increases in winter periods due to the reactivity of these compounds (Figures 1-5). It was also observed that the BTEX concentrations were quite high in winter season than summer. These species follow the given trends in Agra during November 2008 to October 2009:

Winter season > Summer season > Monsoon season > Post-monsoon season

Figure-1. Average monthly variation of BTEX at Avas Vikas Colony (Residential) during November 2008 to October 2009.

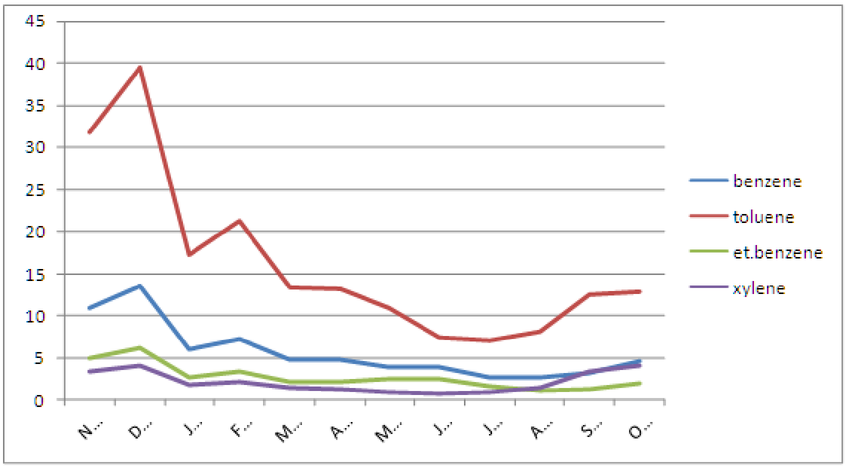

Figure-2. Average monthly variation of BTEX at Sadar Market (Commercial) during November 2008 to October 2009.

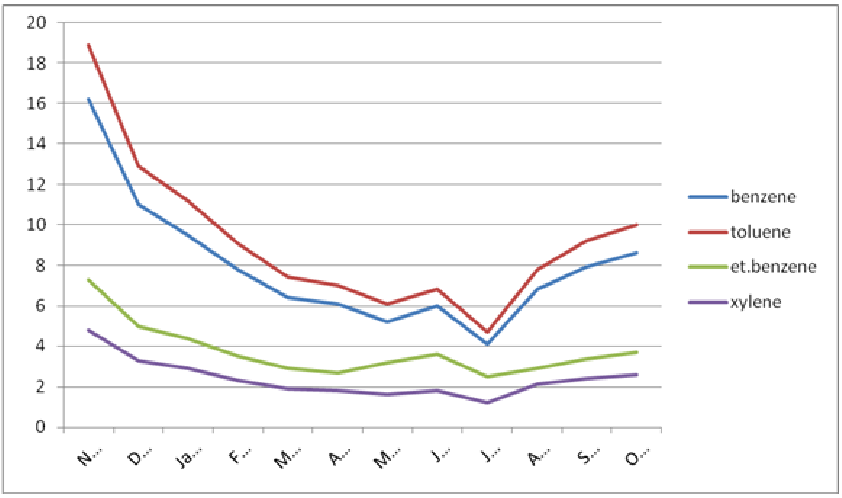

Figure-3. Average monthly variation of BTEX at Foundary Nagar(Industrial) during November 2008 to October 2009.

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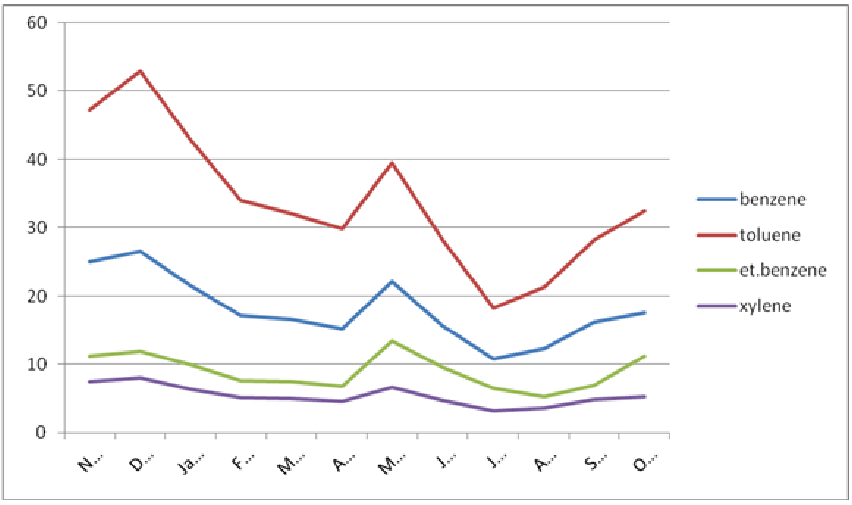

Figure-4. Average monthly variation of BTEX at St. John's Crossing (Traffic Intersection) during November 2008 to October 2009.

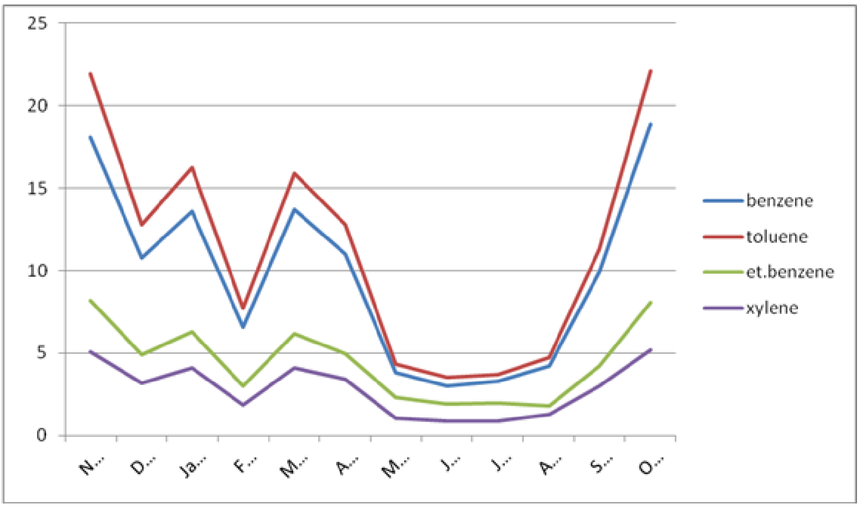

Figure-5. Average monthly variation of BTEX at Hariparwat (Refuelimg pump station) during November 2008 to October 2009.

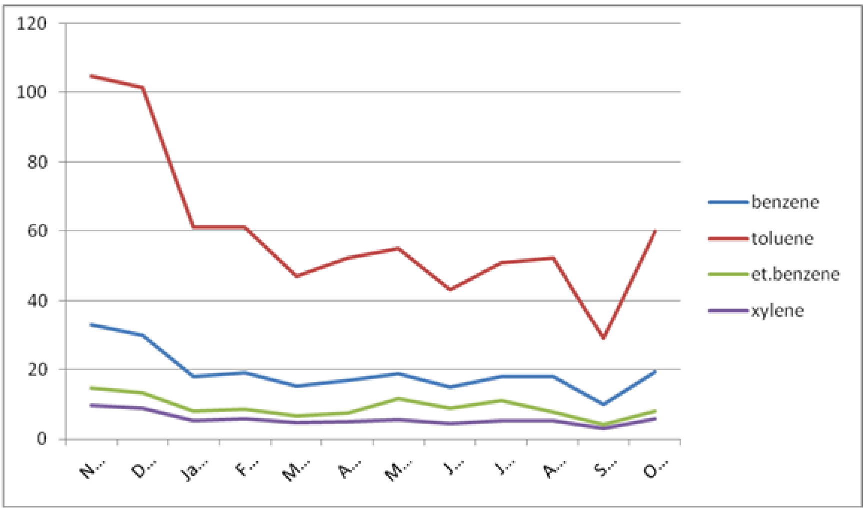

Table-2. Presents the comparision of benzene and toluene concentrations at Agra with other sites of India and abroad. The levels of benzene and toluene were observed to be comparable to Hannover [24], Kaoushing City[27] Mexico [26], and.

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Table -2 Comparision of benzene and toluene with other sites.

Sites	Benzene (mg/m3)	Toluene (mg/m3)	Reference
Mumbai	13.4-38.6	10.9-33.5	[23]
Hannover	9.6	25.7	[24]
China	15.4-67.3	28.06-106.9	[25]
Mexico city	5.29	28.22	[26]
Kaoushing city	10.97	43.36	[27]
Delhi	174.7-369.4		[28]
Hyderabad	120-173	110-126	[29]
Kolkata	13.8-72.0	21.0-83.2	[30]
Agra	3.19-20.21	8.83-62.81	present study

much lower than other megacities like Mumbai [23], Delhi [28], China [25], Hyderabad [29], and Kolkata [30]. Comparatively higher concentrations of benzene and toluene might to be due to more traffic density and hence greater vehicular exhaust emission.

IV. CONCLUSIONS

The distribution of BTEX concentrations in Agra at five locations was found to be dependent mainly on industrial activities such as industrial solvent usage, petrochemical processes, storage and distribution of chemicals, combustion processes, vehicular exhaust emission, petroleum products emission and meterological factors such as wind speed, direction of wind, humidity, rainfall and temperature .

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