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Original Article

Monitoring of Benzene, Toluene, Ethylbenzene and Xylene (BTEX) Concentrations in Ambient Air in Firozabad, India

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ABSTRACT
Mixing ratio of BTEX (benzene, toluene, ethyl benzene xylene) were measured for the first time in ambient air of Firozabad, Uttar Pradesh, India at five sites (residential, industrial, commercial, refueling pump station and traffic intersection) from March to June 2009. Day-time and night-time sampling was done at five selected sites during working time and four emission sources to provides for analysis, using PID detector under operating condition for the identification of BTEX concentration in ambient air, as parts per million (ppm) quantity is often found in environment samples. The concentration ranges of BTEX 0.139 ppm (residential), 0.013 ppm (industrial), 0.073 ppm (commercial), 0.765 ppm (refueling pump station) and 0.276 ppm (traffic intersection), respectively. The average concentrations of benzene 0.207 ppm, toluene 0.209 ppm, ethyl benzene 0.285 .ppm and xylene 0.294 ppm, respectively.
The significant difference observed between the five sites for the residential, industrial, commercial, refueling pump station and traffic intersection areas implies that the five areas have different emission sources. This is also indicated by the significant differences observed between day-time and night-time BTEX concentrations. The four months variation indicates a decrease in concentration of BTEX during summer season of the reactive o-xylene compound. We conclude that air pollution as measured by BTEX levels do not necessarily predict but instead may predict mortality rates. Due to the toxic effect of the BTEX studied, an assessment for health risk due to exposure to the population were calculated. These results are useful in the design of emission source control measures for BTEX in Firozabad, India.

INTRODUCTION

The sources and behavior of anthropogenic aromatic compounds in the atmosphere are of interest because of their association with human health problems and the use of fossil fuels. The major sources of benzene, toluene, ethyl benzene and xylenes are from evaporative losses from petrol as well as the internal combustion process itself. The burning of biomass also results in a release of benzene. The only known important atmosphere loss process for benzene and toluene is by reaction with the OH radical with respect to which an atmospheric lifetime of about 10 days is typical for benzene and about 1-2 days is typical for toluene[1].
For both occupational and non-occupational exposures to volatile organic compounds (VOCs), the gasoline vapor emission and motor vehicle exhaust have long been recognized as the two most important sources. For VOC exposure assessments, BTEX (the acronym for benzene, toluene, ethyl benzene and xylene) are the four most intensively investigated compounds by researchers because of their high contents in gasoline fuel[2].
BTEX is a group of compound including benzene, toluene, ethyl benzene and xylene. All are volatile organic compounds (VOCs). Motor fuels are complex organic mixtures comprised of hundreds of specific compounds. Indicator compounds are usually defined as those compounds which can be considered the most toxic. For these reasons, many state cleanup standard or guidelines focus on benzene, toluene, ethyl benzene and xylene, commonly known as "BTEX" . The relative mobility of these compounds is known, and they are widely recognized as the toxins of concern in fuels such as gasoline. The BTEX compounds represent some of the most hazardous components of gasoline. A variety of test are used to identify BTEX contaminations chronic effects of benzene, toluene, ethyl benzene and xylene include changes in the liver and harmful effects on the kidneys, heart, lungs and nervous system. Except for short term hazards from concentrated spills, BTEX compounds have been more frequently associated with risk to humans' health. Certain carcinogenic effects have been associated with BTEX compounds are often found in association with a PAH compounds [3].The main objective of this study was to obtain quantitative information about the concentrations that would be both spatially and temporally representative for various ambient

environments in the air. The measurements were therefore conducted during four months at five sites (residential, industrial, commercial, refueling pump station and traffic intersection) from March to June 2009.

MATERIAL AND METHODS

In order to assess the BTEX concentrations in the ambient air across the Firozabad city were completed. The sampling points were chosen because ambient BTEX concentration levels were expected to be different at the selected five sites (residential, industrial, commercial, refueling pump station and traffic intersection) from March to June 2009.

Study Site

BTEX was sampled in a different area in Firozabad, Uttar Pradesh, India. The sampling was conducted in the working place. Samples were collected for two times (in a month) during eight hours of normal working period time for in March, April, May and June 2009. The five selected sites used in this study represent residential (Suhag Nagar), industrial (Bhau ka Nagla), commercial (Shastri Market), refueling pump station (Asfabad petrol pump) and traffic intersection (Jain Mandir Tiraha).

BTEX Measurement

In this research, real-time measurements of benzene, tolene, ethyl benzene and xylene concentrations were performed sing the programmable compound specific PID detector designed to provide instantaneous exposure monitoring of a specific organic gas. It monitors a specific gas by utilizing a gas separation tube and the photo-ionization detector (PID) with a 9.8 eV gas discharge lamp (range- 50 ppb to 200 ppb).

Statistical analysis

Collected data has been analyzed under SPSS 15 software and using One-sample t-test to compare concentration environmental and personal sampling air benzene, Toluene ethyl benzene and xylene by the threshold level recommended (TLV) by the American Conference of Governmental Industrial Hygienists (ACGIH).

RESULTS AND DISCUSSION

In the present study, mixing ratios of BTEX (benzene, toluene, ethyl benzene and xylene) were measured in ambient air at the five selected sites in Firozabad for 24 hours duration in Table 1. The mean concentration of benzene (ranging from 0.197 ppm to 0.207 ppm), toluene (0.198 ppm to 0.209 ppm), ethyl benzene (0.195 ppm to 0.285 ppm) and xylene (0.195 ppm to 0.205 ppm) were found at all the five selected sites. From Table 2 the BTEX concentrations ranged from 0.139 ppm to 0.148 ppm (residential), 0.0127 ppm to 0.013 ppm (industrial), 0.073 ppm to 0.075 ppm (commercial), 0.675 ppm to 0.784 ppm (refueling pump station) and 0.185 ppm to 0.287 ppm (traffic intersection) were found at all the five selected sites in Firozabad, Uttar Pradesh, India. BTEX levels in Firozabad showed lower values with respect to the studies undertaken in different cities[4] in India and in different countries. When compared to the other mega-cities of India, the BTEX levels in study of Firozabad were much lower than those obtained in Mumbai (13.4 - 38.6 μgm^{-3} benzene, 10.9 - 33.5 μgm^{-3} toluene, Mohan Rao[5] et al. 1996), BTEX obtained in Delhi (TVOC values varied from 174.7 to 369.4 μgm^{-3}, Srivastava[6] et al. 2005) and BTEX obtained in Collate (mean concentration of BTEX 97.92 μgm^{-3}, Dutta[7] et al. 2008). In different countries like Taiwan (10.97 and 13.28 g m−3 for benzene and 43.36 and 54.49 g m−3 for toluene over two sites of Kaohsiung city, Lai and Chen [8], Northern Germany (9.6 g m−3 benzene and 25.7 g m−3 toluene at Hannover, Ilgen et al. [9], and Mexico (benzene 5.29 g m−3 and toluene 28.22 g m−3 at Mexico city Metropolitan Zone, Bravo et al. [10].

Figure 1 show as the four months BTEX concentration at refueling pump station and traffic intersection was high as comparatively with industrial and residential sites. While figure 2 shows as the BTEX concentration at refueling pump station is high as compare with industrial and residential sites.

The higher values of BTEX concentration represent at the refueling pump station site because the decisive source of atmospheric emissions of BTEX is exhaust gases from petrol driven automobiles.

Table 1: Monthly average concentrations of BTEX during March- June 2009

Sites	Months / 2009	Benzene			Toluene			Ethyl benzene			Xylene		
		Min. (ppm)	Max. (ppm)	Mean (ppm)	Min. (ppm)	Max. (ppm)	Mean (ppm)	Min. (ppm)	Max. (ppm)	Mean (ppm)	Min. (ppm)	Max. (ppm)	Mean (ppm)
Residential	March April May June	0.000 0.000 0.000 0.000	0.680 0.381 0.048 0.014	0.104 0.921 0.029 0.005	0.000 0.000 0.000 0.000	0.678 0.763 0.004 0.027	0.104 0.231 0.177 0.008	0.000 0.000 0.000 0.000	0.697 0.416 0.041 0.028	0.103 0.973 0.005 0.005	0.000 0.000 0.000 0.000	0.176 1.065 0/459 0.010	0.148 0.231 0.177 0.008
Industrial	March April May June	0.000 0.000 0.000 0.000	0.169 0.236 0.025 0.000	0.018 0.049 0.002 0.000	0.000 0.000 0.000 0.000	0.176 0.221 0.002 0.000	0.051 0.677 0.031 0.000	0.000 0.000 0.000 0.000	0.122 0.214 0.021 0.000	0.012 0.049 0.003 0.000	0.000 0.000 0.000 0.000	0.171 0.307 0.023 0.000	0.023 0.677 0.031 0.000
Commercial	March April May June	0.000 0.000 0.000 0.000	2.722 0.604 0.252 0.213	0.221 0.274 0.002 0.048	0.000 0.000 0.000 0.000	2.787 0.638 0.015 0.214	0.232 1.765 0.039 0.312	0.000 0.000 0.000 0.000	2.222 1.621 0.299 0.203	2.324 0.044 0.029 0.032	0.000 0.000 0.000 0.000	1.250 1.357 0.144 0.137	1.244 1.765 0.039 0.312
Refueling pump station	March April May June	0.000 0.000 0.000 0.000	10.163 5.925 6.396 5.969	2-232 1.697 0.816 0.447	0.000 0.000 0.000 0.000	10.981 6.809 5.369 5.855	1.22 4.353 1.059 0.495	0.000 0.000 0.000 0.000	9.564 5.546 5.483 5.767	1.545 1.063 1.987 0.438	0.000 0.000 0.000 0.000	5.933 6.191 5.387 4.286	4.374 4.353 1.059 0.495
Traffic intersection	March April May June	0.000 0.000 0.000 0.000	3.197 1.171 1.281 2.613	1.136 0.286 0.013 0.277	0.000 0.000 0.000 0.000	3.031 1.599 0.012 2.655	0.324 0.290 0.275 0.284	0.000 0.000 0.000 0.000	2.969 2.567 1.616 2.517	3.564 0.283 0.289 0.262	0.000 0.000 0.000 0.000	2.262 2.214 2.629 4.812	1.434 0.290 0.275 0.284
Total Four Months Concentrations (ppm)		0.207			0.209			0.285			0.294		

Figure 1: Monthly average concentrations of BTEX during March- June 2009

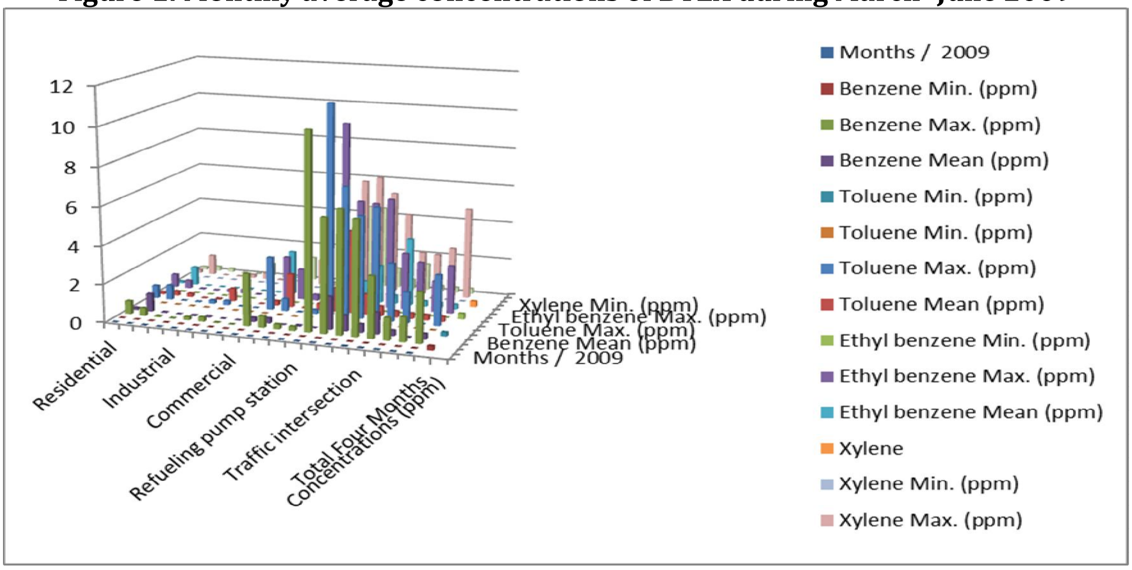
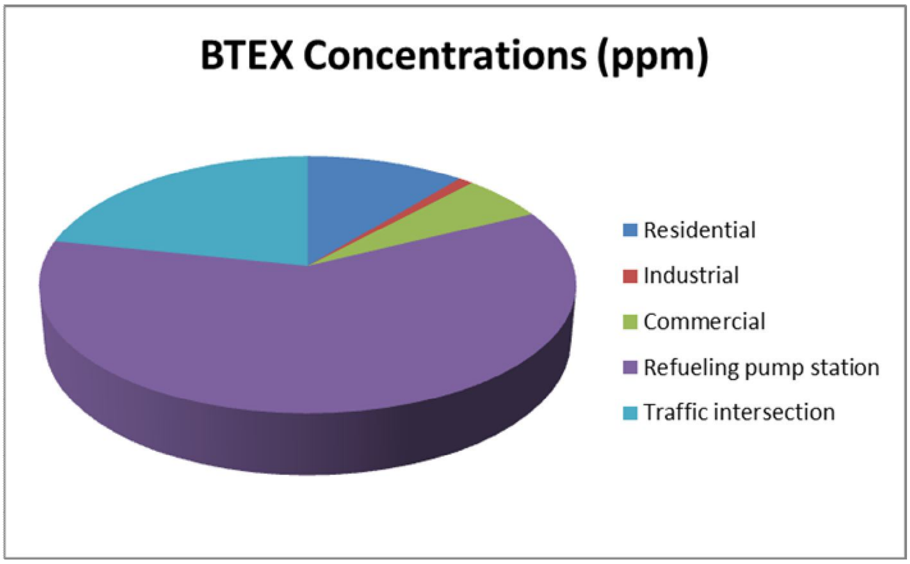


Table 2: Four months average concentrations of BTEX (ppm) during March- June 2009

Sites	BTEX Concentrations (ppm)
Residential	0.139
Industrial	0.013
Commercial	0.073
Refueling pump station	0.765
Traffic intersection	0.276

Figure 2: Four months average concentrations of BTEX (ppm) during March- June 2009



The other sources include evaporative emissions produced during petrol handling, storage, distribution and solvent usage. The lower values of BTEX concentration represent at the industrial site because these content mostly present in petrol and automobiles. The four month variation indicate a lower concentration of BTEX during summer season of the reactive o-xylene compound because the photochemical reactivity of BTEX towards OH radical [11]. Hydroxyl radicals are extremely short-lived species and play the role as the chemical scavengers of the atmosphere in cleansing earth, s atmosphere of harmful organic pollutants, in the season of summer. O – Xylene participates in ancillary photo-oxidation reactions including the conversion of nitric acid to nitrogen dioxide [12].

The BTEX concentrations turned out to be not normally distributed. The two factors, effect of seasons and effect of sampling places, always effected on the concentrations of BTEX on the ambient air.

Effect of season on the concentrations in ambient air

According to the Kruskal-Wallis test was applied to test the effect of the season on the BTEX concentrations in ambient air foe all sites sampling places separately. At all sampling places, no effect of the season was found at a significant level of $p > 0.05$ for the BTEX concentrations in the ambient air [13].

Effect of sampling places on the concentrations in ambient air: At all sampling places, all ambient air BTEX concentration data were lumped per site, resulting in a data set with two factors, country and site. As for the ambient air, the factor “site” cannot be considered independent of the factor “country” for the ambient air concentrations. Therefore, all “sampling places” had to be used [14].

CONCLUSION

We have evaluated the ambient concentration of BTEX in Firozabad, Uttar Pradesh, India, by using day-time, night-time and four-monthly measurements in March to June 2009 at five selected sites, and by PID detector. In Firozabad, the average ambient levels of BTEX were quite low and comparable to studies in mega-cities in India and different countries due to use of petrol and automobiles at busy roads (residential, industrial, commercial, refueling pump station and traffic intersection sites). Sources other than exhaust of petrol driven vehicles, contribute to an extent to BTEX concentrations in ambient air.

The concentration ranges of BTEX 0.139 ppm (residential), 0.013 ppm (industrial), 0.073 ppm (commercial), 0.765 ppm (refueling pump station) and 0.276 ppm (traffic intersection), respectively. The average concentrations of benzene 0.207 ppm, toluene 0.209 ppm, ethyl benzene 0.285 .ppm and xylene 0.294 ppm, respectively. The variations of BTEX ambient air concentrations were found at five selected sites. This is also indicated by the significant differences observed between day-time and night-time BTEX concentrations. The BTEX concentrations in ambient air were found to be dependent on the season. In spring and summer, concentrations were much lower than in autumn and winter, especially for BTEX. Also, the sampling sites was found to influence the BTEX concentrations in ambient air of Firozabad. In ambient air at the refueling pump station in Firozabad quite higher concentrations were measured than at the other sites. The probability of additional source of BTEX indicates adulteration of the fuels which used in vehicles and releases exhaust in an ambient air. Modifying certain fuel parameters, like reducing BTEX content in petrol will as well reduce BTEX content in ambient air[15]. In the prevailing level of BTEX, they pose both cancer risk and non-cancer hazard for the health of general population as estimated at all five sites.

REFERENCES

1. T.S. Clarkson, R.J. Martin, J. Rudolph and B.W.L. Graham (1996). Benzene and Toluene in New Zealand Air. *Atmospheric Environment*, **30**, 4, 569.
2. P.J. Tsai, C.C. Lee, M.R. Chen, T.S. Shih, C.H. Lai and S.H. Liou (2002). Predicting the contents of BTEX and MTBE for the three types of tollbooth at a highway toll station via the direct and indirect approaches. *Atmospheric Environment*, **35**, 5961.
3. V. Standford, Overton and J. J. Manura (1991). Identification of Volatile Organic Compounds In a New Automobile. *J. Chromatography : Biomedical Applications,* **562**, 1-2, 493.
4. H. Hallen, J. Kukkonen, M. Kauhaniemi, H. Hakola, T. Laurila and H. Pietarila (2005). Evaluation of atmospheric benzene concentrations in the Helsin Ki Metropolitan Area in 2000-2003 using diffusive sampling and atmospheric dispersion modeling. *Atmospheric Environment*, **39**, 4003.
5. M. Rao, A. M. Pandit, G. C. Sain, P. Sharma, S. Krishnamoorthy, T. M. Nambi, and K. S. V. Nambi (1996). Nonmethanehydrocarbons in industrial locations of Bombay. *Atmospheric Environment*, **31**, 1077.
6. A. Srivastava, A.E. Joseph, A. More and S. Patil (2005). Emissions of VOCs at Urban Petrol Retail Distribution Centres in India (Delhi and Mumbai). *Environmental Monitoring and Assessment*, **109**, 1, 22.
7. C. Dutta, D. Som, A. Chatterjee, A. K. Mukherjee, T. K. Jana and S. Sen (2009). Mixing ratios of carbonyls and BTEX In ambient air of Kolkata, India and their associated health risk. *Environmental Monitoring and Assessment,* **148**, 97.
8. C. H. Lai and K. S. Chan (2004). Characteristics of C2–C15 hydrocarbons in the air of urban Kaohsiung, Taiwan. *Atmospheric Environment* , **38**, 1997.
9. E. Ilgen, N. Karfich, N. K. Levsen and J. Angerer (2001). Aromatic hydrocarbons in the atmospheric environment: Part I. Indoor Versus outdoor sources, the influence of traffic, *Atmospheric Environment* , **35**, 1235.
10. H. Bravo, R. Sosa, P. Sanchez, E. Bueno and L. Gonzalez (2002). Concentrations of benzene and tolene in the atmosphere of the southwestern area at the Mexico City Metropolitan Zone. *Atmospheric Environment*, **36**, 3843.
11. K. R. Darnall, A. C. Lloyd, A. M. Winer and J. N. Pitts Jr (1971). Raectivity scale for atmospheric hydrocarbons based on reaction with hydroxyl radical. *Enviromental Science & Technology,* **5**, 1009.
12. A. P. Altshuller, I. R. Cohen, S. F. Sleva and S. L. Kopczynski (1962). Air Pollution : Photooxidation of aromatic hydrocarbons. *Science,* **138**, 442.
13. A. Pennequin – Cardinal, H. Plaisance, N. Locoge, O.Ramalho, S. Kirchner and J.C. Galloo (2005). Performances of the Radiello diffusive samplar for BTEX measurements : Influence of environmental conditions and determination of modelled sampling rates. *Atmospheric Environment,* **39**, 2535.
14. R. Keymeulen, M. Gorgenyi, K. Heberger, A. Priksane and H.V. Langenhove (2001). Benzene, toluene, ethylbenzene and xylenes (BTEX) in ambient air and *Pinus sylvestris* L. needles : a comparative study between Belgium, Hungary and Latvia. *Atmospheric Environment*, **35**, 6327.
15. A. Srivastava (2004). Source apportionment of ambient VOCS in Mumbai City. *Atmospheric Environment*, **38**, 6829.