International Archive of Applied Sciences and Technology
Volume 3 [2] June 2012: 75 - 79
ISSN: 0976-4828

Website: www.soeagra.com/iaast/iaast.htm

Original Article

Study on Refueling Pump Stations Caused By BTEX Compounds in Firozabad City

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ABSTRACT

In Firozabad City, the BTEX in ambient air at refueling pump stations were investigated. The air data collected from three refueling pump stations and by using programmable compound specific PID detector designed to provide instantaneous exposure monitoring of a specific organic. The concentration ranges of BTEX 25.62 μg/m³ (Hindustan Petrol Pump – Jain Mandir), 23.54 μg/m³ (Barat Petrol Pump – Jalesar Road) and 20.30 μg/m³ (Barat Petrol Pump – Asfabad), respectively were observed. It is known that benzene, toluene, ethyl benzene and xylene isomers, volatile organic compounds (VOCs) commonly called BTEX, have toxic health effects on humans and plants depending on duration and levels of exposure. Benzene in particular is classified carcinogenic, and exposure to benzene at concentrations above 64 g/m3 can be fatal within 5–10 minutes. Therefore, real-time monitoring of BTEX in ambient air is essential for the early warning detection associated with their release and in estimating the potential exposure risks to living beings and the environment.

INTRODUCTION

The fate of a chemical in the environment is controlled by its physico-chemical properties, the nature of introduction of the chemical in the environment [1] and also by the environmental conditions. Volatile organic com-pounds (VOCs) are omnipresent in lower urban atmosphere. Various typical anthropogenic activities like in-tense transportation, industrial and commercial activities prevailing in Firozabad city in addition to natural emissions are responsible for elevated VOC levels in Firozabad city.

The mono-aromatic volatile compounds like benzene, toluene, ethyl benzene, xylenes (BTEX), emitted to the ambient air, constantly take part in partitioning and distribution between the major environmental compartments like water, soil, vegetation etc. or it may entail partitioning between phases within an environmental compartment [2].

Benzene, toluene, ethyl benzene and xylene (BTEX) are volatile organic compounds. Due to their toxicity and ambient air concentrations, they are regarded as significant air pollutants [3]. In Canada, BTEX was reported to constitute about 18 percent of gasoline and are significantly used as solvents in various industries[4]. Aside from independent toxicity, BTEX also serve as precursors of secondary ambient air pollutants such as peroxyacetylnitrite, ozone, free radicals and nitrogen oxides [5]. Generally, the origin of BTEX in the environment is through vaporization and incomplete combustion of these compounds in motor vehicles[6-7]. According to toxicological studies, all BTEX compounds are neurotoxins and irritants; however, "International Agency for Research on Cancer" (IARC) considers benzene and ethyl benzene as confirmed and probable carcinogens respectively [8-14].

Many studies on air pollution and health effects use an exposure definition based on traffic counts, traffic density or modeled concentrations[15-16] but there are also studies investigating long-term health effects of BTEX and NO_2 through direct measurements of air pollution exposure in the homes of the participants[17-20]. Because people spend most of their time indoors and concentrations of certain pollutants, for example NO_2, have been shown to vary substantially over even short distances [21], an approach that directly measures the concentration of air pollutants at people's homes should be preferred over other methods.

In the present study, the ambient seasonal concentration of BTEX in a metropolitan city, namely Kolkata, India, have been measured during four months at three sites refueling pump station (Hindustan Petroleum - Jain Mandir, Bharat Petroleum - Jalesar Road and Bharat Petroleum -

Asfabad) from September to December 2009. Contribution of Firozabad city towards global warming due to its environmental load of BTEX has been estimated as carbon dioxide equivalent. Estimation of non-cancer health hazard as well as integrated lifetime cancer Risk (ILCR) due to the inhalation exposure of the general city population towards BTEX was also made.

METHODS AND MATERIAL

In order to investigate 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 three sites of refueling pump stations (Hindustan Petroleum - Jain Mandir, Bharat Petroleum - Jalesar Road and Bharat Petroleum - Ashabad) from September to December 2009.

Study site: This study was carried out in pre and mid-winter 2009 (during September to December 2009) at three refueling pump stations, Firozabad city, India. The selected refueling pump stations were three high sale stations. BTEX 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 September, October, November and December 2009. The three selected sites used in this study represent refueling pump stations (Hindustan Petroleum - Jain Mandir, Bharat Petroleum - Jalesar Road and Bharat Petroleum – Ashabad.

BTEX measurement: In this research, real-time measurements of benzene, toluene, and ethyl benzene and xylene concentrations were performed using 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

The results of BTEX were measured in ambient air from the selected site in Firozabad city for 24 hours duration in table 1.

Table 1: Monthly average concentrations of BTEX during September - December 2009

Refuelling Pump Stations	Months / 2009	Benzene (μg/m^3)			Toluene (μg/m^3)			Ethyl benzene (μg/m^3)			Xylenes (μg/m^3)		
		Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Hindustan Petrol Pump – Jain Mandir	Sep.	0.00	8.12	17.24	0.00	13.11	28.12	0.00	4.21	9.11	0.00	11.12	24 33
	Oct.	0.00	9.40	20.8	0.00	14.22	31.11	0.00	4.46	10.22	0.00	17.17	36.22
	Nov.	0.00	11.12	25.34	0.00	15.11	32.22	0.00	6.66	13.42	0.00	19.94	39.21
	Dec.	0.00	12.40	28.81	0.00	16.22	34.44	0.00	6.88	14.92	0.00	20.99	44.40
Bharat Petrol Pump – Jalesar Road	Sep.	0.00	7.44	15.21	0.00	13.43	27.56	0.00	4.68	10.49	0.00	10.22	22.11
	Oct.	0.00	8.12	18.34	0.00	11.12	24.34	0.00	5.22	11.12	0.00	13.22	28.44
	Nov.	0.00	10.22	21.11	0.00	14.12	30.24	0.00	7.94	15.99	0.00	17.24	36.11
	Dec.	0.00	12.10	23.20	0.00	15.01	32.00	0.00	9.91	18.89	0.00	20.11	41.44
Bharat Petrol Pump – Asfabad	Sep.	0.00	8.12	18.34	0.00	11.96	26.12	0.00	6.24	14.72	0.00	7.84	16.22
	Oct.	0.00	9.21	21.40	0.00	13.20	27.41	0.00	6.81	13.46	0.00	11.44	24.41
	Nov.	0.00	11.21	23.12	0.00	14.22	30.44	0.00	7.82	16.01	0.00	17.42	38.92
	Dec.	0.00	12.20	25.41	0.00	16.01	33.12	0.00	10.66	21.20	0.00	20.11	39.91
Total Four Months Concentrations (μg / m^3)	(Sep. – Dec.)	31.53			43.74			20.92			48.21		

The mean concentration of benzene at the Hindustan Petrol Pump – Jain Mandir (ranging from 17.24 μg/m³ to 28.81 μg/m³), at the Barat Petrol Pump – Jalesar Road (ranging from 15.21 μg/m³ to 23.20 μg/m³) and at the Barat Petrol Pump – Asfabad (ranging from 18.34 μg/m³ to 25.41 μg/m³). The mean concentration of toluene at the Hindustan Petrol Pump – Jain Mandir (ranging from 28.12 μg/m³ to 34.44 μg/m³), at the Barat Petrol Pump – Jalesar Road (ranging from 27.56 μg/m³ to 32.00 μg/m³) and at the Barat Petrol Pump – Asfabad (ranging from 26.12 μg/m³ to 33.12 μg/m³). The mean concentration of ethyl benzene at the Hindustan Petrol Pump – Jain Mandir (ranging from 09.11 μg/m³ to 14.92 μg/m³), at the Barat Petrol Pump – Jalesar Road (ranging from 10.49 μg/m³ to 18.89 μg/m³) and at the Barat Petrol Pump – Asfabad (ranging from 14.72 μg/m³ to 21.20 μg/m³). The mean concentration of Xylenes at the Hindustan Petrol Pump – Jain Mandir (ranging from 24.33 μg/m³ to 44.40 μg/m³), at the Barat Petrol Pump – Jalesar Road (ranging from 22.11 μg/m³ to 41.44 μg/m³) and at the Barat Petrol Pump – Asfabad (ranging from 16.22 μg/m³ to 39.91 μg/m³) at the three selected sites.

Figure 1: Monthly average concentrations of BTEX during September - December 2009

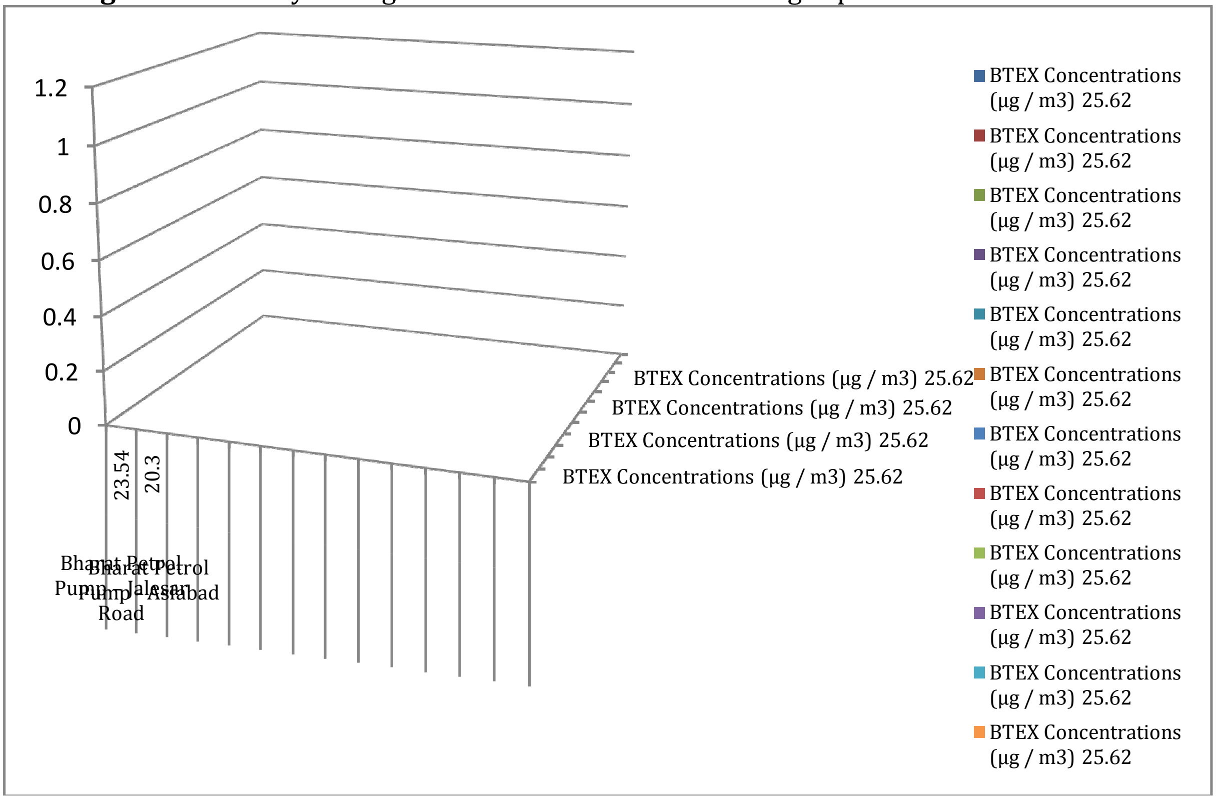
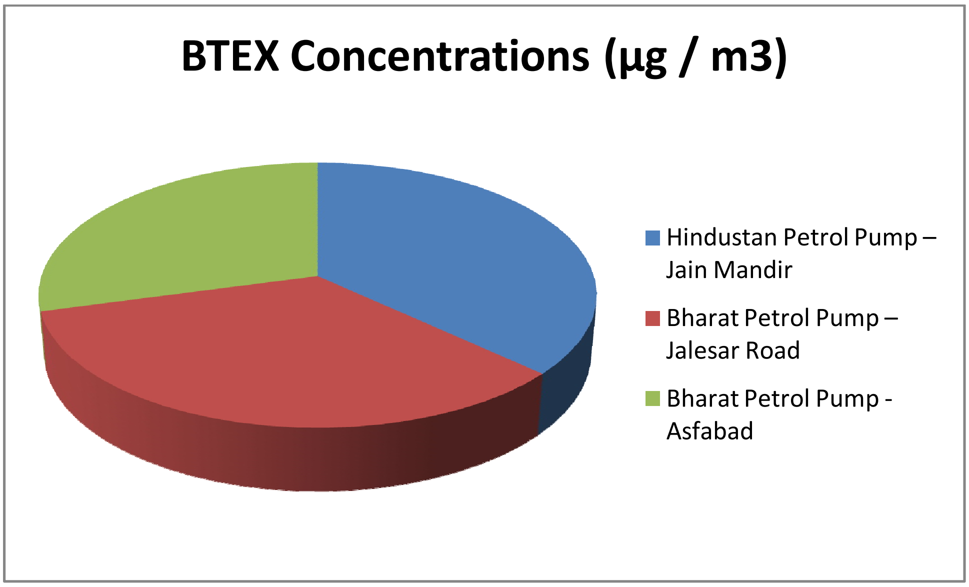


Table 2: Four months average concentrations of BTEX (μg / m³) during September - December 2009

Site – Refuelling Pump Stations	BTEX Concentrations (μg / m³)
Hindustan Petrol Pump – Jain Mandir	25.62
Bharat Petrol Pump – Jalesar Road	23.54
Bharat Petrol Pump - Asfabad	20.30

Fig 2: Four months average concentrations of BTEX (μg / m^3) during September - December 2009



From table 2, the average BTEX concentrations at the selected sites ranged 25.62 μg/m^3 (Hindustan Petrol Pump – Jain Mandir), 23.54 μg/m^3 (Barat Petrol Pump – Jalesar Road) and 20.30 μg/m^3 (Barat Petrol Pump – Asfabad). Some studies have been reported on the indoor and outdoor concentration levels of carbonyl compounds and BTEX the studies in Finland[22, 23] reported that the pump-island concentration of MTBE (97-1,790 g/m^3) and benzene (5-17 g/m^3). In Brazil and Korea, the levels of MTBE and BTEX in traffic area were about 56.3, 30.3, 104, 9.5, and 53.1 g/m^3, respectively [24 -25].

Figure 1 and 2 shows the BTEX concentration at Hindustan petroleum pump; Jain Mandir was high comparatively with Bharat petroleum Jalesar road and Asfabad.

The concentration of BTEX at the selected site Hindustan Petrol Pump – Jain Mandir, shows higher emission because the decisive source of atmospheric emissions of BTEX is exhaust gases from petrol driven automobiles and this refueling pump station situated in near about traffic point and the center in the Firozabad city. The other sources include evaporative emissions produced during petrol handling, storage, distribution and solvent usage. At the site of Bharat petrol pump – Asfabad shows lower emission of BTEX because this site situated in outer area of the Firozabad city. The four month variation indicate a higher concentration of BTEX during winter season. BTEX level in winter season was higher than summer because pollutants were more homogeneously distributed in winter. Seasonal variation was also influenced by emission sources and changes in emission activity, removal rates, or dispersion / dilution / transport may explain the seasonal variation [26]. We can see variation in source strength and availability of OH radical were identified to be the controlling factors [27]. The concentration of the BTEX were found to be quite high in the present study in winter season and their level could be threat to the health of the Firozabad city [28].

CONCLUSION

Ambient concentration of Benzene, Toluene, Ethyl benzene and isomers of Xylene (BTEX) have been found to be appreciably high in Firozabad city. The concentration ranges of BTEX 25.62 μg/m^3 (Hindustan Petrol Pump – Jain Mandir), 23.54 μg/m^3 (Barat Petrol Pump – Jalesar Road) and 20.30 μg/m^3 (Barat Petrol Pump – Asfabad), respectively were observed. The variation of BTEX ambient air concentrations were found at three selected sites. The BTEX concentrations in ambient air were found to be dependent on the season. The probability of additional source of BTEX indicates adulteration of the fuels which used in vehicles and released exhaust in an ambient air. Modifying certain fuel parameters, like reducing BTEX content in petrol will reduce BTEX content in ambient air [29]. The prevailing level of BTEX, may pose both cancer risk and non-cancer hazards for the health of general population as estimated at all three sites.

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