Research Journal of Chemical Sciences ______________________________________ ISSN 2231-606X
Vol. **2(4),** 45-49, April **(2012)** *Res.J.Chem.Sci.*

Monitoring, Assessment and Status of Benzene, Toluene and Xylene Pollution in the Urban Atmosphere of Delhi, India

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Available online at: www.isca.in
(Received 20th February 2012, revised 25th February 2012, accepted 27th February 2012)

Abstract

BTX (Benzene, Toluene and Xylene) are potentially toxic air pollutants among the volatile organic compounds (VOCs). These are present in the urban atmosphere in both exhaust and evaporative emissions from vehicles and fuel delivery outlets. The present paper gives an account of BTX levels in urban environment of Delhi measured since May 2008 to April 2010. Active sampling technique has been employed for measurements. A significant decrease (from 17.05/58.98/15.45 µg/m^3 to 16.00/52.99/14.22 µg/m^3 for B/T/X respectively during 2008-2009 and 2009-2010) was observed in the levels in the initial stage but the levels were found higher than the limiting value prescribed by CPCB (i.e. 5 µg/m^3- annual average for benzene). This indicates that in the urban atmosphere BTX do not dissipate easily in the environment and therefore, needs serious thought for reduction.

Key words: Volatile organic compounds (VOCs), benzene, toluene and xylene (BTX), active sampling, GC-FID.

Introduction

BTX are potentially toxic air pollutants among volatile organic compounds (VOCs) and has been subjected to significant investigations in western countries as well as in India[1-3]. BTX are present in both exhaust and evaporative emission from vehicles and at the fuel delivery outlets in the urban atmosphere.

The exposure to high level of BTX causes neuro-toxic symptoms. Persistent exposure to high level of toxic benzene, toluene and xylene may cause injury to human bone marrow, DNA damage in mammalian cells, damage to immune system. Mild exposure causes irregular heartbeat, headache, dizziness, nausea and even unconsciousness, if exposure is continued for long time. Early manifestation of toxicity is anaemia, leucocytopenia and thrombocytopenia. Benzene is a known human carcinogen[4, 5]. WHO estimates 4 in one million risk of leukemia on exposure to a concentration of 1 microgram per cubic meter[6].Together with other pollutants, BTX also participate in photochemical process, which results in formation of oxidants and smog.

About 50% of inhaled BTX in air is absorbed in the body[3]. Thus air toxics can pose special threats in urban areas because of the large number of people and the variety of toxic sources such as cars, trucks, large factories, gasoline stations and dry cleaners. Active smoking of tobacco is another important source of BTX in air[7]. Individually, some of these sources may not emit large amount of toxic pollutants, however, all of these pollution sources combined can potentially pose significant health threats.

Material and Methods

Sampling sites: Delhi is positioned with the Thar desert of Rajasthan to the west and southwest central hot plains to the south and Gangetic plains of Uttar Pradesh to the east while cooler hilly regions to the north. It is situated at latitude 28° 24'17" and 28° 53' 00"(north); longitude 76°45'30" and 77° 21'30"(east) at about 160 kilometer south of Himalayas at an elevation of 225 meter above the mean sea level. Delhi is drained by river Yamuna. Delhi region experiences total annual rainfall of 700-800 mm; maximum during monsoon months. It covers an area of 1483 square kilometer.

The sampling locations were selected based on land use pattern i.e. gasoline filling station, residential, commercial, institutional and industrial areas. The sampling locations were as follows:

Bahadurshah Zafar Marg (ITO): It is one of the busiest stretches on a main road connecting New Delhi with Old Delhi. During peak office hours traffic management becomes extremely difficult with long wait at traffic signals. Two thermal power plants located in nearby area of ITO could also have impact on air quality of this area.

Shahdara (SHD): This site is situated in the east part of the Delhi near national high way connecting Ghaziabad to ISBT Mori Gate. Sampling site was located in the vicinity of small scale industries in the nearby area of electricity grid after crossing Shahdara flyover from ISBT Mori Gate side.

Dhaula Kuan (DK): Dhaula Kuan is one of the biggest and busiest traffic intersections which is situated in the south west part of Delhi. The sampling site was situated on main road connecting Delhi with Jaipur near the traffic intersection (Dhaula Kuan).

Pitampura (PP): Pitampura is situated in the west part of Delhi. The sampling site was located near Netaji Subhash Palace Metro station. This is a residential location. There are TV tower and Kasturaba Gandhi Women polytechnic in the nearby area.

JNU (Jawaharlal Nehru University): Jawaharlal Nehru University the most prestigious University of India which has given a number of high profile peoples to this country is situated in south part of Delhi. This is a commercial location. Sampling sight was located in old JNU campus.

Preet Vihar (PV): This location is in the east part of Delhi about 3 kms from the national highway. This is a residential area and sampling site was located near Petrol pump.

Sampling and storage of samples: The charcoal tubes were available in different sizes and contain varying amount of activated charcoal. The tube contained two layers; the sampling layer and the control layer. The ambient air was sucked through the tube using a portable low flow and constant volume sampler (with a flow rate of about 20-25 ml/min. and sampling duration 150-180 minutes) in a way that first of all, the air flow saved the sampling layers. These results in an enrichment of the relevant substances in the activated charcoal. As the sampling time completed, the sampling charcoal tube were removed off from sampling train. Tubes were wrapped with aluminum foil and placed in an opaque, clean and air tight container which was immediately sent back to laboratory and placed in a refrigerator (< 4^oC).

The sampler was located at height of 2.0 to 3.0 meter above the ground level at the sampling sites.

Analysis: Samples collected through active sampling technique (activated charcoal tube method) were desorbed by conventional solvent (generally CS_2, 2ml) in an ultrasonic bath for 30 minutes. Carbon disulphide desorbed samples were analyzed using gas chromatograph (GC) fitted with capillary column and flame ionization detector (FID).

Amount of compounds found on the tube can be converted in to $\mu g/m^3$ by using formula:

$$\text{Concentration } (\mu g/m^3) = \frac{\text{Weight of compound found on tube } (\mu g) \times 10^6}{\text{Sampling rate (ml/min)} \times \text{Sampling time (min.)}}$$

Where the following conversion factors at 25^0C were used
Benzene- 1ppb= 3.19 $\mu g/m^3$
Toluene- 1ppb= 3.75 $\mu g/m^3$
Xylene - 1ppb= 4.35 $\mu g/m^3$

Results and Discussion

The results of monthly data for the study period during May 2008 – April 2010, showed that B/T/X concentrations in ambient air of Delhi varied between 4.95- 35.31 μgm^{-3}/17.33-120.28 μgm^{-3}/ 4.70 - 29.13 μgm^{-3} respectively. Lowest values were observed at JNU in the month of May 08 and highest at PV in the month of Jan 09.

Highest concentrations of B/T/X were observed in the vicinity of petrol pump at Preet Vihar location. The occurrence of maximum levels of B/T/X at PV location could be attributed to evaporation of gasoline during filling process in addition to vehicular exhaust emission and varying traffic density.

Total average (2008-2010) B/T/X concentrations varied between 8.52±1.90 to 25.02±2.10 μgm^{-3} / 21.86±2.32 to 84.01±8.15 μgm^{-3} / 9.95±1.88 to 22.32±1.76 μgm^{-3} respectively. Lowest values were observed at JNU whereas highest at PV location.

Total annual average (all site combined) B/T/X concentrations have decreased as 17.05 to16.00 μgm^{-3} / 58.98 to 52.99 μgm^{-3} /15.45 to 14.22 μgm^{-3} respectively during 2008-2009 and 2009-2010 approximately by 6.15% /10.15% / 6.67%. The significant decrease in B/T/X levels in ambient air of Delhi was probably due to betterment in fuel quality, smooth running of CNG driven vehicles, banning of old vehicles expansion in metro train routes in Delhi up to NCR(National Capital Region) and some other control measures being taken and implemented by the government. Average concentrations of B/T/X during study period were calculated as16.52 gm^{-3} / 55.99 μgm^{-3} / 4.94 μgm^{-3} respectively.

Area wise B/T/X concentrations in ambient air of Delhi at all locations followed the order near petrol pump > traffic intersection > industrial > residential > commercial.

Seasonal B/T/X concentrations for the study period varied as 7.30 to 27.41 μgm^{-3} /19.89 to 92.32 μgm^{-3} / 8.64 to 24.18 μgm^{-3} respectively. Lowest concentrations were observed during Monsoon and highest during winter season. Seasonal B/T/X concentrations at all location followed the trend monsoon < post monsoon < summer < winter.

Higher concentrations values of B/T/X were observed during winter season at all locations. It could be due to low rate of dispersion, low rate of degradation and low mixing height at low temperature in winter season. Lowest concentration in monsoon season may be due to rain washout.

Results of active B/T/X monitoring conducted at selected locations in Delhi are summarized in figures (1-6).

Monthly ratio of T/B, B/X and T/X were calculated as

T/B = 1.88 to 4.82, B/X = 0.61 to 1.50, T/X = 1.77 to 6.19
Monthly ratio of T/B, B/X and T/X for different sampling periods and sites indicate a good correlation between T and B, B and X, T and X at most of the sampling sites.

The B/T/X level in the present study (i.e. 4.95-35.31 μgm^{-3}/17.33-120.28 μgm^{-3}/ 4.70 -29.13 μgm^{-3} respectively) in comparison to the past studies (i.e. 13.03- 174.62μgm^{-3}/14.71-228.83 μgm^{-3}/11.20-68.40 μgm^{-3} respectively) also showed significant reduction in its level in ambient air of Delhi[8, 9].

Conclusion

Although in the present study significant decrease in B/T/X level (i.e. by 6.15% /10.15% /6.67%) have been observed in the ambient air of Delhi but the level may increase during the course of time with continued economic growth of city associated with increased vehicular traffic. However, preventive measures such as smooth flow of vehicular traffic, better road management, improved inspections and management of vehicles etc. would be of great help in fast dispersal of pollutants.

Acknowledgement

The author is thankful to Dr. S.K. Tyagi, Scientist 'D', CPCB, Delhi and Principal MMH college, Ghaziabad (U.P.) for his valuable suggestions, guidance and encouragement during the course of study. He is also thankful to his friend Sh. A. Kumar who had helped during the monitoring of BTX at different locations.

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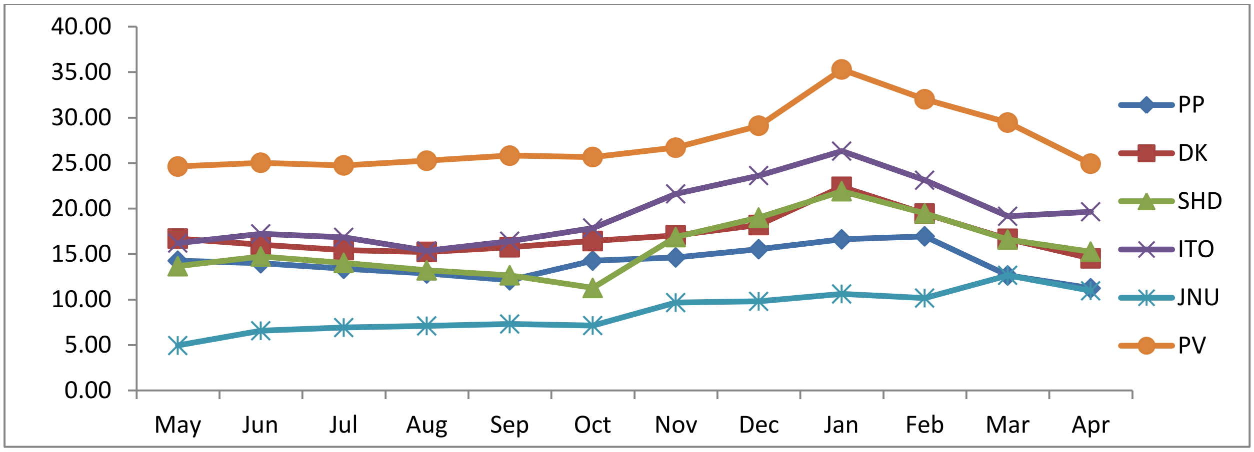

Figure-1
Benzene concentration (μg/m^3) in ambient air of Delhi during May 2008-April 2009

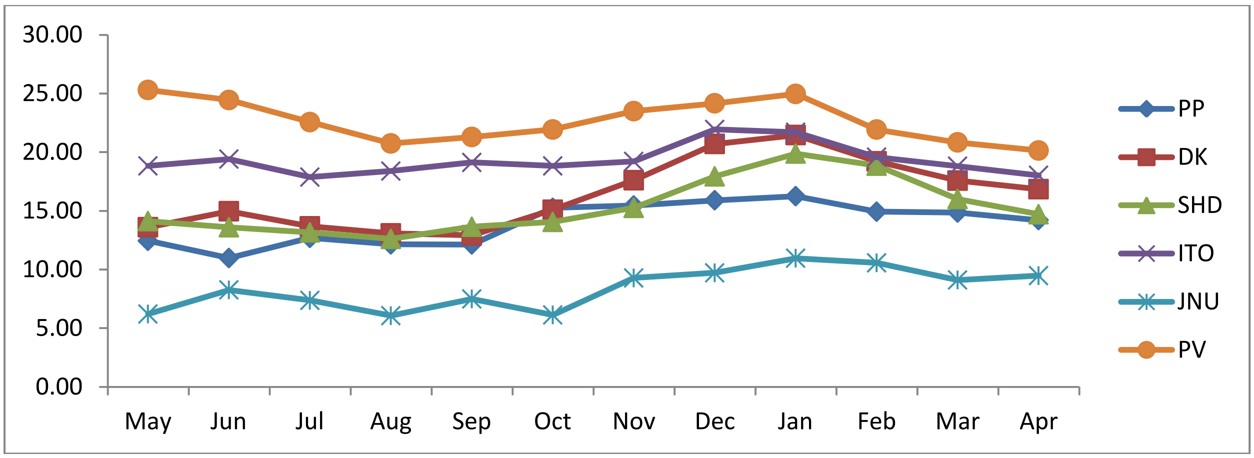

Figure-2
Benzene concentration (μg/m^3) in ambient air of Delhi during May 2009-April 2010

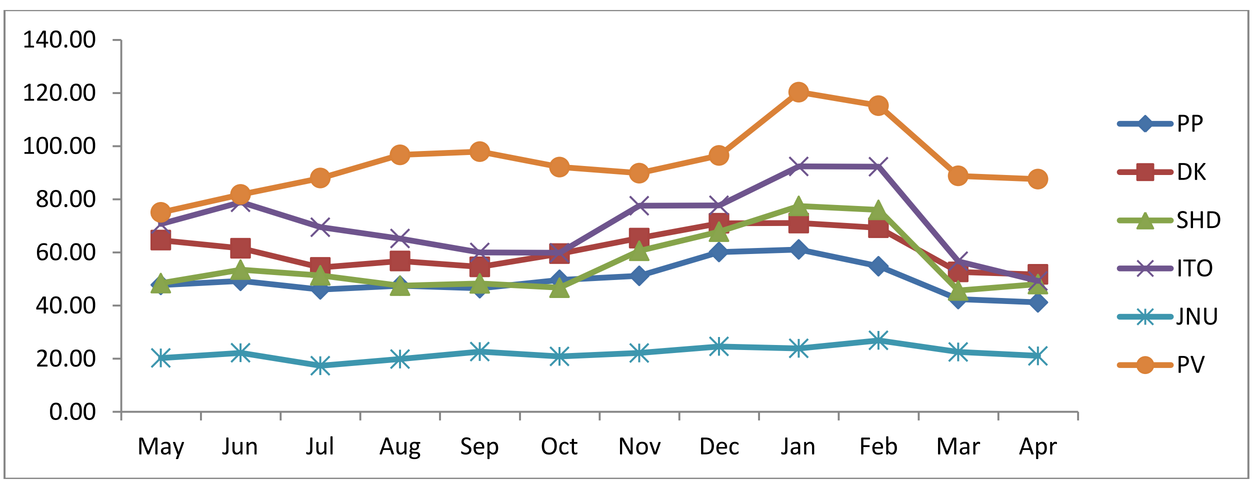

Figure-3
Toluene concentration (μg/m^3) in ambient air of Delhi during May 2008-April 2009

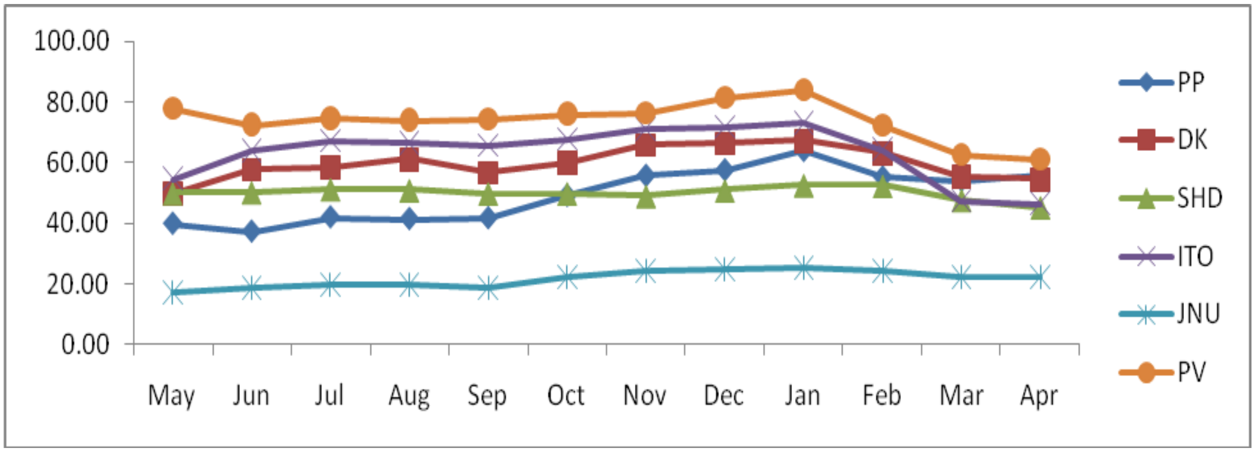

Figure-4
Toluene concentration (μg/m^3) in ambient air of Delhi during May 2009-April 2010

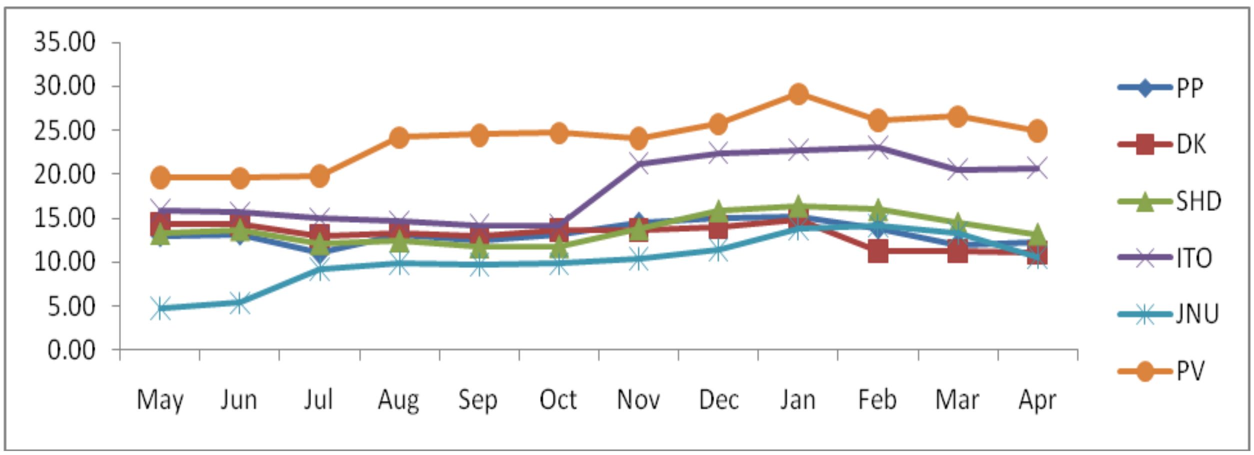

Figure-5
Xylene concentration (μg/m^3) in ambient air of Delhi during May2008-April 2009

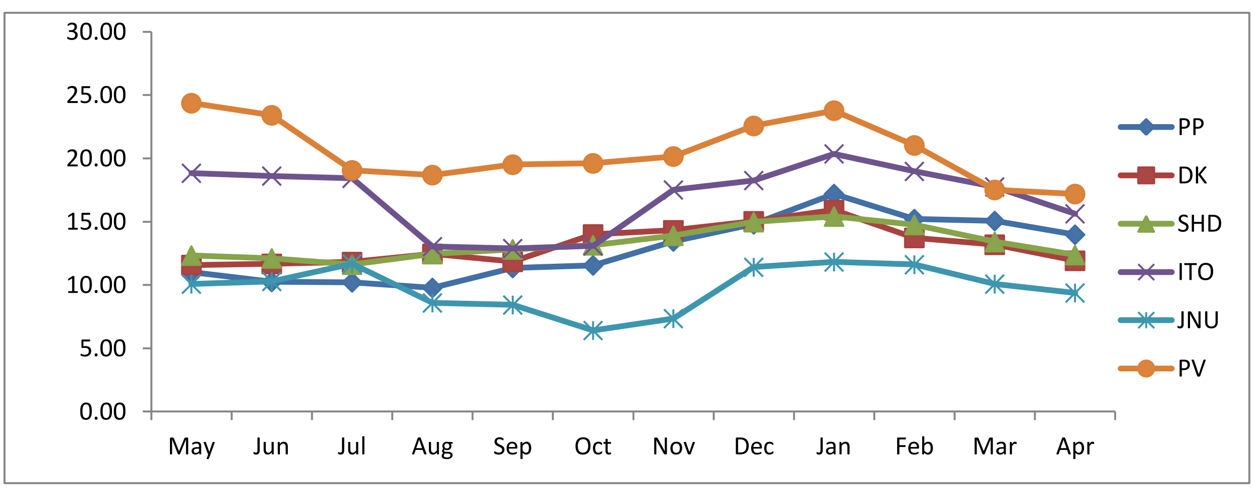

Figure- 6
Xylene concentration (μg/m^3) in ambient air of Delhi during May 2009-April 2010