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Research Article

CONCENTRATION OF VOLATILE ORGANIC COMPOUNDS (VOCS) IN URBAN ATMOSPHERE OF NATIONAL CAPITAL DELHI, INDIA

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ABSTRACT

Volatile Organic Compounds (VOCs) present in ambient air are potentially toxic among the air pollutants. They are present in the urban atmosphere in both exhaust and evaporative emission from vehicles and the fuel delivery outlets.

The present study aims the measurement of VOCs (Benzene, Toluene and Xylene) concentration and to investigate their existing profiles in the urban environment of Delhi, India. The samples were collected by active sampling on to activated charcoal tube using a portable constant low flow volume sampler. Sampling flow rate ranged 20-25 ml/min and sampling duration 150-180 minutes. The samples were analysed by capillary Gas Chromatograph (GC) followed by desorption of adsorbed VOCs in conventional solvent carbon disulphide (CS_2). The external calibration was performed by using five concentration level of standard solution in CS_2. The Benzene, Toluene and Xylene concentration ranged between 4.90-25.28µg/m^3, 14.93-87.33µg/m^3 and 6.92-24.75µg/m^3, respectively in different land used areas (residential, commercial, industrial, traffic-intersection and near gasoline filling station etc.). The present study indicates that the mean concentration of VOCs (BTX) at all sites were found higher than the limiting value prescribed by central pollution control board (i.e. 5µg/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, active sampling, GC-FID.

INTRODUCTION

In the urban cities, mostly traffic accounts for emission (>70%) of volatile non-methane hydrocarbons (NMHCs) in the atmosphere[1]. The consumption of NMHCs is quite different in various cities but predominant species are aromatic hydrocarbons, majority of which are toxic and produce toxic intermediate in the

Photochemical reactions. Since 1980, a variety of studies have documented toxic emission from mobile sources as a major contributor to overall health risk[2]. These compounds also play a key role in the

formation of secondary atmospheric pollutants, particularly Ozone[3,4].

The U.S. clean air act Amendments (1990) specially targeted the reduction in 5 toxic air pollutants (Benzene, 1, 3-Butadiene, formaldehyde, acetaldehyde and polycyclic aromatic hydrocarbons) form mobile sources. Many urban centers have been studied for levels of these pollutants and possible sources and impact[4-6].

VOCs present in both exhaust and evaporative emission from vehicles are liquid at normal ambient temperature but readily evaporates and small amounts are detected in the atmosphere.

In atmosphere, transport sector releases benzene, toluene and xylene (80-85%) in different modes (vehicular, evaporative, and transportation etc[7]. VOCs constitutes one group of pollutants (benzene, toluene and xylene) known for their toxicity to some species and for their major roll in photo oxidation and formation of ozone and peroxyacetyl nitrates.

Adverse health effect of Benzene is respiratory disorder, narcosis, and change in blood pattern, carcinogenesis, neurotoxicity, anaemia and leukaemia. Toluene is less toxic and causes drowsiness, impaired coordination and liver and kidney damage. Acute xylene exposure may be marked by dizziness, weakness, headache, nausea, vomiting, breathing difficulty and loss of coordination. In severe exposure, there are visual blurring, tremors, heart beat irregularities, paralysis and loss of consciousness.

Thus air toxics (VOCs) 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 VOCs in air [9]. Individually, some of these sources may not emit large amount of toxic pollutants, however all of these pollution sources combinedly 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 the latitude 28°24`17`` and 28°53`00`` (North); longitude 76°45`30``and 77°21`30`` (East) at about 160 kms south of Himalayas at an elevation of 216m above the mean sea level.

Delhi is drained by river Yamuna. Delhi region experiences total annual rain fall of 700-800 mm; maximum during monsoon months. Measurement of VOCs levels in urban environment of Delhi have been made at selected locations based on land use i.e. gasoline filling station, residential, industrial, institutional and commercial areas.

Samples were collected on fortnightly basis, three times in a day (i.e. morning, afternoon and evening time).

The sampling locations were as follows

ITO (bahadur shah zafar marg)

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 the 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 intersection 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 of Delhi. The sampling site is located near Netaji Subhash palace metro station. This is a residential location.

JNU

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.

PreetVihar (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 was available in different sizes and contained varying amount of activated charcoal. The tube contained two layers; the sampling layer and the control layer. The ambient air is sucked through the tube using a portable low flow and constant volume sampler (with a flow rate of about 20-25ml/min. and sampling duration 150-180 minutes) in a way that first of all, the air flow saved the sampling layers. These resulted 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°C).

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

Sampling was carried out on fortnightly basis for morning peak period (MPP), noon lean period (NLP) and evening peak period (EPP) monitoring at different identified locations in ambient air of Delhi.

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 compound found on the tube was converted in to µg/m³ 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°C were used:

Benzene – 1ppb = 3.19 µg/m³

Toluene - 1ppb = 3.75 µg/m³

Xylene - 1ppb = 4.35 µg/m$_3$

RESULT AND DISCUSSION

According to the collected data about BTX levels at different said locations, it was observed that the concentration followed the intensity of traffic. In most cases concentration were found higher in the morning peak period (MPP) followed by drop during noon lean period (NLP) and further increase in the evening peak period (EPP).

Benzene, toulene and xylene do not dissipate in to the environment immediately after release. Benzene, toluene and xylene as mono aromatic hydrocarbons reacts only very slowly with O_3 and NO_3 radicals. Their rate constants being in the order of $<10^{-20}$ to 10^{-16}cm³ mol^{-1} sec^{-1}.

Thus their depletion in the atmosphere via these reactions is negligible. The only significant process for atmospheric loss of these compounds is their photochemical reactions with OH radicals.

The result of monthly data (monthly average of MPP, NLP and EPP) of benzene, toluene and xylene during November 2010 – February 2011 are summarized in Table-1, 2 and 3 respectively.

Average benzene, toluene and xylene concentrations in ambient air at Shahdara ranged between 13.93 -17.92 µg/m^3, 30.84-48.6 µg/m^3 and 9.85-17.51 µg/m^3 respectively, while BTX concentration at Pitampura were found to be 12.04-16.41 µg/m^3, 35.48 -52.16 µg/m^{3}and 12.76-18.23 µg/m^3 respectively.

The range of BTX concentration in ambient air at ITO were 18.87-23.80 µg/m^3, 39.02-59.26 µg/m^3 and 14.57-19.78 µg/m^3 respectively, while average BTX concentration at JNU ranged between 5.92-11.13 µg/m^3, 15.37-22.37 µg/m^3, and 7.50 - 15.00 µg/m^3 respectively.

The average value of BTX concentration at Daula Kuan traffic intersection ranged between 13.44-17.00 µg/m^3, 32.81-51.22 µg/m^3 and 9.86-14.27 µg/m^3 respectively and the range of BTX near Gasoline filling station at Preet Vihar were 18.09-22.55 µg/m^3, 39.54-84.00 µg/m^3 and 11.40 - 14.99 µg/m^3 respectively.

Gasoline consumption in Delhi has shown major growth during 2006-2011 as compared to diesel consumption during the same period due to the introduction of CNG in commercial vehicles. In petrol driven two wheelers, emission of VOCs is significant because 20-30% of fuel comes out as un burnt-hydrocarbons (HCs) [8]. In view of this the present study indicates that their levels in ambient air of Delhi are directly related to the intensity and magnitude of traffic character. Their (VOCs) concentration is also indirectly related to dispersion, stability and wind speed[9].

The maximum level of benzene was found at Preet Vihar followed by ITO, Shahdara, Dhaula Kuan, Pitampura and JNU. Lowest benzene concentration was at JNU. The maximum level of toluene was at Preet Vihar followed by ITO, Pitampura, Dhaula Kuan, Shahdara and JNU. The lowest Toluene level was found at JNU.

The maximum level of xylene was found at ITO followed by Pitampura, Preet Vihar, Shadhara, Dhaula Kuan and JNU. The lowest xylene concentration was noted at JNU. Toluene had higher values in all cases followed by benzene and xylene. The occurrence of maximum level of benzene and toluene at Preet Vihar location may be attributed to evaporation of petrol during filling process in addition to vehicular exhaust emission.

Area wise (residential, commercial, industrial, Traffic Intersection and near petrol pump) monthly variation in BTX concentration during November 2010 to February 2011 are shown in figures 1, 2 and 3 respectively.

The following can be seen from these (**figure-1, 2 and 3**) bar graphs

Benzene concentration in Delhi at all locations followed the trend near petrol pump> traffic intersection> industrial> residential> commercial Toluene concentration at all locations followed the trend ear petrol pump> traffic intersection> residential> industrial> commercial Xylene concentration at all said locations followed the trend residential>industrial>traffic intersection>commercial>near petrol pump

Generally the benzene concentrations at all sites were found higher than the limiting value prescribed by central pollution control board (i.e. 5 µg/m^3 annual average).

The past studies have also shown that average BTX concentration monitored in Delhi[10,11] (at residential area ,traffic intersection, commercial area and in vicinity of petrol pump) varied between13.03-174.62 µg/m^3, 14.71-228.83 µg/m^3 and 11.20-68.40 µg/m^3 respectively. But the present levels of BTX (4.90-25.28 µg/m^3, 15.37-84.00 µg/m^3 and 7.57-19.78 µg/m^3 respectively) have significantly decreased down perhaps due to betterment in fuel quality, smooth running of CNG driven vehicles in Delhi, extension in metro train routes up to national capital region (NCR) and some other control measures being taken and implemented by the

Government.

CONCLUSION

In the present study significant decrease in BTX levels have been observed in national capital Delhi as compared to the previous studies. But the levels 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, betterment in fuel quality, better road management, improved inspection and management of vehicles etc. would be of great help in fast dispersal of pollutants.

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Table 1: Benzene concentration (µg/m³) in ambient air of Delhi during Nov. 2010 – Feb. 2011

S. No.	Months	ITO	SHD	DK	PP	JNU	PV
1.	Nov	19.50	15.36	13.44	12.04	5.92	20.04
2.	Dec	18.87	15.86	15.58	15.79	8.96	20.76
3.	Jan	23.80	17.92	17.00	16.41	10.27	22.55
4.	Feb	19.10	13.93	14.87	15.57	11.13	18.09
5.	Average =	20.31	15.76	15.22	14.95	9.07	20.36

Table 2: Toluene concentration (µg/m³) in ambient air of Delhi during Nov. 2010 – Feb. 2011

S. No.	Months	ITO	SHD	DK	PP	JNU	PV
1.	Nov	52.47	33.75	41.98	40.62	22.21	84.00
2.	Dec	49.98	30.84	35.31	52.16	22.25	57.16
3.	Jan	59.26	48.60	51.22	35.48	22.37	49.73
4.	Feb	39.02	34.99	32.81	36.30	15.37	39.54
5.	Average =	50.18	37.05	40.33	41.14	20.55	57.61

Table 3: Xylene concentration (µg/m³) in ambient air of Delhi during Nov. 2010 – Feb. 2011

S. No.	Months	ITO	SHD	DK	PP	JNU	PV
1.	Nov	14.57	17.51	9.86	12.76	7.50	13.11
2.	Dec	17.00	12.21	13.54	13.66	8.86	11.40
3.	Jan	19.78	9.85	14.27	18.23	15.00	14.99
4.	Feb	15.71	10.39	11.75	17.04	11.76	13.66
5.	Average =	16.77	12.49	12.36	15.42	10.80	13.27

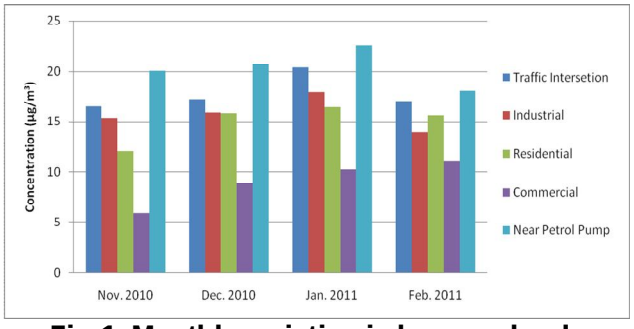

Fig. 1: Monthly variation in benzene levels in Delhi during Nov.2010 -Feb.2011

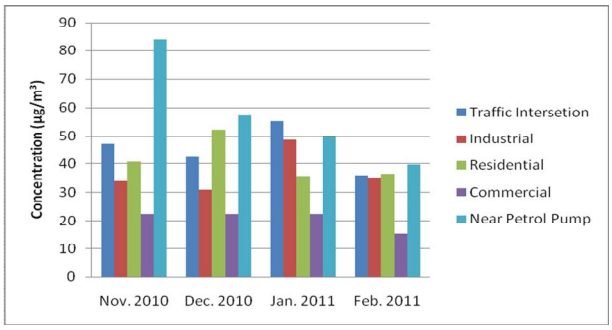

Fig. 2: Monthly variation in toluene levels in Delhi during Nov.2010 -Feb.2011

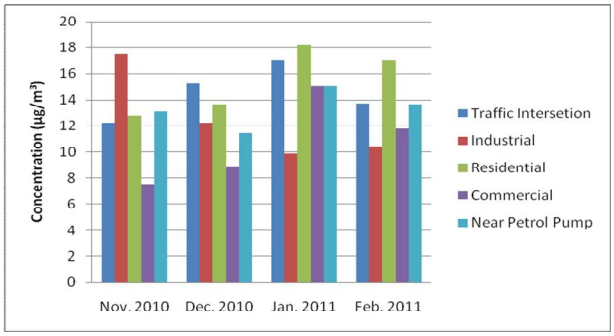

Figure 3: Monthly variation in xylene levels in Delhi during Nov.2010 -Feb.2011

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