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Short communication

Studies on commuters' exposure to BTEX in passenger cars in Kolkata, India

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Abstract

Commuters' exposure to volatile organic compounds (VOCs) especially BTEX travelling in passenger cars in Kolkata, India were quantified in Phase I (2001–2002) and Phase II (2003–2004). Monitoring was made inside and in the immediate outside of passenger cars fitted with and without catalytic converters using different types of fuels, along two congested urban routes. During Phase I of the study, the benzene content in gasoline was 5% and the mean concentration of in-vehicle benzene in cars without catalytic converter was found to be as high as 721.2 $\mu g/m^3$. In Phase II when the benzene content was reduced to <3% and with modified engine type, the mean in-vehicle benzene concentration was reduced to 112.4 $\mu g/m^3$. The in-vehicle concentration varied with engine type and age of the vehicle. Roadside ambient mean concentration of benzene was 214.8 $\mu g/m^3$ and 30.8 $\mu g/m^3$ in Phase I and Phase II respectively.

Keywords: In vehicle BTEX; Commuter exposure; Kolkata (Calcutta) air; Catalytic converter

1. Introduction

Kolkata (formerly known as Calcutta), with a population of 14.7 million, is the second largest city in India and ranks seventh in the world in terms of population. The span of Kolkata is 1851 km^2 with a high population density of 7950/km^2. (VISION-2025, 2005). There are 0.82 million registered vehicles of different types on roads in Kolkata (Fig. 1). From 1995 to 2002, there was a total growth of 44.5% of registered vehicles, and the number of vehicles is projected to be about 1.3 million by 2015. At present, total land used for the purpose of transportation in Kolkata is only about 7% and as a result, the vehicular density in city streets is tremendous (MPTT, 2001).

The rising concentration of Volatile Organic Compounds (VOCs) in urban air is a cause of much concern. Large amounts of VOCs are emitted from mobile and stationary sources (Tolnai et al., 2000). Motor vehicles make a significant contribution (~35%) to ground-level concentrations of VOCs (Perry and Gee, 1995). Benzene, toluene, ethyl benzene and xylenes (BTEX) are the major and most studied components in motor vehicle (Srivastava, 2004; Brocco et al., 1997). Refuelling of motor vehicles is another contributor of benzene in the atmosphere. Benzene content in fuel significantly affects the ambient level of VOCs (Simon et al., 2004). VOCs are also released by industries and are components of fossil fuel emissions, including wood stoves. In addition to their adverse impact on health,

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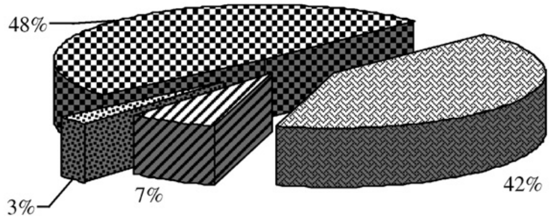

Fig. 1. Distribution of registered vehicles in Kolkata (data from 2002).

VOCs play an important role in photochemical processes in the lower atmosphere.

In-vehicle concentrations of VOCs have been measured in important cities throughout the world for the past decade along with their ambient level. The vehicular emission of these pollutants depends on the technology of vehicle, which includes modified engine, and use of catalytic converter. Considering its detrimental health effect, benzene in gasoline is being reduced as far as practicable all over the world. The permissible limit of benzene in gasoline had been reduced to less than 1% in the EU and in parts of the US and Asia (Royall, 2005).

In Kolkata, use of tetra ethyl lead (TEL) in fuel was phased out between 1994 and 1998 along with other cities of India. Ambient concentrations of BTEX at few locations in some cities of India have been reported (Srivastava et al., 2000, 2005; Samanta et al., 1998; MohanRao et al., 1996). However, only one study reported (Mukherjee et al., 2003) VOCs concentrations inside Kolkata state transport buses.

The present work studied commuters' exposure to BTEX travelling in motor cars with different engine types and using different fuels plying along congested traffic routes in Kolkata. The aim of the study was to determine the effect of reduction of benzene content in petroleum fuel (from 5% to <3%) with respect to vehicular emission of VOCs and its impact on ambient level of VOCs.

2. Experimental

2.1. Study period and selection of vehicles

The study was carried out in two phases. Phase I of study was conducted in December 2001–January 2002 and Phase II in December 2003–January 2004. Two congested routes (hourly fleet volume around 1500 with average vehicular speed between 15 and 25 km/h) with two way traffic were chosen for the study. Both routes originated from University College of Science, situated almost at the centre of the city. One route (R-1) headed towards southern Kolkata up to Garia. The total length of road travelled was 30 km (up and down) with an average speed of about 18 km per hour. The type of locality along this route is residential cum commercial. The width of the road varied between 18 and 49 m with about 20 petrol pumps and 15 traffic intersections along the route.

The other route (R-2) stretched towards the extreme north of Kolkata up to Dakshineswar. Total length of this road was 22 km (up and down) with an average speed of about 20 km per hour. The type of locality along the route is mainly residential. The width of the road varied between 12 and 37 m having about 10 petrol pumps and 15 traffic intersections along the route.

Sampling was conducted during office hours between 10:30 am and 4:00 pm in two trips. The first trip (S_1) was made between 10:30 am a 12:30 pm and the second one (S_2) between 2:00 pm and 4:00 pm. The experiments were performed on 17 days in both the phases. In Phase I, a single route was chosen on each sampling day involving one car and the same car was used for driving along the second route the following day. In Phase II, two cars were run simultaneously (depending on the availability of the cars) along the selected routes on 14 days and one car (petrol fuelled Ambassador without catalytic converter) was run singly on R-1 for 3 days. The details of the cars used for the study in both the phases along with sampling protocol are given in Table 1.

2.2. Sampling and analysis of target compounds

The VOCs collected by drawing air at a rate of ~0.1 l/min for about 2 h were absorbed in charcoal sorbent tubes (Uniphos, India) placed in a holder connected to a constant flow low volume pump (SKC, USA). Sampling flow rates were determined before and after sampling. For in-car VOC sampling, the holder was attached to the collar of the driver. For out-vehicle sampling, the holder was fixed to the wiper in front of the car. To eliminate impact of widely varying stoppage time (e.g. signal halts, traffic jam etc.), the car engine was kept running throughout the sampling duration. The in-vehicle VOC samples were collected under non-smoking condition keeping two front windows open and rear windows closed. The average in-vehicle temperature and relative humidity during the study period was 29.1 °C and 55% respectively. Roadside static ambient