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Mass concentrations of BTEX inside air environment of buses in Changsha, China

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ABSTRACT

In order to estimate the mass concentrations of benzene (B), toluene (T), ethylbenzene (E) and xylenes (X) inside air environment of buses and to analyze the influencing factors of the BTEX pollution levels, 22 public buses were investigated in Changsha, China. The interior air was collected through activated charcoal adsorption tubes and then the air samples were analyzed with thermally desorbed gas chromatograph. The mass concentrations ranged from 21.3 to 106.4 μg/m^3 for benzene, from 53.5 to 266.0 μg/m^3 for toluene, from 19.6 to 95.9 μg/m^3 for ethylbenzene and from 46.9 to 234.8 μg/m^3 for xylenes. Their mean values were 68.7, 179.7, 62.5 and 151.8 μg/m^3, respectively. The rates of buses tested where the interior concentrations exceeded the limit levels of Chinese Indoor Air Quality Standard were 45.5% for toluene and 13.6% for xylenes. The BTEX levels increased when in-car temperature or relative humidity rose, and decreased when car age or travel distance increased. The BTEX concentrations were higher in leather trims buses than in non-leather trims ones, in air-conditioned buses than in non-air-conditioned ones, and in high-grade buses than in low-grade ones. According to the analysis of multiple linear regression equation, car age and in-car temperature were two most important factors influencing the BTEX pollution levels in the cabins of public buses.

1. Introduction

In modern motorized society, the automotive cabin is an important part of the living environment because many people spend a long time in it during business, shopping, recreation or travel activities. Unfortunately, there are many harmful gases from interior materials, gasoline loss, infiltration of outdoor air pollutants, exhaust leakage or traffic emissions in vehicular air environment [1]. These toxic gases are mainly volatile organic compounds (VOC_S) such as benzene (B), toluene (T), ethylbenzene (E) and xylenes (X, total p-/m-/o-xylene) etc, which deteriorate indoor air quality (IAQ) and threaten human health. For example, benzene may lead to carcinogenic [2] and neurotoxic [3] effects to humans being and toluene could cause vertigo symptoms [4] with inhalation of low concentrations. The exposure to these gases normally has a long term cumulative effect on health conditions [5]. Therefore, knowledge concerning the pollution levels of BTEX inside air environment of cars is very important for evaluating the health effects of exposure to the chemicals on humans.

Recently, in-car air pollution has aroused extensive attention. For example, World Health Organization has thought that the interior air pollution of vehicle as a major threat to human health. In Japan, Yoshida and Matsunaga [1] identified 162 organic compounds in the cabin of a new car, and simultaneously reported that the concentrations of BTEX were 6.3, 225.8, 360.9 and 4002.9 μg/m^3, respectively. Then, a total of 242 organic compounds were quantitated in the interior air of cars and the sum of their concentrations was approximately 600 μg/m^3 as a median, ranging from 136 to 3968 μg/m^3 [6]. Afterwards, in-car air quality has been of great public concern in China. Li et al. [7] found that the in-train levels of BTX were mainly influenced by the ambient air concentrations, and also shown that the ambient levels of BTX were significantly higher in downtown area than in the suburb as the pollutants from vehicle exhaust. Zhang et al. [8] confirmed that the highest values of toluene, xylenes and benzene measured in the vehicles were 81, 18 and 16 times higher than their respective limit levels of Chinese IAQ Standards [9]. In terms of the above studies, it is self-evident that the air in the cabin of cars was contaminated by high concentrations of volatile organic compounds.

As for the airborne VOC_S in public buses, their pollution levels were the highest in downtown, followed by those in suburban, rural and tourist areas [5,10], and their values owed to the density

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