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Automobile proximity and indoor residential concentrations of BTEX and MTBE

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ABSTRACT

Attached garages have been identified as important sources of indoor residential air pollution. However, the literature lacks information on (1) how the proximity of cars to the living area affects indoor concentrations of gasoline-related compounds, such as benzene; and (2) the origin of these pollutants, i.e., vapor or tailpipe emissions. We analyzed data from the Relationships of Indoor, Outdoor, and Personal Air (RIOPA) study to evaluate indoor (C_{in}) and outdoor (C_{out}) concentrations for 114 residences with cars either in an attached garage, a detached garage or carport, or without cars. Results indicate that single-family detached homes with cars in attached garages were affected the most by parked vehicles, followed by homes with vehicles in carports. Concentrations in homes with cars in detached garages were similar to those in residences without cars. Low ventilation rates exacerbated C_{in} in homes with attached garages. In general, the contribution from gasoline-related sources to indoor benzene and MTBE concentrations appeared to have been dominated by car exhaust, or by a combination of tailpipe and gasoline vapor emissions. Residing in a home with an attached garage could lead to benzene exposures that are an order of magnitude higher than exposures from commuting in a car in heavy traffic, with a risk of 17 excess cancers in a population of a million. Strategies to lower exposure to gasoline-related contaminants in homes include improving construction practices to prevent the infiltration of pollutants into the living quarters or incorporating detached garages.

1. Introduction

Various gasoline-related volatile organic compounds (VOCs) have been identified by the U.S. Environmental Protection Agency (EPA) as hazardous air pollutants. Benzene, toluene, ethylbenzene and xylenes (BTEX) vaporize from liquid gasoline, and are emitted in car exhaust and by some consumer products. Benzene has been classified by the U.S. EPA as a known human carcinogen (Group A), and risk assessments among nonsmoking populations have repeatedly identified benzene as an important contributor to cumulative environmental cancer risk [1–4]. Adverse health effects associated with elevated concentrations of other BTEX components and methyl tert-butyl ether (MTBE) have been reported [5,6]. Up until 2000, MTBE was emitted almost entirely by gasoline, making it an ideal tracer for gasoline-related exposures.

Even though exposure to BTEX commonly occurs in many microenvironments, personal concentrations for these compounds have been primarily associated with attached garages [7,8] because of sources within garages and because Americans spend on average nearly 70% of their time in their homes [9]. Sources of BTEX and MTBE include stored gasoline, gasoline-powered devices (e.g., automobiles and lawn mowers), and occasionally consumer products such as paints, cleaners, detergents, adhesives, paint thinners and oils/lubricants [10–12]. These sources can lead to BTEX levels in garages that are five to 18 times higher than in the adjacent living area of single-family homes [13,14].

Air contaminants can migrate from attached garages into the occupied space partly because the shared wall between these two areas tends to be among the leakiest components of the house envelope [15], and because of the presence of heating, ventilation and air conditioning (HVAC) components in some attached garages [16]. Batterman et al. [13] estimated that about 6.5% of the whole-house air exchange rate can originate from the attached garage. Thus, the contribution of sources within garages to indoor concentrations of BTEX and MTBE has been determined to range from 9 to 85% [13,17,18]. In the case of benzene, such contributions can be similar or higher than that of tobacco smoke. Thomas et al. [14] concluded that mass transfer rates of benzene from the garage

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