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Carbonyl compounds from urban activities and their associated cancer risks: The influence of seasonality on air quality (Fortaleza-Ce, Brazil)

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ABSTRACT

The main carbonyl compounds (CCs) were determined at gas stations for the first time in Fortaleza city, CE, Brazil, and the results were compared with other urban centers. The influence of seasonality on the production, distribution and balance of CCs, as well as the associated cancer risks, was also estimated. Formaldehyde was the most abundant carbonyl, followed by acetaldehyde, nonaldehyde, acrolein, butyraldehyde and benzaldehyde. The total CC concentration (Σ_{CC}) averages are less than most other studies in outdoor environments and gas stations. The Σ_{CCs} were higher in the dry period than in the wet period. It was observed that the insolation, cloud cover and precipitation should be influencing CCs distribution, while the ambient temperature should not. The study showed that the cancer risks associated with formaldehyde and

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acetaldehyde are 3.9 and 1.5 times higher, respectively, during the dry period than during the wet period. The cancer risk in the months of dry period of the year were observed to exceed the recommended exposure limit established by National Institute for Occupational Safety and Health (NIOSH).

1. Introduction

Gas stations (GSs) are engaged in the activity of selling retail liquid fuels derived from petroleum, as well as ethanol and other automotive fuels. In their routine work, these facilities employ many workers and gas station attendants, who are exposed daily to many potentially dangerous fuel vapors, while lacking any personal protective equipment. According to the literature, activities and supplies associated with vehicles are major sources of emissions of volatile organic compounds (VOCs), which constitute a potential risk to users and attendants (Cruz-Nunes et al., 2003; Han et al., 2005). Professionals are thus occupationally exposed to elevated levels of hazardous substances, and the level of exposure is largely dependent on the type of combustion. Moreover, most GSs are avenues of high vehicular traffic, which further increases the risk of exposure (Woodruff et al., 2000).

Among these compounds, we highlight atmospheric carbonyl compounds (CCs), pollutants primary or secondary are produced directly from incomplete combustion of biomass, gasoline and diesel fuels (Zhang and Smith, 1999; Schauer et al., 2001; Correa et al., 2003; Correa and Arbilla, 2005) and formed as major reaction products in the atmospheric oxidation of many anthropogenic hydrocarbons and other volatile organic compounds (VOCs) (Carlier, 1986; Aschmann et al., 2001; Jo and Song, 2001; Lee et al., 2002). Natural sources also contribute to atmospheric concentrations of several carbonyls through biogenic emissions of some plants and photochemical oxidation of naturally emitted hydrocarbon precursors, e.g. isoprene (Grosjean et al., 1993; Müller et al., 2002; Wildt et al., 2003; Villanueva, 2004). Furthermore the carbonyls play a significant role in a formation of photochemical smog of peroxyacetyl nitrate (PAN), and of regional ozone. Photo-dissociation of aldehydes represents an important source of free radicals in the lower atmosphere (Atkinson, 1990; Grosjean, 1982; Duan et al., 2008).

These compounds, easily inhaled by users and attendants, are recognized as powerful depressants of human health, even at low concentrations (Buczynska et al., 2009). In particular, formaldehyde is classified as carcinogenic in humans, and others CCs are recognized as toxic (e.g., acrolein) (IARC, 1982; ACGIH, 2003). The literature also reports acute effects, such as irritation of the eyes and throat, headache, sickness, vomiting, dizziness, and memory loss, due to long-term or even low-dosage exposure to different levels of acetaldehyde and acrolein (IPCS/INCHEM, 1997; IARC, 2004; USEPA, 2005). Due to the harmful nature of these compounds, certain government agencies have established national and international levels for occupational maximum exposure to these compounds for an 8-h work day. According to NR-15, NIOSH and ACGIH, the permissible exposure limits for formaldehyde are 2300 $\mu g\ m^{-3}$, 20 $\mu g\ m^{-3}$, 370 $\mu g\ m^{-3}$, respectively, and those for acetaldehyde are 140,000 $\mu g\ m^{-3}$, 45,000 $\mu g\ m^{3}$ 32,400 $\mu g\ m^{-3}$ (MTE-NR-15, 1978; NIOSH, 2003).

However, there are few studies of CC levels and risk assessment in places with CC sources, such as GSs (Som et al., 2008), especially in Latin America. Furthermore, hot climate regions are known to increase the fugacity of VOCs, thus increasing the health risk (Woodruff et al., 2000). Because GSs are outdoor places with abundant sources of hazardous substances, this study was designed to assess the CC levels, compare them to other outdoor environments and estimate their health risk. Due to the lack of work in warm climates, such as tropical and subtropical, we also evaluated the influence of the seasonality on the production, distribution and balance of CCs, as well as on the associated cancer risk. We think these results will be important in providing a useful baseline for future assessments of air quality, as well as contributing to politics related to the health protection of professionals engaged in similar activities or other outdoor activities in highly urbanized cities.