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Determination of carbonyl compounds in air and cancer risk assessment in an academic institute in Fortaleza, Brazil

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Abstract

Carbonyl compounds (CCs) were measured in outdoor and indoor air of libraries, classrooms, laboratories, and offices at the Universidade Federal do Ceará, Fortaleza, Brazil, from 5 November to 20 December 2004. Indoor air was sampled during normal activities of personnel and students. The results showed that acetone was the most abundant carbonyl compound in outdoor and indoor air, with an average concentration of 52.48 $\mu g\,m^{-3}$, followed by formaldehyde (12.42 $\mu g\,m^{-3}$), acetaldehyde (2.90 $\mu g\,m^{-3}$), benzaldehyde (2.35 $\mu g\,m^{-3}$), butyraldehyde (2.31 $\mu g\,m^{-3}$), and acrolein (2.02 $\mu g\,m^{-3}$). Acetone was the main compounds in research laboratories and offices, whereas formaldehyde was predominantly present in the libraries, student laboratories, and classrooms. The indoor/outdoor (I/O) ratio indicated that levels of CCs in indoor air are more elevated than in outdoor air. Ratios were 11.20 for acetone in research laboratories, 8.48 for acetaldehyde in offices, and 8.37 for formaldehyde in student laboratories. The cancer risk for professionals was 5–30-fold higher than that for students, while the risk was even higher in some libraries and offices when compared to particular laboratories. For women, the estimated cancer risk is 4% higher than that calculated for men.

Keywords: Carbonyl compounds; Formaldehyde; Cancer risk assessment; Academic environment; Indoor air quality

1. Introduction

Sources of carbonyl compounds (CCs) in the air include primary emissions from natural vegetation, industrial plants, incinerators, and automobiles, as well as secondary emissions via photo-oxidation of biogenic and anthropogenic hydrocarbons (Graedel, 1986; Grosjean et al., 2002). Formaldehyde and acetaldehyde are major carbonyls in urban air and

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they are greatly contributing to urban photochemical smog (Graedel, 1986).

CCs in indoor air are important because of their health hazards. Air quality has been monitored in working environments (Guo et al., 2003; Miguel et al., 1995), schools (Lee and Chang, 2000; Meininghaus et al., 2003; Cavalcante et al., 2005), leisure places (Righi et al., 2002; Feng et al., 2004), and residences (Zhang et al., 1994; Weschler et al., 1992; Muller et al., 2003). As people spend most of their lifetime indoors (houses, offices, shopping centers, restaurants, libraries, and others), increased air exposure may be a risk to human health (Graedel, 1986; Gioda and Aquino Neto, 2003). Therefore, the World Health Organization (WHO) recognizes diseases due to low quality of indoor air a threat to public and occupational health (WHO, 1982).

A working group, convened by the IARC Monographs Programmer (IARC, 2004a), concluded that formaldehyde is carcinogenic to humans and sufficient evidence is available that exposure to formaldehyde causes nasopharyngeal cancer in humans, a rare cancer in developed countries. Although formaldehyde was previously classified by IARC in Group 2A (''probably carcinogenic to humans''), it was reclassified as an agent belonging to Group 1 (''carcinogenic to humans'') (IARC, 2004b).

In this perspective, several authorities worldwide have established regulations or guidelines for the use and production of formaldehyde. The Occupational Safety and Health Administration (OSHA) has determined the permissible exposure limit (PEL) at 0.75 ppm as an 8-h time-weighted average (TWA) and 2 ppm in 15 min as a short-term exposure limit (STEL) (OSHA, 2002). The American Conference of Governmental and Industrial Hygienists (ACGIH) has established a threshold limit value (TLV) of 0.3 ppm, which should not be exceeded at any time (ACGIH, 2000). More rigidly, the National Institute for Occupational Safety and Health (NIOSH) has fixed a recommended exposure limit (REL) for occupational exposure at 0.016 ppm in 10 h (TWA), and a STEL of 0.1 ppm in 15 min (NIOSH, 2004). Acetaldehyde (classified in Group 2B), is a potential human carcinogen based on sufficient evidence in animals and inadequate evidence in humans (IARC, 2004b), and the legal airborne PEL is 200 ppm averaged over a 8-h workshift (OSHA, 2002). Other CCs are classified within Group 3 or Group 4 or are not classified, indicating a low cancer risk (IARC, 2004b).

People exposed to chemicals, mainly in workplaces (industries, laboratories, hospitals, and others) have an increased probability of acquiring degenerative diseases (USEPA, 1996a; ATSDR, 1999; USEPA, 2002). CCs can be produced outdoors and it is well known that formaldehyde is directly emitted from wood combustion, cigarette smoking, carpets, household cleaners, and furniture (Zhang et al., 1994; Wolkoff et al., 1998; ATSDR, 1999; Nazaroff and Weschler, 2004).

The present study was initiated by results from previous reports (Báez et al., 2003; Feng et al., 2004) showing that levels of CCs are not only a concern related to areas of high industrialization, but also in the neighbourhood of big cities (Williams et al., 1996; Woodruff et al., 2000; Baéz et al., 2001; Tam and Neumann, 2004). Furthermore, increased exposure to chemicals in an academic environment could also contribute to a higher cancer risk (Cavalcante et al., 2005). In addition, CCs from vehicular and industrial emissions in major Brazilian cities (Salvador, São Paulo and Rio de Janeiro) are elevated (Miguel et al., 1995; de Andrade et al., 1998; Montero et al., 2001; Grosjean et al., 2002). It occurred to us that comparable data from the Fortaleza area are urgently needed by lack of any previous study. Thus, academic places at the Pici Campus (Universidade Federal do Ceará) were chosen for indoor and outdoor measurements of six selected CCs. The cancer risk associated with indoor exposure to CCs levels during normal activities of the academic population has been evaluated as well.

2. Materials and methods

2.1. Sampling sites

Fortaleza city is localized on Atlantic coast of Brazil at 3°30′S and 38°50′W (Northeast region), with about 2.3 million inhabitant distributed over a 313 km^2 area. Fortaleza is a tropical city with yearly average maximum and minimum temperature of 32 and 26 °C, respectively. The study has been carried out at the Universidade Federal do Ceará, Campus do Pici (20 ha occupied by buildings and green area; approximately 950 employees and 7000 students), which is located 6 km southwest of downtown Fortaleza between 5 November and 20 December 2004. There is no industry near the campus, however, it is surrounded by a populated district, some highways, and, inside the campus, there is