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Air Mercury Levels in a Pharmaceutical and Chemical Sciences School Building

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In its elemental form, mercury is the only metal that is in a liquid state at room temperature. It readily volatilizes at room temperature and is emitted into the atmosphere from a number of natural as well as anthropogenic sources, where it is predominantly found as three species: gaseous elemental ($Hg^{0}_{(g)}$), reactive gaseous ($Hg^{2+}_{(g)}$) and particulate ($Hg_{(p)}$), each with different chemical properties. Its presence in open containers or devices can result in biologically significant air concentrations in unventilated or poorly ventilated spaces. In recent years, elemental mercury has proven to be a potential source of toxicosis through either unintentional exposure or exposure resulting from inappropriate handling of liquid mercury acquired from school science laboratories, spilling during transportation, cultural and religious practices (Riley et al. 2001), occupational settings (Bhan and Sarkar, 2005), or as a chemical abandoned in industrial facilities, warehouses or mines. Two well-known episodes are the elemental mercury spill in Cajamarca, Peru, and the mercury-contaminated condominium building in Hoboken, NJ, USA (Gochfeld, 2003; Orloff et al. 1997).

The shiny, silvery appearance of mercury in its liquid form makes it particularly enticing to unprevented students, and its high vapor pressure make this element easily dispersed in open and closed environments. Although mercury exposure to elemental mercury vapor can result in adverse health effects in exposed individuals (Franko et al. 2005), both in the workplace and in indoors, few studies have been performed in academic, medical or research buildings (Tezel et al. 2001), despite the fact that mercury mitigation must be of particular necessity in public education facilities (Risher et al. 2003).

MATERIALS AND METHODS

The School of Pharmaceutical and Chemical Sciences at the University of Cartagena is located in the City of Cartagena, Colombia (10°23.971''N and 75°30.147''O). This touristic city has a population of approximately one million people and the university is a public high education institution with approximately nine thousand students, four hundred of which are enrolled in the pharmaceutical chemistry or chemistry program at the campus of Zaragocilla. These programs are localized in a building with three floors and a basement, all of them connected

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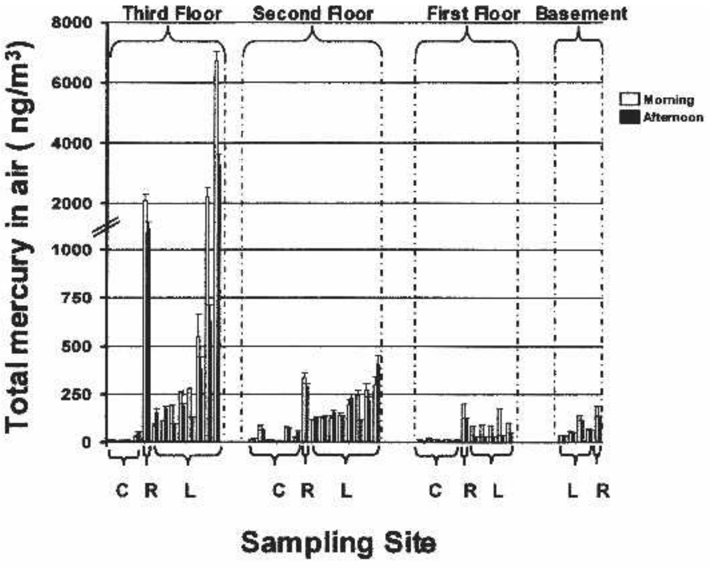

Figure 1. Total air mercury levels in different rooms at the Pharmaceutical and Chemical Sciences School building. Types of rooms: C, Class; R, Reagent store; L, Lab.

through stairs. Mercury levels in air were measured using a Zeeman atomic absorption spectroscopy implemented in a RA-915+ mercury analyzer (Lumex, St. Petersburg, Russia). A detailed explanation of its functioning is provided elsewhere (Sholupov et al. 2004). The detection limit is 2 ng/m^3 (average time being 1 s) and 0.3 ng/m^3 (average time being 30 s) for real-time measurements of total mercury concentration in air. Air mercury monitoring was performed at one meter high at least during three different days during equal number of weeks at both morning (9:00 – 11:00 a.m) and afternoon (3:00 – 5:00 p.m) hours. Average room temperatures oscillated between 26-27 °C, as a result of air conditioning functioning. Each measurement was taken once the rooms were equilibrated after closing the doors for at least ten minutes. All the data are presented as media±standard error for at least three different measurements.

RESULTS AND DISCUSSION

Total mercury levels found in the air of the several types of rooms of the Pharmaceutical and Chemical Science building are presented in Figure 1. Mean air mercury concentrations in the building were 361.8±162.1 (median: 96.0) and 205.6±77.9 (median: 68.1) ng Hg/m^3 in the morning and the afternoon, respectively. Overall air mercury levels were 283.7±89.8 (median 88.0) ng Hg/m^3. At the first floor, the maximum Hg concentration was observed at the reagent store, whereas at the second floor, the carbo-chemistry lab and the reagent store rooms presented the highest values. High mercury levels were observed in the

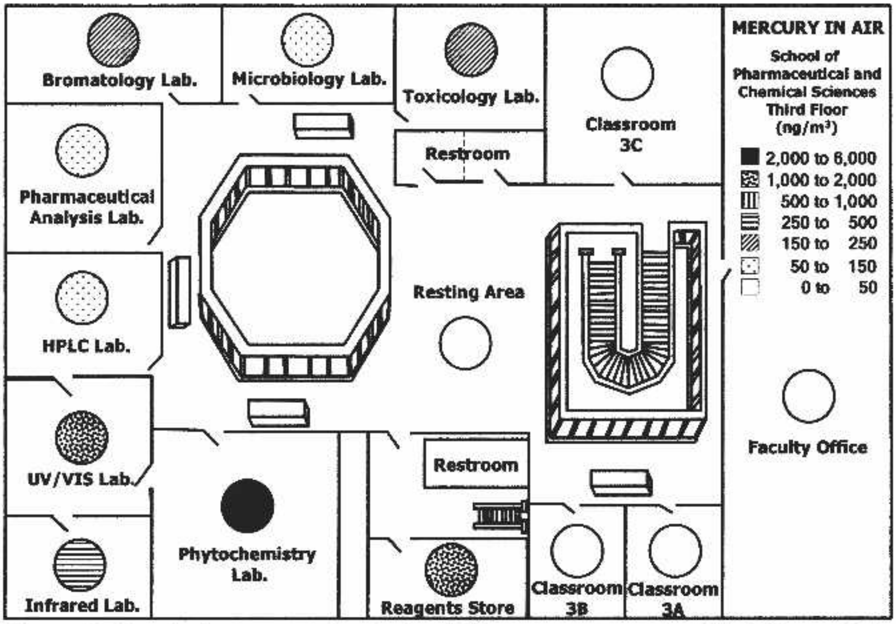

Figure 2. Total air mercury levels in different rooms at the third floor of the Pharmaceutical and Chemical Sciences School.

phytochemistry lab and adjacent rooms located in the third floor. The source of mercury in this lab was a pressure-measurement device. Other rooms with moderately high levels were the reagents store room and in this case, the sources were broken thermometers that were not properly stored. Air mercury levels measured outside the building (eight meters far from the walls) were 24.4 ± 0.95 ng/m^3.

Obtained data for the third floor distributed according to the different rooms is presented in Figure 2. Several rooms were highly contaminated with mercury concentrations up to 6724 ng/m^3. It is evident that the source of mercury contamination in the third floor of the building is the phytochemistry lab. From there, mercury is clearly diffusing into the UV-VIS and the Infra-red labs, probably through the doors or the air conditioning system.

After measuring air mercury levels, the source of mercury was located and primary preventive measures were taken in order to decrease the airborne levels of this metal. Water was added to the pressure-measurement device in both ends and they were tightly closed. Broken thermometers were stored in sealed recipients and disposed in a special sanitary landfill for hazardous materials. Air mercury levels taken before and after these actions are presented in Figure 3. It is clear that simple procedures can prevent airborne mercury exposure.

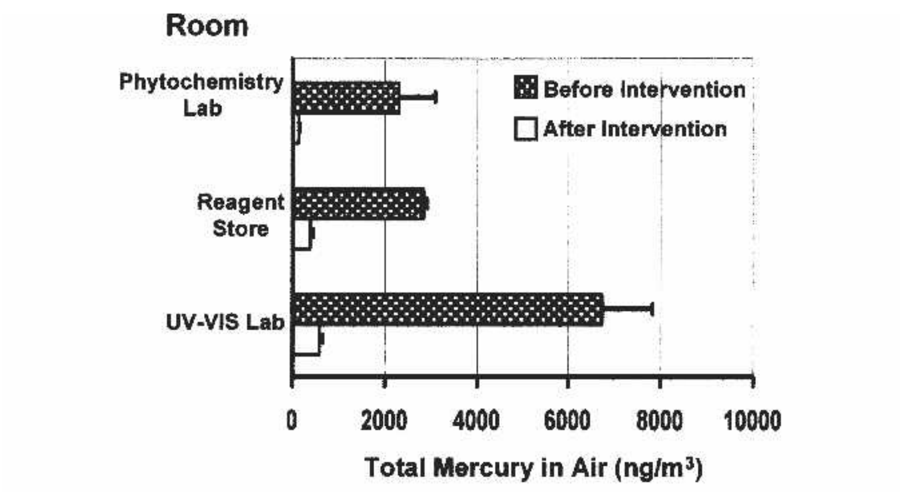

Figure 3. Air mercury levels taken before and after primary preventive measures.

After controlling the source of mercury, some residual levels were still at concentrations that are greater than that suggested by the U.S. Environmental Protection Agency (300 ng Hg/m^3) and the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) (200 ng Hg/m^3), as a reference concentration for exposure to vapor-phase Hg^0.

After fish consumption, indoor air is the most important exposure source of mercury in the general population. Air mercury levels in remote areas are not usually greater than 10 ng/m^3. Several authors have reported background levels of air mercury in pristine or low polluted sites such as the Canadian Arctic (1.58 ±0.04 ng/m^3) (Steffen et al. 2005), or the Lake Balaton in Hungary (0.4 to 5.9 ng/m^3) (Nguyen et al. 2005), among others. On the other hand, in residential areas where some mercury accidents might occur, those airborne Hg concentrations could range between 6.5 to 523 ng/m^3 (Carpi and Chen, 2001). Similarly, values have been registered for ambient air in city places that use mercury in a diversity of industries or processes. In that case, air mercury concentrations have been reported to rise up to 150-300 ng/m^3 (Breval et al, 1996). Air pollution by gaseous mercury with concentrations as high as 10 mg/m^3 have been detected after spilling mercury from a mercurial sphygmomanometer on a hot carpet (Ye et al. 2000). Similarly, the two-hour use of a mechanical amalgamator could produce mercury vapor concentrations from a background level of 0.003 mg Hg/m^3 to 0.018 mg Hg/m^3 in an unventilated room (Glockmann et al. 1990). The greatest concentration found in this study, ~7 μg Hg/m^3, might be considered similar to those observed after functioning of an amalgamator. Although different publications regarding the levels of air mercury have been reported for several environments, to the best of our knowledge, this is the first one regarding a Latin-American university building.

From this study, it is clear that there are a number of potential sources of mercury in a pharmaceutical or chemical department in a typical university. Periodically real-time monitoring of airborne mercury could help to protect exposed individuals to mercury vapor. This is particularly important in academic environments due to the deleterious effects on the central nervous system caused by mercury.

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