Atmospheric Pollution Research xxx (2016) 1–7

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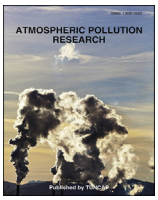
Atmospheric Pollution Research

journal homepage: http://www.journals.elsevier.com/locate/apr



Monitoring of lead, arsenic and mercury in the indoor air and settled dust in the Natural History Museum of Rouen (France)

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ARTICLE INFO

Article history:
Received 3 October 2016
Received in revised form
29 November 2016
Accepted 3 December 2016
Available online xxx

Keywords:
Museum
Air monitoring
Health risk
Arsenic
Mercury
Settled dust

ABSTRACT

For more than 100 years, mercury and arsenic have been used for the preservation of natural history collections. This may represent a risk for staff as they may be exposed to these substances by inhalation, by skin contact or by unintentional ingestion of settled dust. In this work, we present results from a monitoring of lead, mercury and arsenic in the air and settled dust at the Natural History Museum of Rouen (Normandy, France). Relatively high levels of arsenic were measured in the air, with concentrations occasionally over the recommended value of 2 μg m^{-3} for a working atmosphere (NIOSH REL). Analysis of settled dust has shown a significant contamination with arsenic, lead and mercury compared to house dust respectively with median values of 58, 5507, 11 mg kg^{-1}. Finally, Hg(0) concentrations were measured with highest values in the herbarium storage area (150–200 ng m^{-3}) with a peak value of up to 1100 ng m^{-3} when manipulating herbarium sheets. Generally, the exposure of staff to these toxic substances appeared to be quite limited when compared for instance, with dietary intake. However, the concentration of arsenic in the air leads to an excess lifetime cancer risk by inhalation estimated to be 5.26 10^{-4}, which requires special consideration.

1. Introduction

In order to preserve natural history collections, many different and most often toxic products have been used. These specimens, usually made of organic materials, are indeed prone to degrading due to the action of insects, bacteria, fungi … It is probably reasonable to think that without pesticide and fungicide treatments they could not remain intact after sometimes more than 200 years. Thus, both organic biocides such as DDT, lindane, paradichlorobenzene (Purewal, 2001; Wörle et al., 2012), and inorganic compounds such as arsenic trioxide or mercuric chloride have been found in museum collections (Sirois and Taylor, 1989; Péquignot et al., 2006). For instance arsenic employed from the 18th century until the 20th century is abundantly found on old specimens as well as on recent ones [3,4]. Indeed, arsenic soap was applied to the skin of stuffed specimens (Sirois and Sansoucy, 2001). Mercuric chloride was widely used until the late 70's, especially for the preservation of botanical specimens. For example it was diluted with methylated spirit and phenol (Briggs et al., 1983). Mercuric chloride was also rubbed inside skins, or applied in solution inside or outside of the specimen skins (Sirois and Sansoucy, 2001). However, serious health effects of these arsenic and mercuric compounds, which are both classified as carcinogenic by the EPA, led preservation curators to ban their use.

The presence still today of these biocide residues in collections raises questions about the safety of staff, and potentially of that of visitors. Museums are required to take measures to limit staff exposure by wearing appropriate equipment, decontaminating certain specimens and proceeding with the containment of

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Peer review under responsibility of Turkish National Committee for Air Pollution Research and Control.

http://dx.doi.org/10.1016/j.apr.2016.12.002

contaminated object (Lee et al., 2001; Fellowes et al., 2011; Wörle et al., 2012). In particular, one of the concerns of Natural History Museums is the problem of indoor air and settled dust pollution by these biocides. Some studies have been conducted on organic biocides such as formaldehyde, DDT, paradichlorobenzene, …(Burroughs et al., 2006; Schieweck et al., 2007; Marcotte et al., 2014). Concerning inorganic biocides in the indoor air, pollution with gaseous mercury (Hg (0)) is quite well documented (Oyarzun et al., 2007; Kataeva et al., 2009; Fellowes et al., 2011). Arsenic contamination has been much studied on specimens, but rarely on the air and dust. For instance; Schieweck et al. (2007) reported high levels of arsenic in dust from the storage room of the Lower Saxony State Museum in Hanover.

A recent monitoring of organic biocides in the air and dust at the Natural History Museum of Rouen in 2011–2012 established a rather low air contamination, but a higher one for settled dust (Marcotte et al., 2014). We decided to perform a similar study, but, this time, focusing on the inorganic pollution, and more specifically, on the three toxic trace elements: mercury, arsenic and lead, given that a preliminary screening showed their occurrence in the museum environment. Lead is potentially present due to the use of lead paint on stuffed specimens but also on the walls of this old museum.

The aim of this study was to determine the exposure of employees to these trace elements, and to quantify the related pollution in the Museum. Measurements were carried out in different locations (exhibition rooms, storage rooms, windows …) in the Museum of Rouen over two years (2013–2014). The results presented in this study provide an estimate of the situation there and the potential risks for employees. Other museums could use this study taking adequate protective and safety measures and, if necessary, carry out their own investigations.

2. Materials and methods

2.1. Museum description

The Natural History Museum of Rouen houses an important collection comprising between 600,000 and 800,000 objects, of which approximately half are exposed (See Fig. 1). This includes specimens of birds, mammals, invertebrates, minerals, paleontology and ethnology. The permanent exhibitions, offices and laboratory are on the 2nd and 3rd floors of the main building. The temperature in these rooms varies from 17 to 22 °C during the year. The main stockroom is located in a separate building, where the temperature is not controlled, and which varies from 12 to 29 °C over the year. In all these premises, the relative humidity is maintained at between 45 and 60%. There is no ventilation or air treatment in the museum, nor in the main stockroom.

2.2. Sampling of airborne particles

Sampling was performed during working days (8h) with a sampling rate of 3 L min^{-1} according to NIOSH 7082 and 7900 methods respectively for the determination of lead and arsenic compounds. The active sampling of fine particles suspended in the indoor air was performed using a Microvol 1100 pump (3 L min^{-1}, 8h, Ecotech) holding a glass fiber filter (47 mm diameter, QMA grade, Whatman). The Microvol 1100 pump was equipped with a TSP sampling inlet. Sampling locations are listed in Table 1. Sampling was triplicated.

Fig. 1. a) Mammal's Gallery of the Natural History Museum of Rouen; b) cardboard boxes for storing plant specimen sheets; c) White particles on a marsh harrier specimen.

Please cite this article in press as: Marcotte, S., et al., Monitoring of lead, arsenic and mercury in the indoor air and settled dust in the Natural History Museum of Rouen (France), Atmospheric Pollution Research (2016), http://dx.doi.org/10.1016/j.apr.2016.12.002