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Exhaled breath condensate as a biomonitor for metal exposure: a new analytical challenge

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Abstract The study of exhaled breath condensate (EBC) obtained by cooling exhaled air under conditions of spontaneous breathing is considered one of the areas with higher interest in respiratory health research. The use of EBC for elemental determination in occupational exposure requires a standard methodological procedure to implement its practice in occupational studies. EBC is an inhomogeneous sample with organic and particulate matter in suspension, which may hamper analytical results reliability. Total reflection X-ray fluorescence and inductive coupled-plasma mass spectrometry (ICP-MS) techniques were chosen as both are multielemental, require small sample volumes and have appropriate detection limits. Estimation of the overall uncertainty in both techniques was carried out using a pool of EBC collected from a group of workers of a lead processing industry to perform precision and trueness studies for K, Mn, Cu, Cd, Sb and Pb. Precision was estimated in terms of repeatability using the native EBC sample pool and trueness in terms of recovery obtained from spiking aliquots of the EBC pool with K, Mn, Cu, Cd, Sb and Pb at different concentrations. Recovery was the most significant contribution to total uncertainty. The overall uncertainties obtained for ICP-MS enabled to discriminate between groups of individuals exposed to different levels of contaminants. Therefore EBC proved to be useful in human biomonitoring.

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Introduction

Exhaled breath condensate (EBC) is obtained by condensing the exhaled air into a cooled collection device by breathing tidally. The EBC is a matrix in which numerous volatile and non-volatile substances can be detected, enabling the assessment of biomarkers of effect (e.g., occupational assessments) and response (e.g., pulmonary pathobiology assessments) in real-time or in conditions close to real-time [1]. Measuring metals in EBC is a promising method of risk assessment, comparing with other common indicators (like blood), once it is non-invasive and quickly and easily collected [2, 3].

In occupational assessments where workers are exposed to metal dust the EBC may provide unique indication of direct exposure [4–6]. The emerging use of EBC for metal quantification in occupational exposure studies needs a standard methodological procedure [1], based on the requirements of both method validation and uncertainty estimation, in order to implement its practice in exposure assessments. The EBC sample is a water suspension, highly diluted, inhomogeneous, containing organic and significant amounts of particulate matter [7]. Moreover, an EBC sample has only a few millilitres of volume, which has to be enough to perform accurate analysis of occupationally relevant elements, usually present at the workplace in trace levels. These issues influence sample representativeness and raise analytical difficulties, limiting direct analysis of the sample and constraining the use of conventional pre-treatment methods. So, multielemental analysis of EBC