Assessment of personal exposure to atmospheric pollutants: A comprehensive study using innovative smart sensors in the urban environment of Thessaloniki

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Abstract

According to the World Health Organization (WHO), atmospheric pollution is a major threat to human health and causes approximately nine million premature deaths worldwide per year. Human exposure to atmospheric pollutants varies according to each person's habits, living conditions, and working conditions. This project investigated the exposure of 246 individuals living in the wider area of Thessaloniki city to atmospheric pollutants by using innovative smart sensors. For this purpose, a low-cost, portable, sensor was assembled that simultaneously records airborne PM_1, $PM_{2.5}$, PM_{10} particles, volatile organic compounds, formaldehyde and CO2, as well as ambient air temperature and humidity values. Correction factors were used in different environmental conditions in order to improve the sensor's performance. These factors were parameterized against measurements taken by the validated automated real-time data recording samplers Mini Laser Aerosol Spectrometer and Cairnet. By comparing the low-cost sensor with the validated analysers, multi-linear and non-linear methods were established, that also take into account temperature and humidity values. Coefficients of determination (R2) were examined for every condition using LR, NLR, MNLR, MLR, MLR_RV and ANN methods. The results showed that including additional environmental factors in a calibration equation can significantly improve the performance of a statistical model. It was also observed that the coefficient of determination value changes depending on the statistical method applied. The ANN and MLR_RV methods performed better in this study. The calibration results showed that different calibration models should be used for the various PM sizes under different conditions. Individual exposure to pollutants was identified by combining data on location, activities and atmospheric pollution, and exposure comparisons were made between different population and social groups. Exposure was calculated further by employing the Multiple-Path Particle Dosimetry model that calculates the mean daily rate of inhalation and deposition of PM along the respiratory tract. The above methodologies were applied within the campaign for novel, portable, pollutant sensors that are part of the European URBANOME (H2020) project and allowed us to calculate the actual pollutant intake of the participating volunteers and highlight the significant differences between these actual values and those attributed to static air quality monitoring stations.

KEYWORDS: Air pollutants, low-cost sensors, human exposure, calibration models