Abstract

Poor indoor air quality has been associated with health issues and decreased work performance. Personal exposure that takes place both in outdoor and indoor environments is the result of dynamic processes and complex interactions between people and surroundings, contingent upon spatio-temporal variations of air pollutants and their diversity, source-receptor proximity, individual activities, and others. However, existing knowledge on the impact of air pollutants on human health is based on the results of epidemiological studies that associate data from morbidity and mortality with measurements from stationary ambient monitors, which may poorly resemble the inhaled air. Nevertheless, even when considering various ambient air pollutants, the majority of their inhalation occurs indoors as a result of the time people spend in buildings.

Relative to outdoor measurement stations, indoor monitoring stations, typically limited to one location that hardly captures the effect of personal activities and proximity of emission sources, better correlate with daily human exposures. The personal cloud effect refers to an increment of pollutants concentration inhaled compared to stationary indoor or outdoor monitors; nevertheless, the nature and significance of this effect are not yet well understood despite existing studies pointing toward its significant impact on human daily exposures. Thus, understanding the dynamics of air pollutants in the human vicinity can help us better characterize inhalation exposures and identify and mitigate the underlying sources.

Three field campaigns were done in home and office environments in Switzerland: one, home and office campaign; second, office campaign; and third, home campaign during COVID-19 pandemic where participants worked from home. Overall, personal and indoor stationary real-time measurements were taken for CO_2, particles (size range 0.3-10 µm) and total volatile com-pounds (TVOC), and time-integrated samples were taken for PM_{10}, VOCs, aldehydes and semi-volatile organic compounds (SVOCs). Participants' location and activities were monitored using a time-activity diary application in the two home campaigns. While in one office campaign, participants were monitored with a motion sensor under their workstations. The main results from these studies show that using a time-activity diary or motion sensors can improve exposure estimation with indoor stationary monitors by selecting data when participants were present in the environments/rooms. The bedroom was the best location to monitor exposure to CO_2 in residences and the living room for particles. Personal monitors recorded higher levels of CO_2 and PM_{10} than indoor stations, confirming the existence of personal clouds. Home environments were the main contributors to daily exposure to CO_2 and PM_{10}. The personal cloud was detected in 29 VOCs and SVOCs in homes. Average personal measurements of formaldehyde, acetaldehyde, butyraldehyde, hexaldehyde and propionaldehyde were higher in offices than in homes; nevertheless, TVOC levels were higher at homes. Through the three field campaigns, this thesis contributes to a better understanding of factors that affect personal exposure and the feasibility of exposure characterization by employing stationary indoor monitoring stations. Additionally, it proposes mitigation strategies for personal exposures and the improvement of monitoring techniques in residences and offices.

Keywords: Personal exposure, personal cloud effect, IAQ in residences and offices, spatio-temporal variation, wearable monitoring, optimal sensor density and location