Building and Environment 212 (2022) 108847

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

# Personal exposure and inhalation doses to $PM_1$ and $PM_{2.5}$ pollution in Iraq: An examination of four transport modes

Osamah J. Al-sareji [a,b], Ruqayah Ali Grmasha [a,b,*], Khalid S. Hashim [c,d], Jasim M. Salman [e], Raed A. Al-Juboori [f]

[a] Environmental Research and Studies Center, University of Babylon, Al-Hillah, Iraq
[b] Sustainability Solutions Research Lab, Faculty of Engineering, University of Pannonia, Egyetem str. 10, Veszprém H, 8200, Hungary
[c] School of Civil Engineering and Built Environment, Liverpool John Moores University, UK
[d] Department of Environmental Engineering, College of Engineering, University of Babylon, Al-Hillah, Iraq
[e] Department of Biology, College of Science, University of Babylon, Al-Hillah, Iraq
[f] Water and Environmental Engineering Research Group, Department of Built Environment, Aalto University, P.O. Box 15200, Aalto, FI-00076, Espoo, Finland

ARTICLE INFO

*Keywords:*
Air pollution
Transportation
Particulate matter
Inhalation dose
Al-Hillah
Iraq

ABSTRACT

Particulate matter (PM) is a major indicator of urban air quality deterioration due to its impact on human health, atmospheric visibility and climate change. However, sufficient data on personal exposure to air pollution is still rare or unavailable in developing countries such as Iraq. Thus, this paper investigated the personal exposure and inhalation doses of $PM_1$ and $PM_{2.5}$ in Al-Hillah city, Iraq, for four common motorized transportation modes, namely open windows car, closed window car, bus, and motorbike. A portable monitoring device was used to collect the data during morning and afternoon hours in two main streets in the city. A *t*-test examination of the obtained results showed that the mean exposure concentration for both $PM_{2.5}$ and $PM_1$ were significantly different in the two streets form most of the transportation modes. The difference in the means of the measured $PM_1$ and $PM_{2.5}$ in the morning and afternoon trips were statistically significant for all the transportation modes except for bus in 60 street. This highlights the special and temporal variation of air pollution in the city. This is largely due the deteriorated infrastructure and lack of control policies in the city. Overall, $PM_{2.5}$ and $PM_1$ measured exposure concentrations were higher in the morning trips than in the afternoon ones. Regardless of the time or place of measurements, closed windows cars always had the lowest exposure concentrations to $PM_1$ and $PM_{2.5}$. The alarming observation in this study was the high levels of $PM_1$ and $PM_{2.5}$ that exceeded the recommended WHO limits, and were higher than the reported concentrations in the world bank database. The study findings present preliminary data on personal exposure concentrations and inhalation doses for travelers in Al-Hillah city, which can be utilized for global studies of air contamination in countries in similar situations as Iraq and for developing local control strategies.

## 1. Introduction

Several health impacts such as respiratory and cardiovascular morbidity result from increasing the levels of ambient air pollution. Particulate matter (PM) with an aerodynamic diameter $\leq$2.5 μm and $\leq$1 μm ($PM_{2.5}$ and $PM_1$) can easily enter the lungs through inhalation [1]. Studies have shown that long-term exposure to $PM_{2.5}$ can impact lung development [2,3,4], neurological development and cognitive function development [5,6]. Exposure to $PM_{2.5}$ and $PM_1$ pollution, especially among the elderly, children, and those with pre-existing cardio-pulmonary diseases, could negatively impact their health as they are considered more vulnerable [7]. Many factors could increase PM doses and accelerate their movement into children's lungs, such as their mouth-to-nose breathing high ratio, their developing system, and high inhalation rate [8,9]. A study has shown that ambient $PM_{2.5}$ was the 5$^{th}$ among the mortality risk factor in 2015 [10]. The Global Burden of Diseases data in 2015 also indicated that exposure to $PM_{2.5}$ was the cause of 4.2 million deaths and about 103.1 million global disability-adjusted life-years [10,11]. Ambient $PM_1$ contributed nearly to 80% of $PM_{2.5}$ in most PM observation stations in China [12]. The smaller size fractions of PM have more toxic mortality impacts [13]. This portion is more likely to reach deeper into the respiratory system

* Corresponding author. Environmental Research and Studies Center, University of Babylon, Al-Hillah, Iraq.
*E-mail address:* ruqayah.grmasha@uobabylon.edu.iq (R.A. Grmasha).

https://doi.org/10.1016/j.buildenv.2022.108847
Received 25 November 2021; Received in revised form 22 January 2022; Accepted 26 January 2022
Available online 29 January 2022
0360-1323/