DOCTORAL THESIS

Air pollution and human health risk assessment in e-waste recycling sites and urban indoor environment in South China

Zhang, Manwen

Date of Award:
2017

ABSTRACT

With the emphasis on particulate matter (PM) and persistent organic pollutants (POPs) from uncontrolled sources, this study focused on the ambient air pollution of e-waste recycling regions and the indoor air quality of urban areas in South China.

In the past decades, severe PM and POPs pollutions were recorded in e-waste recycling regions in China. Since the 2010s, more effective measures, stricter regulations and sophisticated dismantling technologies have been implemented in Guiyu and Qingyuan by local authorities. In this study, total suspended particles (TSP), fine particles ($PM_{2.5}$), gas phase samples, and indoor settled dust were collected simultaneously in the primary recycling areas as well as reference sites in Guiyu and Qingyuan in August, 2013. The results showed that both PM, PCDD/Fs (polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans) , PBDEs (polybrominated diphenyl ethers) and PCBs (polychlorinated biphenyls) in ambient air showed significantly reduced levels in the regions, compared with the former corresponding reports. The changed source patterns of the POPs confirmed the environmental effects of the implementation of stricter regulation and advanced technologies in these years. Nevertheless, the remained uncontrolled e-waste recycling activities in Guiyu, including plastics recycling and circuit board baking, still made significant influence to the air environment and resulted in alarming levels of PCDD/Fs (0.73~2.43 pg I-TEQ/m^3) in the recycling areas. While in Qingyuan, high environmental PCBs burden was observed both in informal (1737 pg/m^3) and formal recycling areas (1075 pg/m^3), which could attribute to the uncontrolled dismantling of PCB-contained

transformers. The estimated non-cancer risk for children and adults in the recycling regions were 2.7~25.2 and 1.2~3.2, respectively, and moderate cancer risk were found for the residents living in the recycling regions of Guiyu and the vicinage of the formal recycing factory ($CR>10^{-4}$). The unacceptable estimated risk for both children and adults suggested unsafe air environments in the two recycling regions.

To date, few studies have focused on PM air quality in office areas with different indoor conditions. Rare risk assessment has been reported for the integrated human risk with the consideration of human activity pattern in different daily spaces. The aim of the present study was to investigate fine particle and associated chemicals in indoor and outdoor air of South China urban areas. The indoor and outdoor fine particle samples were collected in 14 offices and 3 residential houses from March to October 2015 in Guangzhou. The major chemical composition of PM including water-soluble ions, carbon species, and metal elements, as well as certain compounds with possible adverse effects on human health such as polycyclic aromatic hydrocarbons (PAHs) and organophosphate flame retardants (OPFRs) were analyzed for investigating the influence of indoor source and outdoor pollution to indoor air quality. Both indoor and outdoor average concentrations were found substantially higher than the guideline value of WHO Air Quality Guideline ($25\mu g/m^3$), suggesting unsafe air quality in the urban areas. The indoor $PM_{2.5}$ and PM associated pollutants could be characterized by the presence or absence of PM sources. Smoking and photocopying were found to be significant indoor sources of $PM_{2.5}$ and associated pollutants in related indoor spaces on normal days. While on haze days, serious

outdoor pollution greatly increased the impact of the outside on office environments, even to the point of masking the original differences of the indoor characteristics, which caused even poor indoor quality. PAHs were found to be the important PM-associated POPs in various daily spaces. Over 85% of PAHs exposure were found from indoor exposure, dominating by the contribution from private homes. The risk assessment results indicated unacceptable indoor air quality in Guangzhou in terms of PAHs exposure. In addition to PAHs, the substitutes of brominated flame retardants, OPFRs, were found to be other kind of ubiquitous organic pollutants in indoor areas. Although the integrated averaged daily doses (ADDs) and estimated non-cancer risk of the studied population appear tolerable to the exposure of OPFRs, due to the uncertainty of insufficient toxic data of OPFRs, the preliminary assessment results could not be felt optimistic. The dominated contribution of halogenated OPFRs in the selected indoor areas may reveal a contradictory problem in human daily life for the popular application and the unpopular POPs characteristics on halogenated OPFRs.

Collectively, our results suggest unsatisfactory air quality in both e-waste recycling regions and common urban areas. The air problems could both attribute to the uncontrolled sources of the related spaces. The obtained results firstly indicated that a long way to solve e-waste issues and more effective measures are needed to control the contaminants release and the exposure to the local residents. Secondly, indoor air quality standard for fine particulate matters as well as associated toxicants such as PAHs is urgently needed to guide common populations and communities.

Keywords: Air pollution; E-waste recycling; Urban areas; Indoor air; Ambient air; $PM_{2.5}$; Persistent organic pollutants; Health risk assessment

LIST OF CONTENTS