Cod: 5.1006

EVALUATION OF THE RELATIVE HEALTH RISK IMPACT OF ATMOSPHERIC PCDD/FS IN PM2.5 IN TAIWAN

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Introduction

$PM_{2.5}$ (particle matter with an aerodynamic of less than or equal to 2.5 μm) is a crucial air pollutant on the basis of its adverse human health effects and degradation of visibility[1]. The standard has been strengthened in 2012 and currently set at 35 μg/m^3 for 24 hours and 15 μg/m^3 for annual average in the U.S. Epidemiological and toxicological studies have demonstrated that increased particulate matter cause increased cardiovascular mortality and morbidity, and this PM toxicity may increase as the particle size decreases. $PM_{2.5}$ is a complex mixture from both natural and anthropogenic sourced, including primary and secondary particle species, and consists mainly of water soluble ions, carbonaceous species (OC and EC) and elements (Al, Si, Mg, Fe, Pb, Zn, etc)[2,3]. Exposure to fine particulate matter ($PM_{2.5}$) was associated with increased risk of active tuberculosis, in addition, traffic-related air pollution including nitrogen dioxide, nitrogen oxides and carbon monoxide was associated with tuberculosis risk[4]. Particularly, the contents of dioxin-like compounds and other pollutants exist in suspended particles. One of the dioxin-like compounds, the 2,3,7,8-TeCDD was classified by International Agency for Research on Cancer (IARC) as a "known human carcinogen"[5]. The objective of this study is to survey the information regarding the environmental burdens of PCDD/Fs in the vicinity of the stationary pollution sources in air were established, while human relative health risks for the population living in the vicinity of the stationary pollution sources and other regions (urban area and suburban area) were also assessed.

Materials and method

In this study, we collected ambient air samples at different regions (urban, suburban, industrial area) around Taiwan during winter and summer season in 2014 and 2015 (Figure 1). The atmospheric concentrations of seventeen 2, 3, 7, 8-substituted PCDD/Fs in suspended particles were monitored. The sampling procedures were performed following the main guideline of European Union EN-14907 $PM_{2.5}$ for ambient air collection. Ambient air samples for both vapor phase and solid phase of dioxin-liked compounds were collected. The ambient sampling instruments consisted of HVS $PM_{2.5}$ sampler (Analitica), the samplers were equipped with Whatman quartz fiber filters for collecting particle-bound compounds while polyurethane foam (PUF) plugs were used for retaining PCDD/F compounds in the vapor phase. HVS $PM_{2.5}$ sampler (Analitica) was connected to a vacuum pump and 700 m^3 of air mass was collected in 24 h at a sampling flow rate of 500 L/m^3. The PUF and filter samples were than Soxhlet extracted with toluene for 24 hours, treated with concentrated sulfuric acid, and then passed through a series of clean-up columns containing sulfuric acid-silica gel, acidic aluminum oxide and celite/carbon. In this study, the seventeen 2,3,7,8-substituted PCDD/F congeners were analyzed with high-resolution gas chromatography (HRGC)/high-resolution mass spectrometry (HRMS) (JEOL JMS-700) equipped with a fused silica capillary column DB-5 MS (60 m x 0.25 mm x 0.25μm, J&W). In addition, the concentration of PCDD/Fs are used to calculate Relative Ratio (RR) with Taiwan Cancer Registry database, and then investigated the relationships of PCDD/Fs concentrations and disease deaths rate at different regions.

Results and discussion

The results shown in Tables 1 to 3 indicated the $PM_{2.5}$ concentrations in daily average measured at different area in Taiwan, the higher $PM_{2.5}$ (60.4±7.39 μg/m^3, 35.1±4.75 μg/m^3) concentrations were measured at industrial station (Site I4) and urban station (Site U6), respectively. For the PCDD/F analysis, Fig. 2 demonstrated that the PCDD/Fs concentrations of $PM_{2.5}$ samples in winter and summer season, the highest concentration of PCDD/Fs was 122±51.1 fg I-TEQ/m^3 measured at Site I4. In addition, the results indicated that the atmospheric PCDD/Fs mostly distributed in solid phase ($PM_{2.5}$) especially during the winter season. Moreover, the higher concentration of PCDD/Fs was 31.1±16.3 fg

I-TEQ/m^3 at Site I1 and higher percentage concentration of PCDD/Fs in vapor phase. Especially for the northern urban area (Site U4), the total quantity of PCDD/Fs in $PM_{2.5}$ (1,182±294 pg I-TEQ/g) were higher than other station (Figure 3). The northern urban area (Site U4) was set up at the city with higher densely populated and also was affected by traffic and monsoon. In summer, the higher total quantity of PCDD/Fs in $PM_{2.5}$ was 698±159 pg I-TEQ/g at Site I6. All the measurements indicated that the atmospheric PCDD/Fs measured in this study were all lower than the air quality standards for dioxins in Japan (0.6 pg-TEQ/m^3). Table 4 indicated that the health relative risk of all causes and cancers of liver and intrahepatic bile ducts in high $PM_{2.5}$ concentration exposure all group were significant higher than low $PM_{2.5}$ concentration exposure all group. In addition, the health relative risk of malignant neoplasms (Relative risk= 1.4145, CI= 1.083-1.847, P= 0.011) in high $PM_{2.5}$ concentration exposure female group were significant higher than low $PM_{2.5}$ concentration exposure female group. However, Table 5 indicated that the health relative risk of the cancers of trachea, bronchus and lung (Relative risk= 1.898, CI= 1.039-3.468, P= 0.037) and female breast cancer (Relative risk= 2.321, CI= 1.027-5.245, P= 0.043) in high PCDD/Fs exposure female group were significant higher than low PCDD/Fs exposure female group. The results demonstrated that the chemical content and levels in $PM_{2.5}$ will be much important than the mass concentration.

Acknowledgements

The authors gratefully acknowledge the financial support provided by Taiwan Environmental Protection Administration (EPA-103-1604-02-05 and EPA-104-1604-02-01) and the Ministry of Science and Technology (MOST 104-2628-M-010-001-MY3) of Taiwan. Assistance provided by Prof. M. B. Chang, Mr. S. H. Chang and Dr. P. C. Hung of National Central University in analyzing the data is also acknowledged.

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