An integrated approach for conducting long-term PM$_{2.5}$ exposure and health risk assessment for residents

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Keywords: Stationary measurements, Mobile measurements, Exposure and Health risk assessment, Residents

Objective: To date, Environmental Protection Agency monitoring station measurements (EPAm) are widely used for characterizing air quality data, but simply using EPAm could be inadequate to characterize residents’ exposures of the specific area. Our study analyzes the correlation of PM$_{2.5}$ data sets of the mobile measurements (Mm), stationary measurements (Sm) and EPAm in order to describe the spatial and temporal variations of PM$_{2.5}$ in the area, and to build a long term databank for conducting exposure and health risk assessment of residents.

Methods: The Shalu area, located in the central Taiwan, was chosen as the target area. A stationary PM$_{2.5}$ monitoring station was built next to EPA monitoring station. In addition, a mobile monitoring station was used to measure PM$_{2.5}$ of the area simultaneously in 2013-2014. Samplings were performed during daytime (7:00-10:00 AM) and nighttime (18:00-21:00 PM) on both weekdays and weekends for one month per season. After eliminated high leverage value and outliers, the correlations of mobile measurements (Mm), stationary measurements (Sm) and EPAm were examined, and spatial and temporal variations of PM$_{2.5}$ in the area were assessed, and finally a long term PM$_{2.5}$ databank was constructed. The Bayesian decision analysis (BDA) were used for conducting long term exposure and health risk assessment of residents by comparing with EPA PM$_{2.5}$ air quality standards (STD$_{24hr}$).

Results: Result indicates that most daytime PM$_{2.5}$ concentrations were significant higher than that of the nighttime for EPAm, Mm and Sm due to higher traffic flow and traffic density occurred during the daytime. Highest PM$_{2.5}$ concentrations were found in winter which could be associated with unfavorable atmospheric diffusion conditions of the season. Comparing the results between the Mm and Sm, the former are higher than that of the latter indicating that the height of the stationary monitoring station would lead to the underestimation PM$_{2.5}$ exposures of residents of the area. Both Mm and Sm are found with higher values than that of EPAm. The coefficient of determination between EPAm and Sm was 62.0% in spring, 75.6% in summer, 61.8% in fall, and 83.2% in winter. Corresponding coefficient of determination between Sm and Mm was 50.2%, 64.3%, 65.2%, and 73.0%, respectively.

![Lung cancer risk](image)

Figure1. Long term exposure profile of residents at Shalu area by Basyien analysis (a)Prior (10 years estimate values) (b)Likelihood (Measure value) (c)Posterior (ER0. < STD$_{24hr}$, ER1. STD$_{24hr}$, ER2. i.e., 1.0 to 2.5 STD$_{24hr}$, ER3. 2.5 to 10 STD$_{24hr}$, ER4. >10STD$_{24hr}$)

Fig 1 shows the profiles associated with resident’s long-term PM$_{2.5}$ exposures as in comparison with STD$_{24hr}$ using BDA. Results show that residents’ exposure ratings are the most probably (97.7%) falling to ER2 (i.e., 1.0 to 2.5 STD$_{24hr}$). Using the same data sets, this study yields the lung cancer risk associated with residents’ long-term PM$_{2.5}$ exposures most probably (99.3%) falling to ER4 (i.e., >10). The above results suggest that both residents’ PM$_{2.5}$ exposures and their resultant lung cancer risk were unacceptable.

Conclusions: The study show that the use of EPAm, Sm and Mm could effectively describe the spatial and temporal variations of PM$_{2.5}$ of the area, and would be able to build a long term databank for conducting exposure and health risk assessment of residents. Both exposures and health risk were unacceptable which urges the needs for identifying main PM$_{2.5}$ pollution sources for initiating proper control strategies in the future.