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

C.H. Chou[1], Y.C. Chen[2], M.Y. Lin[1], L.H. Yang[3], H.T. Hsu[4], and P.J. Tsai[1*]

[1]Department of Environmental and Occupational Health Medical College, National Cheng Kung University, Tainan, 701, Taiwan
[2]National Research Center for Environmental Toxicology, National Health Institutes, Miaoli, 350, Taiwan
[3]Department of Occupational Safety and Health, China Medical University, Taichung, 404, Taiwan
[4]Department of Health Risk Management, China Medical University, Taichung, 404, Taiwan
*Presenting author email: pjtsai@mail.ncku.edu.tw

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■ Objectives :

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.

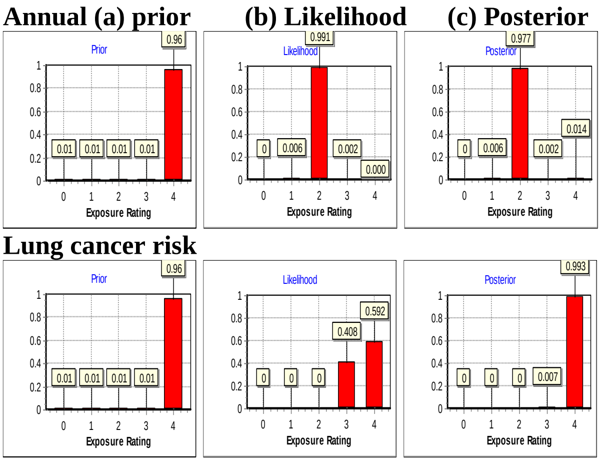

Figure1. Long term exposure profile of residents at Shalu area by Basyien analysis (a)Prior (10 years estimate values) (b)Likelihood (Measure value) (c)Posterior (ER0. < STD_{24hr}, ER1. STD_{24hr}, ER2. i.e., 1.0 to 2.5 STD_{24hr} , ER3. 2.5 to 10 STD_{24hr} , ER4. >10STD_{24hr})

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^{-4}). 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.