# CHAPTER VI
# CONCLUSIONS

## 6.1 Conclusions

1. A personal exposure monitor could be used for measurement PM-10 concentrations with high precision. PM-10 concentrations measured by PEM were comparable to the PM-10 data obtained by a Hi-Vol air sampler. Changing the battery of the air sampler pump to a metal hydride battery allowed the pump to achieve a 24 hr sampling period with an intermittent run protocol without requiring any battery charge during the period. The noise of the air sampler could be reduced by lining the bag with acoustic material. However the weight of the modified sampling bag could be an obstacle during carrying of the PEM.

2. Personal exposure PM-10 concentrations were similar to those previously found by studies in Europe and the United States. The average concentration was 81.6 $\mu g/m^3$ and the standard deviation was 14.3 $\mu g/m^3$. The average exposure concentrations were higher than the Thailand National Ambient Air Quality Standards (NAAQS) for annual average of PM-10, 50 $\mu g/m^3$. Most of the people participating in the study spent most of their time indoors. Personal PM-10 concentrations varied widely from house to house and could be different even for two people who were living in the same house.

3. Indoor concentrations were lower than outdoor concentrations. Indoor concentrations fluctuated from day to day and house to house. Moreover, indoor concentrations varied significantly from room to room. Thus, for measurement of indoor PM-10 concentrations the numbers of indoor sampling sites should be considered carefully in order to get reliable representative data. Outdoor concentrations were high with a mean of 130.7 $\mu g/m^3$ and were similar to those measured at the On-Nuch roadside station which had an average concentration of about 155.0 $\mu g/m^3$. The ambient

roadside concentration was higher than the NAAQS, which for a 24 hr average was 120 $\mu g/m^3$ and 50 $\mu g/m^3$ for an annual average.

4. The results of this study generally support that the concept that the relationships among personal, indoor and outdoor PM-10 concentrations are significantly correlated. Personal PM-10 exposure was better associated with indoor rather than with outdoor concentrations. The correlation coefficients and slopes were quite similar to the other studies in Europe and the United States. This consistent result supported the conclusion that outdoor PM-10 concentration was a reliable surrogate to be used as a representative of personal exposure even in the totally different setting and living style of Bangkok, as compared to the areas where previous studies were carried out.

5. Cross-sectional correlation coefficients for person-outdoor, person-indoor and indoor-outdoor were smaller compared with the longitudinal correlation coefficients. Outdoor concentrations were also well related with the ambient concentration measured at a central site. However, care must be taken in cases of use of a central outdoor concentration measuring site instead of outdoor measurement near the indoor unit because it has been shown that the distance of household from the central site can affect its correlation.

6. The result of regression analyses showed that personal exposure could also be influenced by some personal activities (e.g. incense stick burning, exposure to tobacco smoke and using an air-conditioning system.), house characteristics and season. By contrast, however, location of the house under the sky train station alignment and some personal activities such as exercise and cleaning have no significant influence on personal PM-10 concentrations.

7. The major source of PM-10 exposure would probably be soil/crustal derived materials. This source accounted for approximately 45% of the collected PM-10 mass concentrations. Moreover, there was consistency among personal, indoor and outdoor PM-10 measurements because for all of them soil/crustal origins seemed to be

the major source of PM-10 mass concentrations and accounted for approximately 40%-50% of the PM-10 mass concentrations.

8. Because there was limited information about sources of PM-10 contributions to personal exposure and based upon the results discussed above; incense may contribute to PM-10 exposure concentrations even though it was not significant in the FA/MR analysis. Since the unexplained sources were high, it would be beneficial to identify tracers for this source.

### 6.2 Potential biases and limitations

1. Although, the participating houses were distributed along Sukhumvit Road, the types of businesses have not been accounted for in this study. The reason was that we chose the house based on their location and their willingness to volunteer. Thus, some types of businesses were not in this study such as small restaurants, welding/cutting establishments or bookstores. In these cases, the PM-10 concentration would likely be different both in concentrations and chemical compositions than those observed.

2. Memory recall for the pattern of time activities and time budgeting could not give the level of detail needed. Most of the questions could provide only qualitative not quantitative answers. Thus most of the determinants in this study were qualitative. However, this is a result of a determination that a too detailed questioning of the participants would interfere with their ability to take care of their businesses so the plan was to limit this burden on them. The PEM device would possibly restrict some personal activities and may be left nearby the participant part of the time. Reducing the PEM weight and size would probably reduce this problem.

3. Although this study has answered many questions about PM-10 levels in Bangkok shop houses, results of simultaneous measurement of personal, indoor and outdoor PM-10 still remains quite limited for other living styles in warm-climate countries like Thailand. Understanding the variations of PM-10 concentrations due to spatial, temporal and living style still requires more investigation.

4. In addition, the other limiting was due to, in this study, PM-10 measurements were conducted on weekday only. PM-10 exposure would be different because people may travel or go to the other place where PM-10 differs from their homes.

5. Some chemical components that are important tracers for identifying sources were not determined in this study, for instance organic carbon, elemental carbon, sulfate and nitrate etc. The reasons were: 1) Teflon filters were used which are not appropriate for high temperature analysis methods and 2) because ICP/MS is a destructive method the filter could not be further analyzed.

5. The amount of PM-10 sampling by PEM may be too small to be used in quantification of some trace elements. To enhance the efficiency in analysis, a longer sampling period would increase the PM-10 mass on sampled filters, for example using the same filter for the whole 3 day measurement. However, it should be noted that the loss of PM-10 mass during the sampling period may be increased.

**6.3 Recommendations for future works**

1. PM-10 exposure assessments and the associated source contributions especially in the residential and industrial areas may lead to a better understanding of health effects of PM-10 pollution. However the information on exposure to PM-10 was quite limited especially in the tropical country like Thailand. Therefore, it is necessity to conduct more study on PM-10 exposure assessment.

2. Because different sources emit different types of PM-10 leading to different health effects, the study on source contributions to PM-10 exposure should identify where the PM-10 come from and how much each of the sources contribute to the PM-10 mass.

3. Currently, there are many studies showed that have shown even in areas where ambient PM-10 concentrations were lower than the ambient air quality standard, an association between health effects and PM air pollution is still observed. By these observations, PM-2.5 is accounts for the health effects. However, there is quite

limited information on PM-2.5 exposure. Measurement of PM-2.5 exposure will provide useful information to enhance understanding of the relationships.