CHAPTER IV
DISCUSSION AND CONCLUSION

4.1 Concentration of airborne particulate matters in Chiang Mai city

In this study, the results demonstrated that monthly averaged 24 hour samples of PM 2.5 and PM 10 taken in rainy season (May to October 1999) at various sites in Chiang Mai city were not exceed the 24 hour levels of USEPA standard which was 65 $\mu g/m^3$ for PM 2.5 and 150 $\mu g/m^3$ for PM 10 (Table 3.1). A similar trend was observed at all sites, even though the sites were located in different part of the city (Figure 3.1). Although the local sources at each site were different, the fact that similar trends were observed, suggested that atmospheric mixing dominated over local particle sources and that human exposure though out the city was similar.

As shown in Figure 3.2 and Figure 3.3 compared the levels of particulate matters collected from outdoor and indoor sites which were not different, however in some days indoor fine particles were much higher than those from outdoor. It was because the airborne particulate matters came from different sources and the air inside a building could not be diffused into other places, thereby the fine particle collected from indoor site might be higher. Thus, outdoor fine particles may affect the level of indoor fine particles. This is consistent the study of Gil *et al.* (1995) that the level of carbon monoxide (CO) changed simultaneously outdoors and indoors especially during traffic rush hours, demonstrating the importance of outdoor infiltration into the indoor air quality and masking the contribution of other CO indoor sources. The maximum CO concentrations were over 800 % and over 1000 % higher indoors and outdoors respectively than 9 ppm CO National Ambient Air Quality. In addition, the important indoor air quality in Hong Kong was PM 10 and it showed in Bangkok that indoor PM 10 level was affluented by that from outdoor (Tsai *et al.*,2000)

Additionally, airborne particulate matter, PM 2.5 and PM10, levels during day-time and night-time from various sites in Chiang Mai city as shown in Table 3.2 that particulate matter concentrations collected during night-time were much higher than those collected during day-time. The level of particulate matters trended to increase during November 2000 to February 2001 which was during the winter months, and seemed to decrease in the summer month (March 2001). It was found in the previous study that the morning 'rush hour' peak of particulate matter was mainly due to vehicle emission, while the late evening peak was mainly attributed to meteorological conditions, particularly atmospheric stability and wind speed (Awang *et al.*, 2000). At night, when the temperature was cooled down with the stagnant of airflow condition, the particulate matters collected in the night-time were much more impact than those collected from day-time.

In general, seasonal variations were present in the ambient concentrations with high levels often occuring in winter months (Qian *et al.*, 2001). One research carried out in Taiwan showed that nonsummer temperature, winter humidity, and traffic- related air pollution were positively associated with the prevalence of asthma (Guo *et al.*, 1999). Chiang Mai is in a valley and given the generally lower ventilation in the winter than the summer months, fine particulate emissions that are produced by open burning and other local sources accumulate in a smaller mixing volume over the city. For example, during the winter months the average wind speed in Chiang Mai (Chiang Mai airport authority's data, 1998) was 3.3 km/h while in the summer month was 5.2 km/h. This, when combined with the lower mixing height during winter, strongly suggests that much more dilution of emission sources occurs in the summer than winter. Due to the temperature condition and higher mixing height in the day-time, particulate matters collected in the night-time were much higher than the day-time.

The only major change in emissions between the winter and summer is the number of forest fire. During the winter months and particularly in February and March, farmers in Chiang Mai burn their field and grass (Chiang Mai Fire Forest Control Unit's record, 1998-1999). View from commercial air flight arriving and leaving Chiang Mai during this season provide direct visual evidence of huge smoke plumes and haze that hangs over the fields and forests. In addition, it is expected that mobile source emission contribute considerable to the fine particle loading of the Chiang Mai atmosphere during winter months. Given that the number of cars and trucks and distant traveled remain relatively constant throughout the year, these emission will also accumulate in the atmosphere under more stagnant and lower mixing volume conditions.

4.2 Mutagenicity and DNA damaging trends

Particulate matters collected from the different air pollution sources contain condensed organic matters that are extractable by organic solvents. A number studies has shown that the organic extractable matter from air particles was carcinogenic in animal (Hueper *et al.*, 1962) and mutagenic in short-term bioassay (Alfheim *et al.*, 1983). Dichloromethane extracts of airborne particulate matters either PM 2.5 or PM 10, collected in Chiang Mai city were mutagenic to

Salmonella typhimurium strain TA100 with and without metabolic (S9 mix) activation. The results showed that mutagenicity in the airborne particulate matters, PM 2.5 or PM 10, could be detected at site 4 in winter time (October 1999). Direct- acting mutagenicity was detected and the mutagenic activity was higher in the presence of metabolic activation (S9 mix) especially from PM 10.

Site 4 is located in Chiang Mai downtown and conducts much traffic between 6 am to 9 pm, vehicle combustion may be responsible for mutagenicity of particulate matters at this site. Lewis *et al.* (1983) reported that vehicles emissions from automobile, bus, trucks, and other mobiles and home heating sources have been shown to account for most of the mutagenic activity associated with air particulate matters in urban areas as well as diesel particle which have high amount of nitro-PAH and are very mutagenic (IARC, 1989). The differences in mutagenicity between sample collected in the same period at different location were detected in Table 3.3 and 3.5 which could be attributed to different sources. The contribution of the atmospheric transformation processes rather than direct emission from vehicle combustion may be responsible for ambient air mutagenicity of Chiang Mai city.

Day-time and night-time airborne particulate matter extract during November 2000 to March 2001 were mutagenic to *S. typhimurium* strain TA100 in the presence of S9 mix especially from night-time samples.

Since Chiang Mai is in a valley and the air flow conditions are more stagnant in the night-time than in the day-time especially in the winter, there is probably more photochemical smog that will react with some PAH *via* OH attack and NO_2 addition to form nitro-PAH which condensed on particles. Ambient air of Chiang Mai may contain PAHs or nitro-PAH, however the concentration of these mutagens differ substantially among the locations depending on different emission sources. The contribution of wood smoke to ambient aerosal mutagenicity was reported. The sources of particulate matter in Chiang Mai in winter time are suspected to come from burning field or grass rather than pyrolytic mobile source (i.e., vehicle emissions).

As the genotoxic effects of airborne particulate, PM 2.5 and PM 10, extract were evaluated by Ames test, the single cell gel assay (Comet assay) was also used to evaluated in terms of DNA damage. Since air pollution in cities has been linked to increased rates of mortality and morbidity in developed and developing countries. The possible genotoxicity of small particulate matter has been under investigation for the last 10 years. Diesel exhaust particles (DEP) are considered as " probably cacinogenic" and a number of studies show genotoxic effects of urban particulate matter (UPM). Carbon black is carcinogenic in rat. Don Porto *et al.* (2001) performed that carbon black, DEP, and UPM were able to cause DNA damage and, therefore, may contribute to the causation of lung cancer. These air pollution may increase DNA damage in human population due to susceptible groups (Sram *et al.*,1999). The organic extracts of inhalable airborne particulate matter, PM 10, form the rubber factories showed mutagenicity with the Ames test and DNA-damaging activity in human leukocytes by Comet assay (Monarca *et al.*,2001). Data on human leukocytes from one research confirmed the sensitivity of the Comet assay and its applicability to assesses genotoxicity in environmental samples, the PM 2.5 fraction, after mutagenicity test (Buschini *et at.*,2001).

The present study showed the DNA-damaging activity in the organic extracts of both PM 2.5 and PM 10 collected during the winter month (September to October 1999) especially in the present of metabolic activation. Additionally, the tail length of human leukocytes treated with the extractable organic matter of PM 2.5 and PM 10 collected during night-time and day-time were determined. The results performed DNA damage as the tail length in extractable samples both day-time and night-time during November 2000 to March 2001 which were consistent with the previous study that the solvent extractable organic compound samples of PM 2.5 derived from winter months induced DNA damage at dosages resulting in no obvious cell killing in the MTT assay. For the PM 2.5, in the winter samples, were significantly more toxic than the summer samples in terms of cell killing. Thus, long-term exposure to non-killing dosage of air pollution may lead to accumulation of DNA lesions, which may be one of the mechanisms responsible for the chronic adverse health effects of particulate air pollution (Hsiao *et al.*,2000).

4.3 Conclusion

Meteorological condition of Chiang Mai may play a significant role and burning may be the prevailing pollution source. Motor vehicle traffic may be a part of pollution source. The samples taken form different site in Chiang Mai city showed similar trend of PM 2.5 and PM 10 levels and genotoxic activity. The increase in PM 2.5 and PM 10 levels may be due to the influence of grass or field burning along with the meteorological condition and traffic. Since high prevalence of asthma in children living in Chiang Mai has been reported (Trakultivakorn *et al.*,1999). Therefore, grass or field burning should be abolished for the health of inhabitants, especially elderly and children with asthma. For the further study, it is worth to identify compounds in the air filters to show which chemicals are responsible to the mutagenicity and DNA-damaging activity in the Chiang Mai city ambient air.