2. EXPERIMENTAL

2.1 Lead levels in roadside dusts

2.1.1 Methods

2.1.1.1 Sampling

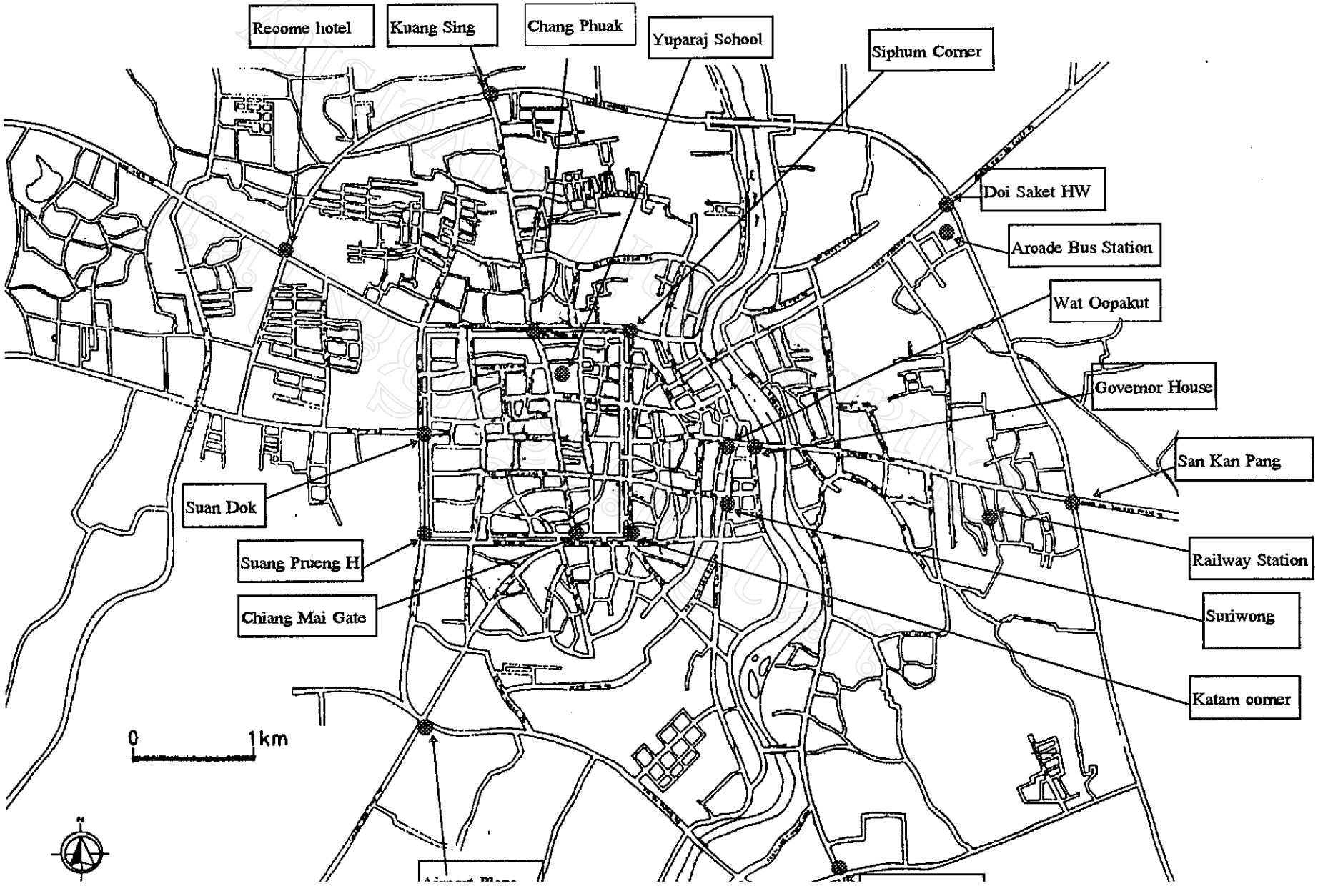
Sampling sites

Eighteen major crossroads of Chiang Mai City including super high way ring-road and downtown road conjunctions were selected for present study and they were as followed and shown in the map (Figure 2.1.1). Including Rincome Hotel, Kuang Sing highway, Doi Saket highway, San Kam Peang highway (Poyluang Hotel), Lamphum highway, Airport Plaza (Chiang Mai-Hangdong crossroads) along the super highways; Railway station, Acrade Bus Station, Katam corner, Siphum Corner, Wat Ooppakut, Nawarat Bridge (Westbank, near Chiang Mai Governor House), Yuparaj School, Suriwong Hotel, Suan Dok Gate, Changphuck Gate, Suang Prueng Hospital, and Chiang Mai Gate in the down town area. Control sample were collected from the headquarters office of Doi Suthep National Park. Special samples were also collected from the car park of Kard Suan Keaw, Tapae Gate Square and roadside of Tapae Road near the Tapae gate, and car parking bay down the temple of Doi Suthep, also samples along the Chiang Mai -San Kam Peang road about 1 km, 2 km, 3 km from the highway (Poyluang Hotel). A self- made quality control (SMQC) sample was collected from five different sites.

Sampling times

Roadside dust samples were collected twice, once in dry season (March 5, 1995) and again in rainy season (August 16 to 18, 1995).

Figure 2.1-1 Map of study sites of the lead level in roadside dust



2.1.1.2 Collecting method

Roadside dust were collected from each of four corners of every study sites in polyethylene bag and labeled the site name and date. The surrounding conditions of sample collection such as construction situations were also recorded.

2.1.1.3 Pretreatment of samples

The collected samples were dried in the air at room temperature. Aliquots of sample from each corner were mixed and become represent sample of that site. Mixed sample was sieved with a 2 mm diameter sieve. The fine particle was then ground using electric motor machine, and sieved again with a 400 μm diameter sieve. The samples were then kept in a small cleaned glass bottle covered with neacofilm and kept in the desiccator containing with hydroscopic agent. Samples were dried at 105°c in the oven over night before further treatment.

2.1.1.4 Apparatus & Materials

Apparatus

(1) Atomic Absorption Spectrometer, Perkin Elemer 3100. Perkin Elemer Corporation, USA.

(2) Blender Mill 2, Moulinex, France; (Department of Geology, Chiang Mai University).

(3) Sonicator bath

(4) Oven

(5) Pipettes

Chemicals

(1) Nitric acid (HNO_3),GR., 65%. from E. Merck, D-61100 Darmstadt, F. R. Germany.

(2) Hydrochloric acid (HCl), AR, 37% from Carlo Erba, Italy.

(3) Lead standard solution, PE Pure Atomic Spectroscopy Standard, concentration of 1,000 μg/ml with 2% HNO_3 matrix from Perkin-Elmer Corporation, USA.

Reference Materials:

(1) Standard Reference Material(SRM): GBW 07401 and GBW 07405 were obtained from the Community Bureau of Reference Mterials, Garmany.

(2) Self- made quality control (SMQC) sample of roadside dust was made from pooled roadside dust collected from Chiang Mai City.

Other Materials

(1) A sieve with 2 mm diameter and 400 μm diameter mesh.

(2) Whatman 1 filter paper, 11.0 cm, made in England by W& R Balston Limited.

(3) Polyethylene bags sized 9x14 cm, small glass bottles, Aluminum foil , watch glass, glass bar .

Deionized water was used throughout the whole research

2.1.1.5 Cleaning of the glassware

The glassware was carefully washed with 15% HCl,tap water, distilled water, and dry in the oven. Just before use, all glassware were soaked for 2 hours in 1% nitric acid and rinsed with 1% nitric scid.

2.1.1.6 Digestion of dust sample

Digestion procedure of dust was conducted according to the ASTM standard method D 3974-81 (reproved 1990) [34] with slightly modified. Aliquots of SMQC dust were used to set up the optimal condition such as digestion time, and sonication time after digestion.

Accurately weighed 1 gram of the prepared dust sample, put it into a 250 ml flask and added 10 ml concentrated HNO_3 and 20 ml concentrated HCl, covered by glasses plate. Put on the electric heater (in the fume cupboard), at 140-150 °c, about one and half hour (the final volume would be less than 5-10 ml). Left the digested sample cool down in the fume cupboard, rinsed the glass cover and wall of the flask with 1% nitric acid. Sonicated the digested samples in the sonicator bath for 20 minutes. Finally, the digested samples were rinsed into 50 ml volumetric flask through filter paper (Whatman 1) up to the line of the flask..

2.1.1.7 Analysis using AAS

All the laboratory analysis were done in Laboratory 3 , Biochemistry Division, Research Institute for Health Sciences, Chiang Mai University.

Atomic Absorption Spectrometer was Perkin Elemer 3100 from Perkin Elemer Corporation, USA. Measurement conditions were as followed : flow spoiler, lead lamp, wave length 217.00 nm, slit 0.7. Linear calibration curve method was employed. The result of absorbancy and concentration of sample, correlation coefficient of standard, and concentration of samples was automatically read out by the connected computer.

The total analytical procedure of lead as shown in the following chart:

Accurately weigh 1 g dust in a 250 ml flask

↓

+20 ml conc. HNO_3

+10 ml conc. HCl

↓ covered with watch glass

Electric heater at 140-150 °c

about 1 and half hours

↓

Leave the flask cool down,

rinse watch glass and the wall of flask with 1% HNO_3

↓

Sonicate for 20 minutes

↓

rinse the digested samples into 50 ml volumetric flask

using 1% HNO_3 through filter paper

↓

analyze using AAS

2.1.1.8 Quality Assurance and Quality Control

Since lead is one of trace elements and proned to contamination, quality assurance and quality control has been considered to be crucial in order to achieve reliable and comparable results. Beside keeping the laboratory surroundings as clean as possible in order to prevent potential sources of lead contamination, the following procedure was also conducted according the quality assurance and quality control of trace metal analysis.

1. Using SMQC sample

Following the set up procedure, SMQC sample was repeatedly measured in 5 batches and then the mean ± SD, median, minimum and maximum of lead level in μg/g dust, and coefficient variant (CV) were obtained and use as known control. An aliqout of SMQC was treated as a sample in every batch of sample analysis in order to obtain intrabatch variation.

2. Using standard reference materials

Soil certificate reference material named GBW 07401 and GBW 07405 were also analyzed both before and within the batch of sample analysis. The SRMs were also been put in 105 °c oven over night before treatment.

3. Consideration of Interference

In lead analysis, one of the most common interference is ions of Iron . Too high concentration of Fe (10,000 mg/L) in the sample would enhaces the lead signal [35]. The Fe levels were measured in the samples. However, Fe levels in all samples were far less than the interference warning level.

4. Reagent blank

At least two reagent blanks were analyzed for each batch of sample analysis.

2.1.2 RESULTS

2.1.2.1 Quality Control

1.1 Twenty five aliquots of SMQC dust were conducted in 5 five batches over 10 day period (each batch/day). Mean ± SD, median, minimum and maximum of lead level in μg/g dust, and coefficient variant (CV) were computed and shown in Table 2.1.1

Table 2.1.1 Lead level of SMQC sample

No.	Mean ± SD μg/g	Median (Min.-Max.) μg/g	%CV
25	101.3 ± 4.7	100.6 (94-109)	4.6

1.2 .Soil certificate reference material GBW 07401 and GBW 07405 also were analyzed both before and with the measurement of samples following the same analysis procedure as sample analysis. The mean ± SD, median, minimum and maximum of lead level in μg/g dust, recovery (the recovery were calculated based on the mean / the reference value * 100%) and coefficient variant (CV) (based on SD/mean * 100%) were shown in Table 2.1.2.

Table 2.1.2 Results of SRMs measurement

Soil SRM	No	Reference value	Mean ± SD	Median (Min.-Max.)	Recovery(%)	C V (%)
GBW 07401	14	98 μg/g	91.4 ± 3.2	91.6 (89-95)	93.21	3.5
GBW 07405	14	552 μg/g	567.5 ± 13.4	564.5(543-587)	102.8	2.35

1.3 During the measurement of lead level in dust, total 22 batches of quality control materials and practical samples were analyzed. The mean ± SD, minimum and maximum, and correlation coefficient of calibration curves were shown in Table 2.1.3

Table 2.1.3 Correlation coefficient (γ) of calibration curve

Batches	Mean ± SD	Min.-Max.
22	0.99966 ± 0.00022	0.99920-0.99997

2.1.2.2 Results of the study samples

1. Roadside dust samples, which collected in March and August 1995, were analyzed according to the procedure set up in the present study and the result was shown in table 2.1.4

Table 2.1.4 Lead levels in roadsides dust from 18 major crossroads

No	Name of Sample Sites		Lead in dust (μg/g)	
	English	Thai	March	August
1	Railway station	สถานีรถไฟ	107.4	74.4
2	Katam Corner	แจ่งขาต้ำ	238.7	61.8
3	Siphum Corner	แจ่งศรีภูมิ	222.5	66.2
4	Wat Ooppakut	วัดอุปคุต	258.1	58.5
5	Nawarat Bridge, Westbank (near the Governor House)	เชิงสพานนวรัฐฝั่งตะวันตก(ใกล้จวนผู้ว่าราชการจังหวัด)	191.6	52.8
6	Yuparaj School	ร.ร. ยุพราช	246.3	113.1
7	Suriwong Hotel	โรงแรมสุริวงศ์	282.8	68.9
8	Suan Dok Gate	ประตูสวนดอก	110.5	112
9	Chiang Mai Gate	ประตูเชียงใหม่	123.8	ND
10	Changphuck Gate	ประตูช้างเผือก	171.4	98.3
11	SuangPrueng Hospital	รพ. สวนปรุง	95.6	83.5
12	Airport Plaza Chiang Mai-Hongdong crossroads.	แอร์พอร์ตพลาซ่า สี่แยกหางดง	147.6	98.3
13	Lamphum HW	สี่แยก ถ. เชียงใหม่-ลำพูน	172.0	178.4
14	Rincome Hotel	โรงแรมรินคำ	210.9	83.9
15	San Kan Pang HW Poyluang Hotel	สี่แยกปอยหลวง สันกำแพง	172.0	83.3
16	Doi Saket-HW	สี่แยกดอยสะเก็ด	63.7	116.6
17	Kuang Sing HW	สี่แยกช่วงสิงห์	193.7	125.5
18	Arcade Bus Station	สถานีขนส่งอาเขต	ND	104.3
Mean ± SE* (n = 18) (min.-max.)			176.96 ± 14.31 (63.7-282.8)	92.96 ± 7.32 (52.8- 178.4)

SE = SD / $n^{1/2}$ ND = Not determine

2. In order to compare the lead level in the roadside dust collected in the city of Chiang Mai , few samples of roadside dust and surface soil samples were taken from Doi Suthep mountain such as at the Headquarters of the National Park Office,

car parking bay down the Doi Suthep Temple. Dust samples were analyzed using the same procedure as done with the roadside dust samples taken from the city and the result was shown in Table 2.1.5

Table 2.1.5 Lead levels in dust from Doi-Suthep National Park

No.	Name of sites	Lead μg / g dust, December 1996
1	Roadside dust at Doi Suthep National Park Headquarters	26.95
2	Surface soil at Doi Suthep National Park Headquarters	10.6
3	Dust sample from Car Park down the Doi Suthep Temple	226.9

3. Lead levels in roadside dusts collected along Chiang Mai -San Kam Peang road in August also been analyzed and the results were shown in Table 2.1-6.

Table 2.1.6 Lead levels along Chiang Mai- San Kam Peang road

No.	Sites	Lead /dust μg/g August
1	San kan Peang Crossroads (Poyluang Hotel)	83.25
2	From Crossroads 1 km	96.7
3	From Crossroads 2 km	121.0
4	From Crossroads 3 km	88.3

4. Addendum of lead analysis

Lead level of dusts collected from Tapae Gate Sqaure area, Tian An Men Square in Beijing, and roadside dust from nearby road of Tapae Gate were reported in Table 2.1.7.

Table 2.1.7 Lead levels from addendum analysis

No.	Sites	Lead /dust μg/g March 1996	Lead /dust μg/g August
1	Road side nearby Tapae Gate	ND	79.8
2	Square of Tapae Gate	ND	168.8
3	TAMS*	193.5	ND
5	1-floor Car park at Central Market	63.3	ND
6	Car parks above 2 floor at Central Market	173.6	ND

* TAMS: Tian An Men Square, Beijing, P. R. China. ND = Not determine

2.1.3 Discussions and Conclusions

2.1.3.1 The set up procedure of lead determination in dust samples of the present study showed reliable and promising results as the mean and the median of an internal quality control called SMQC and of two different levels of SMRs were so closed with the coefficient variation (CV) of 4.6% , 3.5% and 2.35%, respectively. Further more, the recovery of two SRMs, computed from the reported value, were 93.21% and 102.8%, respectively.

2.1.3.2 The lead level of roadside dust samples from Chiang Mai City collected in March and August 1995 were uneven among the major crossroads. For the samples collected in March had lead level varied from 63.65 to 282.75 μg/g, with the mean ± SE of 176.96 ± 14.31, while lead levels in dust samples collected in .

Figure2.1-2 lead levels of roadside dust among major crossroads in Chiang Mai City

comparsion between Dry & Raining Season in 1995

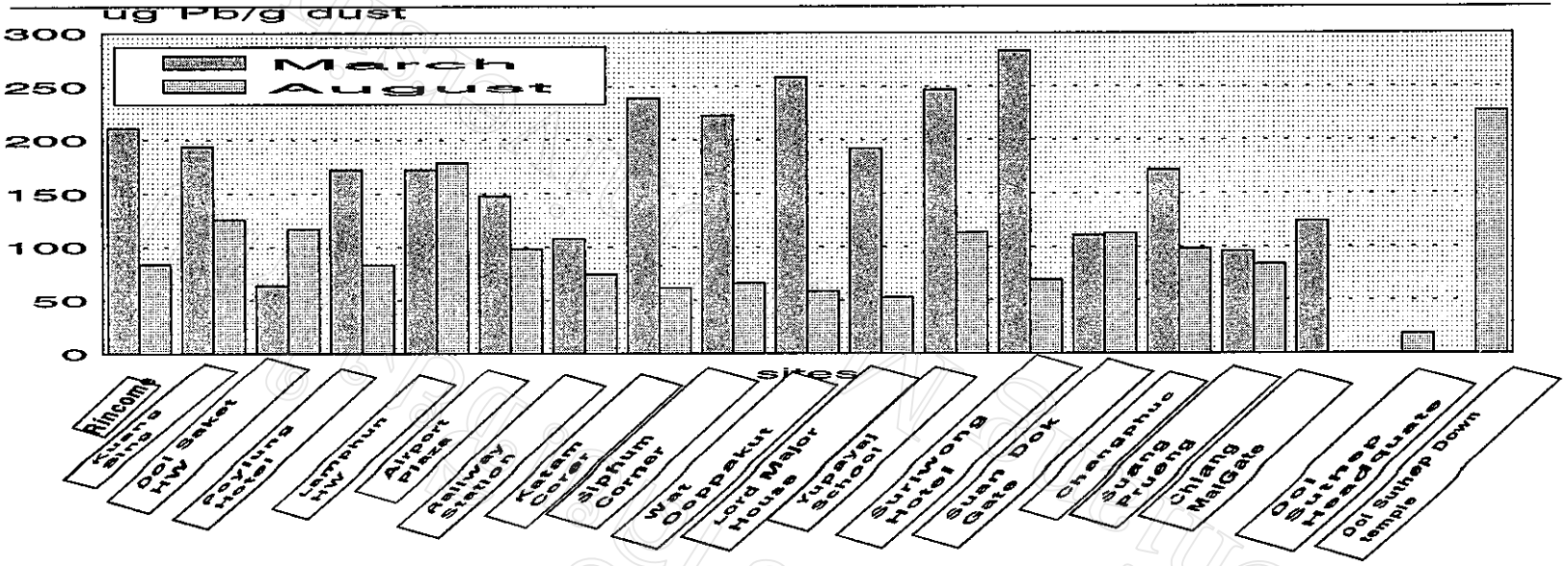
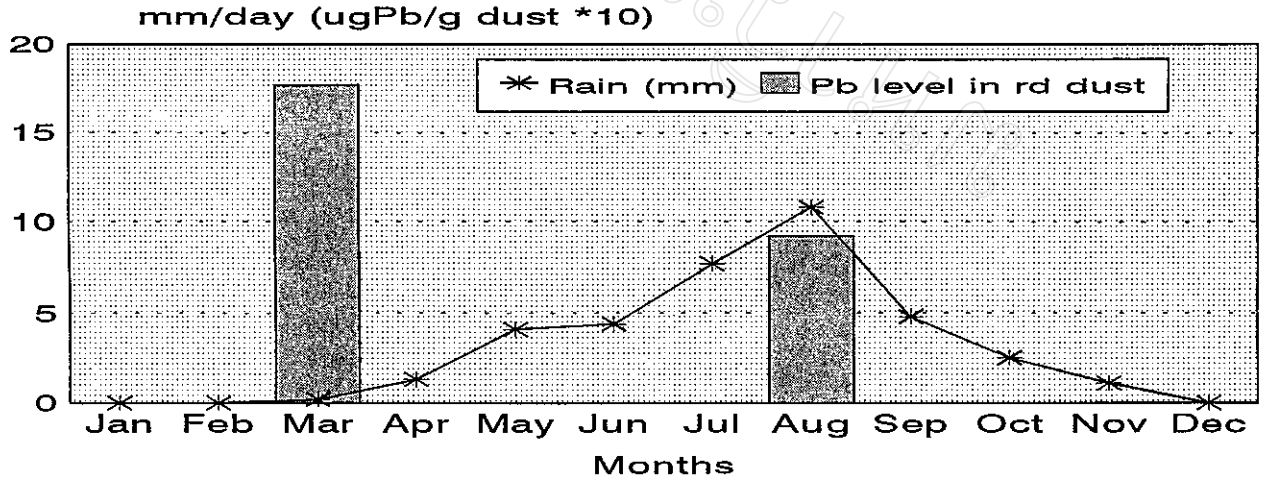


Figure 2.1-3 The Lead level in roadside dust and rainfall amount

1995



August 1995 were from 58.5 to 178.4 μg/g with the mean ± SE of 92.96 ± 7.32 (Figure 2.1.2). The mean of lead level in March was significant higher (p=0.01) than the mean of lead level in August (Figure 2.1.3). In Chiang Mai City, the weather in March was usually rather dry with the least rainfall while in August had more rainfall. The reason for lead level in dry season is higher than rainy season might be that during the rainy season waterflow frequently rinse surface roadside dust away from the road where lead deposited. During the dry season lead can deposit and be kept there for a longer period of time.

2.1.3.3 Lead level in dust sample collected on the Tapae Gate was higher than the sample collected from the nearby roadside (Table 2.1.7). The possibility of higher lead level might be due to the longer period of lead deposition and it would take longer time to leach it away.

2.1.3.4 Lead levels in roadside dust samples which collected from Chiang Mai - San Kan Peang Road at 1,2, and 3 Km from the Chaing Mai Super Highway Ringroad did not show the trend of reducing lead pollution along the road out to the nearby district (Table 2.1.6). This phenomenon possibly showed that the traffic density was not decreased along the road outward from Chiang Mai City.

2.1.3.5 Comparing the lead level in in roadside dust samples collected from Chiang Mai City and the surface soil as well as the roadside dust from the Headquarters National Park Office, which sited on Doi- Suthep Mountain area; the city dust sample contained lead was about 5 times higher than those dust samples collected from mountain area. Interestingly, the lead level in the dust sample from car parking place down the Doi- Suthep Temple was about 12 times higher than in the dust samples from the National Park Office which about 500 meters away (Table 2.1.5). This result together probably indicated that the lead level in roadside dust related with the traffic situation.

2.2 Lead and suspended particulate matters (SPMs) in the air of Chiang Mai City

2.2A Monitoring of air-borne lead and SPMs using mask filters worn by traffic policemen

Almost every crossroads in the urban area of Chiang Mai has traffic congestion problem and most traffic policemen use filter masks (Figure 2.2A.1) while on duty particularly during the rush hours. The present study employed mask filters worn by traffic policemen for the means of measurement of lead and dust levels in ambient air.

In air sampling, it is most important to ensure that the sampler is placed at the breathing zone of the population group under study [36]. Beside at the human breathing level, individual mask filter monitoring also reflect the human physiological properties. So , evaluation of lead and dust level deposited on the mask filter may reflect the air quality concerning human hazard.

2.2A.1 Methods

2.2A.1.1 Materials and Apparatus

Easi-Air™ & 7156 mask filters were from 3M . Other apparatus (except AAS using impact bead), Chemicals and procedure for cleaning of glassware were similar with analysis of Lead in roadsides dust (see 2.1.1)

2.2A.1.2 Distribution and collection of the mask filters.

The study period of mask filter distribution and collection was from April 26 April until 20 December 1995. Twelve batches of mask filters were totally

Figure2.2A.1a Mask filters (from left: white color-new filter, dark color-used filters)

Figure 2.2A.1b Filter mask worn by traffic poliiceman

distributed to traffic policemen in Chiang Mai City. Traffic policemen individually volunteered to use the mask filter distributed from the present study. New mask filters were weighed and marked at the margin of the filter in order to identify their batches. The prepared mask filters were kept individually in new plastic bags until distributed which usually taken places at the traffic police office. Approximately 2 weeks after distribution, the filter was collected. In the mean time, new batch of mask filters was distributed. Policeman's name and his study code were recorded and its post weight was measured. Total 412 mask filters were distributed and 179 (43.4%) with completely information such as matched batch mark, pre- and post -weigh were logical. Questionnaires of their demographic data, working history, health status, and mask filter use were collected individually with their informed consent under the principal study protocol. All completed mask filters were from 57 traffic policemen and covered 47 crossroads in Chiang Mai City.

2.2A.1.3 Analytical Method.

2.2A.1.3.1 Estimation of dust in the air using mask filter.

SPMs calculation based on the period (i.e. how many days and how many hours/day of using) of mask filter using and pure weight increased.

Pure weight of SPMs = Post-weight - Pre-weight

Dust/day = Pure weight of SPMs/ Day

Dust/hour = Dust/hour

Dust/ m^3 = Dust/hour/adult respiratory rate/hour.

Adult respiratory rate is supposed to be 20 m^3 /24 hours [37].

2.2A.1.3.2 Analysis of Lead deposited on the mask filter

1. Sample pretreatment for AAS analysis.

Lead deposited on the mask filter was digested in 120 ml of 1% nitric acid at 140-150 °c, approximately 3-4 hours, until the final volume was less than 20 ml. The flask became cool down and then put it in the sonicator bath for 20 minutes. Then filter the final volume through whatman filer paper (No 1) into a 50 ml volumetric flask. The filter was rinsed with 1% nitric acid fill up to 50 ml mark of the volumetric flask. The filtrate was analyzed using AAS. Two sample blanks (new filters) were analyzed in a batch using the same procedure above. The actual lead amount of studying sample is its reading subtract the average value of sample blank.

2. Recovery of analysis lead level in the mask filter

Recovery of analysis lead level in mask filter was done using spiked sample. No-spiked sample using new mask filter while Spiked sample was new mask filter with added 100 μg lead, analysis was the same as the procedure mentioned above.

$$\text{Recovery (\%)} = \frac{\text{Pb amount in Spiked sample - Pb amoount in No-spiked sample}}{100\ \mu g} \times 100\%$$

3. Estimation of lead level in the air

1. Days of mask filter using
2. Average 3.7 hours/day of mask filter using.
3. Average adult respiratory rate 20 m^3 / day (0.833 m^3/hour)
4. Calculation of lead level.

$$\text{Pb } \mu g / day = \frac{\text{Lead amount, } \mu g}{\text{days}}$$

$$\text{Pb } \mu g / hour = \frac{\mu g \text{ Pb/day}}{3.7 \text{ hours}}$$

$$\text{Pb } \mu g / m^3 = \frac{\mu g \text{ Pb/ hour}}{0.833 \text{ } m^3/hour}$$

2.2A.2 Results

2.2A.2.1 Quality control of lead analysis in monitoring using mask filter

1 Lead level in twelve new mask filters were measured. The mean ± SD and minimum-maximum levels were reported in Table 2.2A.1. The mean of lead level in 12 new mask filters used as background level of lead in mask filter.

Table 2.2A.1 Background Lead level of new filters

Number of new filters	Mean ± SD (min.-max.), μg
12	2.65 ± 2.10 (0.12-4.56)

2. Recovery of lead analysis of monitoring using mask filter was determined by spiked sample. The recovery was performed both during the method set up and the period of practical sample measurement . Average lead level of 8 new mask filters was taken as the non-spiked value, and the average measured value of 8 new filter added 100 μg of lead was as spiked results. The recovery were shown in Table 2.2 A.2.

Table 2.2A.2 Recovery of analysis lead deposited on mask filter using spiked sample

Mean ± SD μg (N)	Mean ± SD μg (N)	Recovery (%)
2.47 ± 1.98 (8)	100.91 ± 4.7 (8)	98.44

3. During the measurement of lead deposited on mask filters, total fifteen calibration curves were performed for the recovery and samples measurement. The correlation coefficient of these calibration curves were shown in the Table 2.2A.3.

Table 2.2A.3 Correlation coefficient (r) of calibration curve, of lead analysis in mask filter.

No. of calibration curves	Correlation coefficient (r)
15	0.9995 ± 0.0003

2.2A.2.2 Lead and SPMs levels monitoring using mask filters

Total 98 mask filters selected from 179 mask filters with full required information were analyzed and calculated to evaluate the air quality concerning human hazards. The result of lead in μg/day, μg /hour, and μg /m^3 ; and SPMs in mg/day, mg/hour, and mg / m^3 were concluded and shown different batches of collecting in Table 2.2A.4.

In order to compare the lead and SPMs level in the air during the earlier period from 24 May to 5 July 1995 and the latter period from September to December . Lead and SPMs level in 67 mask filters collected during the period of 24 May 1995 to 5 July 1995 were concluded in Table 2.2A.9, and the Lead and SPMs level in 29 mask filters collected during the period of time from 27 September to 6 December 1995 were concluded in Table 2.2A.10.

Table 2.2A.5 Lead and SPMs levels in 67 mask samples uesd in the period of 24 May 1995 to 5 July 1995

Parameters	Mean ± SD	Median (Min. - Max.)
Lead amount μg /day	0.58 ±0.51	0.49 (0.01 - 2.96)
SPMs amount mg/day	2.42 ± 2.08	1.74 (0.10-11)
Lead amount μg/hour	0.16 ± 0.14	0.13 (0.003 - 0.80)
SPMs amount mg/hour	0.65 ± 0.56	0.47(0.03 - 2.97)
Lead level (μg /m^3)	0.19 ± 0.17	0.16 (0.004 - 0.96)
SPMs level (mg/m^3)	0.78 ± 0.67	0.56 (0.04 - 3.56)

Table 2.2A.4 Mean±SD, median (min.-max) of lead and SPMs levels monitoring using mask filter in different batches.

Parameters	May-June	June-July	September-October	October	November-Dec.ember
N	67	32	7	5	4
Lead µg/hour	0.17 ± 0.12 0.14(0.01 - 0.56)	0.14 ± 0.15 0.11 (0.02 -0.75)	0.09 ± 0.05 0.08 (0.05 -0.2)	0.10 ± 0.04 0.09 (0.06 - 0.16)	0.15 ± 0.06 0.15 (0.08 -0.21)
Lead µg /m^3	0.20 ± 0.14 0.17(0.01 -0.67)	0.17 ± 0.18 0.13 (0.002-0.9)	0.11 ± 0.06 0.10 (0.06 -0.24)	0.12 ± 0.05 0.11 (0.07 -0.19)	0.18 ± 0.02 0.18 (0.10 - 0.25)
SPMs mg/hour	0.66 ± 0.54 0.65(0.11-2.70)	0.63 ± 0.6 0.27((0.03 - 2.97)	0.36 ± 0.19 0.39 (0.19 -0.77)	0.59 ± 0.46 0.41 (0.14 -1.22)	0.77 ± 0.27 0.77 (0.39 - 1.16)
SPMs mg/m^3	0.79 ± 0.65 0.78 (0.13-3.24)	0.76 ± 0.72 0.32 (0.04 - 3.58)	0.43 ± 0.23 0.47 (0.23-0.92)	0.71 ± 0.55 0.49 (0.17 -1.46)	0.92 ± 0.32 0.92 (0.47 - 1.39)

Table 2.2A.6 Lead and SPMs levels (n=29)) monitoring using mask filter during the period from 27 September 1995 to 6 December 1995

Parameters	Mean ± SD	Median (Min. - Max.)
Lead amount μg /day	0.31 ± 0.19	0.28 (0.1 - 0.76)
SPMs amount mg/day	1.96 ± 1.54	1.43 (0.28-6.9)
Lead amount μg/hour	0.08 ± 0.05	0.08 (0.03 - 0.27)
SPMs amount mg/hour	0.53 ± 0.42	0.39 (0.08 - 1.86)
Lead level (μg /m^3)	0.10 ± 0.06	0.10 (0.4 - 0.32)
SPMs level (mg/m^3)	0.64 ± 0.50	0.47 (0.1 - 2.23)

2.2A.3 Discussions

See in the part of 2.2B.3 of discussions for air-borne lead and air-borne SPMs.

2.2A.4 Conclusions

See the part of 2.2B.4 of conclusions for air-borne lead and air-borne SPMs.

2.2B Monitoring of air-borne lead and SPMs using High Volume Air Sampler

While monitoring of lead and dust level deposited on the mask filters, which was proposed in the present study, would reflect the air quality concerning human hazard, the High Volume Air Sampler is the recommended instrument for sampling large volumes of air for the collection of suspended particulate matter and heavy metals. The physical design of the sampler is based on aerodynamic principles which result in the collection of particles of 100 microns and less. Since High Volume Air Sampler method has been used as the standard method and all standard levels reportedly used are from this method. In order to describe the practical lead and dust levels in the air of Chiang Mai City in comparable way, and also try to find the possible relationship between mask filter and this conventional method, monitoring of lead and dust level using High Volume Air Sampler was also conducted in the present study.

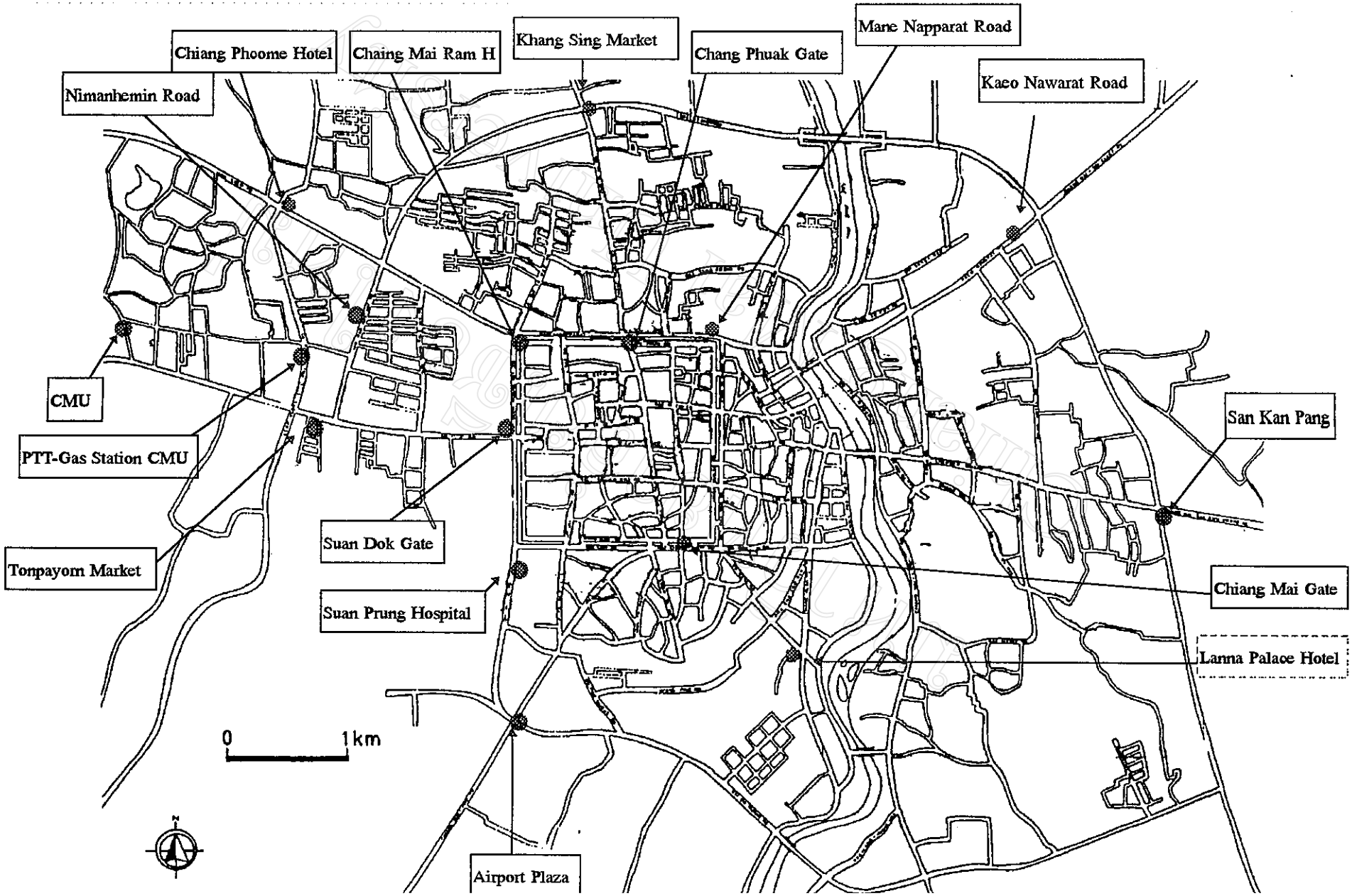
2.2B.1 Materials and Method

2.2B.1.1 Apparatus and Chemicals

GMW High Volume Air Sampler (MODEL GMWL-2000 and TRIPOD GMWT 2200). The sampler consists of a blower/motor unit and a supporting screen for the filter ahead of the blower/motor unit. During the sampling operation, the sampler is supported in a protective shelter so that the 8'' x 12'' surface of the filter is in a horizontal position. In its basic configuration flow meter is connected to a pressure tap at the exhaust end of the motor (Figure 2.2B.2).

Figure 2.2B.2 One of the sampling sites of monitoring using High Volume Air Sampler.

Figure 2.2B-1 Map of sites for air quality study



Other apparatus and materials (except AAS using impact bead), and procedure for cleaning of glassware were similar with analysis of Lead in roadsides dust (see 2.2.1).

2.2B.1.2 Method

2.2B.1.2.1 Study sites and sampling period

Sampling period from September 1995 to December 1995 and total 17 sites were selected as study sites shown in the in the following map (Figure 2.2B.1). There were fifteen out of total 17 sites, namely Suan Dok, Chiang Mai Ram Hospital, Kuang Sing Market, Suan Prueng Hospital, Manee Nopparat Road, Chiang Mai Gate, Kaew Nawarat Road, Airport Plaza, Tonpayorn Market, Lanna Palace Hotel, Chiang Mai Phucome Hotel, Chang Phuak Gate, PTT Gasoline station (Chiang Mai University), and Nimanhemin Road, were major roads in urban area of Chiang Mai City, the other two sites were selected for the control sites. One was between the Department of Environmental Engineering and the housing area of Chaing Mai University, and the other one was at the Headquarters of Doi-Suthep National Park on Doi-Suthep. Each site was collected air sample twice.

2.2B.1.2.2 Collecting Method

Sampling was performed during the day time, 12 hours, from 7 o'clock in the morning to 7 o'clock in the afternoon. Every 2 hours, the flow meter readings was recorded once. The actual flow rates were obtained according the calibration curve which represents the actual flow rate versus the flow meter readings. Then the total air volume per day was calculated according to the actual flow rates' readings.

Counting of traffic volume of each sampling road was carried out manually and continuously for four hours in the morning from 7 a.m to 11 a.m. Traffic volume (car number) means the number of motor vehicles passed the study site in an hour. The motor vehicles included all motor vehicles with over three cycles' engine , such as cars, trucks, motor tri-cycle, but not include motor bicycle. At the same time described the construction condition.

2.2B.1.2.3 Analytical Method

2.2B.1.2.3.1 Measurement of SPMs

New filters were dried at 100 ^{0}c in the oven over night and then pre-weights were recorded. The collected sample filter was dried again in 100 °c oven over night and the post-weight was measured. The filters were then kept in the desiccator with hygroscopic agent until analysis.

Pure weight of SPMs = Post-weight - Pre-weight.

$$\text{SPMs level in the air} = \frac{\text{Pure weight of SPMs (mg)}}{\text{Total air volume } (m^3)}$$

2.2B.1.2.3.2 Analysis of lead deposited on the machine filter.

Half of the filter were cut for lead analysis. The filter was cut along the folder cross line, and taken the two opposite 1/4 parts for analysis (Figure 2.2B-3).

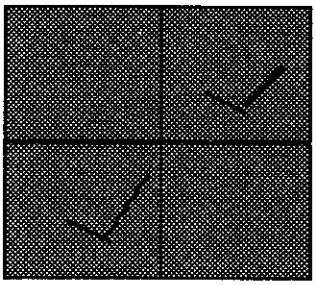


Figure 2.2B.3 The method to chose parts of filter for analysis

The chosen parts of filter were cut into approximately 2 x 2 cm pieces, then put into 125 ml conical flask, add 120 ml 1% nitric acid. The filter treatment was similar to the method for the mask filter treatment, except the digestion at 100 °c, approximately 5-6 hours.

2.2B.1.2.3.3 Calculation of lead level

Calculation of lead level based on the total air volume and measured result of lead amount.

$$\text{Pb } \mu g / m^3 \text{ air} = \frac{\text{Pb amount } (\mu g)}{\text{Air volume } (m^3)}$$

Both during the method setup and measurement of samples, no-spiked sample was a half of new filter (same choosing method), and spiked sample was a half of filter added with 100 μg lead were analyzed.

2.2B.2 Results

2.2B.2.1 Quality control of lead analysis in monitoring using High Volume Air Sampler

1. Background level of lead in new filters

Lead in seven new sampler filter (a half each) was measured, and results were reported in mean ± SD and shown in Table 2.2B.1. The mean of lead level was used as background level of lead in the new filter.

Table 2.2B.1 Background level of lead in new filters

No. of new sampler filter	Lead level (μg) Mean ± SD
7	6.67 ± 0.75

2. % Recovery

Recovery of lead analysis of monitoring using High Volume Air Sampler were measured and calculated using background level of lead as no-spiked value and measured level of new filter added 100 μg lead as spiked value. The average recovery was shown in Table 2.B.2.

Table 2.2B.2 Recovery of lead analysis using spiked sampler filter

Pb in Blank, μg, (7)	Pb in Spiked-blank ,μg, (11)	Average of recovery (%)
6.65 ±0.75	102.18 ± 4.35	95.53

3. During the process of lead analysis of monitoring using High Volume Air Sampler, total 8 calibration curves were set up for quality control and samples analysis. The range and of mean ± SD of correlation coefficient was shown in Table 2.2B.3.

Table 2.2B.3 Correlation coefficient (r) of calibration curves of lead analysis of monitoring using High Volume Air Sampler

No. of Calibration Curves	Range of r	Mean ± SD
8	0.9991 - 0.9998	0.9994 ± 0.0002

2.2B.2.2 Traffic volume

In order to study the traffic volume and the possible relationship of traffic volume and air pollution situation, the result of traffic volume at 15 individual study sites were performed and shown in Table 2.2B.4.

Table 2.2B.4 Traffic volume at air sampling sites

Name of study sites		Number of motor vehicles/ hour		
English	Thai	1st time No./hour	2nd time No./ hour	Average No./hour
Suan Dok	ประตูสวนดอก	2461	3060	2760
Chiang Mai Ram Hospital	รพ. เชียงใหม่ราม	2258	2174	2216
Kuang Sing Market	ตลาดข่วงสิงห์	2258	2174	2216
Suan Prueng Hospital	รพ. สวนปรุง	2064	2072	2068
Manee Napparat Road	ถ. มณีนพรัตน์	1888	1994	1941
Chiang Mai Gate	ประตูเชียงใหม่	1707	1783	1744
Kaeo Nawarat Road	ถ. แก้วนวรัฐ	1686	1711	1698
Airport Plaza	แอร์พอร์ตพลาซ่า	1687	1687	1687
San Kam Paeng	สันกำแพง	1664	1524	1594
Tonpayorn Market	ตลาดต้นพยอม	1413	1530	1471
Lanna Palace Hotel	โรงแรมลานนาพาเลส	1346	1537	1442
Chiang Phucome Hotel	โรงแรมเชียงใหม่ภูคำ	1225	1234	1229
Chang Phuak Gate	ประตูช้างเผือก	1092	1081	1086
PTT-Gasoline Station (CMU)	สถานีน้ำมัน ปตท, มช.	966	953	959
Nimanhemin Road	ถ. นิมมานเหมินทร์	515	542	529
Median (min.-max.) Mean ± SD (N)		1687 (529-2760) 1676 ± 592 (15)		

2.2B.2.3. The level of Suspended particulate matters in the air

Table 2.2B.5 SPMs levels at study sites monitoring using High Volume Air Sampler from September to December 1995

Name of study sites		SPMs levels in air (mg/m^3)		
English	Thai	1st time	2nd time	Average
Suan Dok	ประตูสวนดอก	0.961	0.428	0.701
Chiang Mai Ram Hospital	รพ. เชียงใหม่ราม	0.347	1.300	0.824
Kuang Sing Market	ตลาดข่วงสิงห์	0.473	0.346	0.388
Suan Prueng Hospital	รพ. สวนปรุง	0.490	0.503	0.497
Manee Nopparat Road	ถ. มณีนพรัตน์	1.107	1.030	1.069
Chiang Mai Gate	ประตูเชียงใหม่	1.026	1.267	1.147
Kaeo Nawarat Road	ถ. แก้วนวรัฐ	1.374	0.908	1.141
Airport Plaza	แอร์พอร์ตพลาซ่า	1.002	0.714	0.585
Sam Kam Phang	สันกำแพง	1.049	1.120	1.085
Tonpayorn Market	ตลาดต้นพยอม	1.695	1.726	1.711
Lanna Palace Hotel	โรงแรมลานนาพาเลส	1.334	1.629	1.482
Chiang Phucome Hotel	โรงแรมเชียงใหม่ภูคำ	0.408	0.454	0.431
Chang Phuak Gate	ประตูช้างเผือก	0.291	0.201	0.246
PTT-Gasoline Station (CMU)	สถานีน้ำมัน ปตท.	0.547	0.403	0.475
Nimanhemin Road	ถ. นิมมานเหมินทร์	0.744	1.597	1.171
Mean ± SD (N) Median (Min.-Max.)		0.86±0.04	0.91±0.51	0.86 ± 0.42 (15) 0.82(0.25-1.71)

1. The two times and average level of Suspended Particulate Matters (SPMs) in the air at 15 major road in Chiang Mai City were reported in mg/m^3 shown in the following Table 2.2B.5.

2 The level of SPMs in air at two control sites in Chiang Mai University and on the Doi-Suthep mountain area were shown in the following Table 2.2B.6.

Table 2.2B.6 SPMs levels in air of control sites monitoring using High Volume Air Sampler

Control Sites	SPMs level in the air (mg/m^3)		
Name of study sites	1st. time	2nd time	Average
Headquarters of Doi-Suthep National Park	0.118	0.241	0.180
CMU	0.289	ND	0.289
TOTAL	ND	ND	0.234

ND = Not determined

2.2B.2.4 Lead levels in the air in Chiang Mai City

1. Lead levels in the air of control sites monitoring using High Volume Air Sampler were shown in Table 2.2B.8.

Table 2.2B.8 Lead levels of air at control sites monitoring using High Volume Air Sampler

Name of sites	Lead level of air ($\mu g/m^3$)		
	1st time	2nd time	Average
Headquarters of Doi-Suthep National Park	0.030	0.037	0.034
CMU	0.049	ND	0.049
TOTAL	ND	ND	0.042

ND = Not determined

2. Lead levels in the air of 15 study sites were monitored using High Volume Air Sampler during the period of time from September to December were reported in Pb $\mu g/m^3$ air and shown in Table 2.2B.7.

Table 2.2B.7 Lead levels in the air of study sites monitoring using High Volume Air Sampler from September to December 1995

Name of study sites		Lead level in the air, $\mu g/m^3$		
English	Thai	1st time	2nd time	Average
Suan Dok gate	ประตูสวนดอก	0.200	0.129	0.165
Chiang Mai Ram Hospital	รพ. เชียงใหม่ราม	0.206	0.313	0.260
Kuang Sing Market	ตลาดช่วงสิงห์	0.123	0.153	0.138
Suan Prueng Hospital	รพ. สวนปรุง	0.082	0.099	0.091
Mane Nopparat Road	ถ. มณีนพรัตน์	0.141	0.172	0.167

Name of study sites		Lead level in the air, μg/m^3		
English	Thai	1st time	2nd time	Average
Chiang Mai Gate	ประตูเชียงใหม่	0.283	0.384	0.333
Kaeo Nawarat Road	ถ. แก้วนวรัฐ	0.106	0.168	0.137
Airport Plaza	แอร์พอร์ตพลาซ่า	0.120	0.256	0.188
Sam Kam Phang	สันกำแพง	0.098	0.415	0.157
Tonpayorn Market	ตลาดต้นพยอม	0.136	0.187	0.162
Lanna Palace Hotel	โรงแรมลานนาพาเลส	0.059	0.067	0.064
Chiang Mai Phucome Hotel	โรงแรมเชียงใหม่ภูคำ	0.091	0.273	0.182
Chang Phuak Gate	ประตูช้างเผือก	0.048	0.123	0.086
PTT-Gasoline Station (CMU)	สถานีน้ำมัน ปตท.	0.037	0.131	0.084
Nimanhemin Road	ถ. นิมมานเหมินทร์	0.034	0.059	0.047
Mean ± SD (N) Median (min.-max.)				0.16 ± 0.07 (15) 0.162 (0.05-0.33)

2.2B.3 Discussions

1. Lead levels in the air sample, taken by High Volume Air Sampler, from Chiang Mai City were uneven. The range was from 0.047 to 0.333 μg / m^3. Average of lead level in Chiang Mai City was 0.155 μg / m^3 which was within the US EPA (1.5 μg / m^3) and Thailand standards (10 μg / m^3) of lead level in the air, and so was the highest level (0.33 μg / m^3) [1] (Table 2.2B.8, Figure 2.2B.4). Average of the lead level in the air taken from the roadside in Chiang Mai City was 3

Figure 2.2B.4 Lead levels in the air of Chiang Mai City and the air quality standards

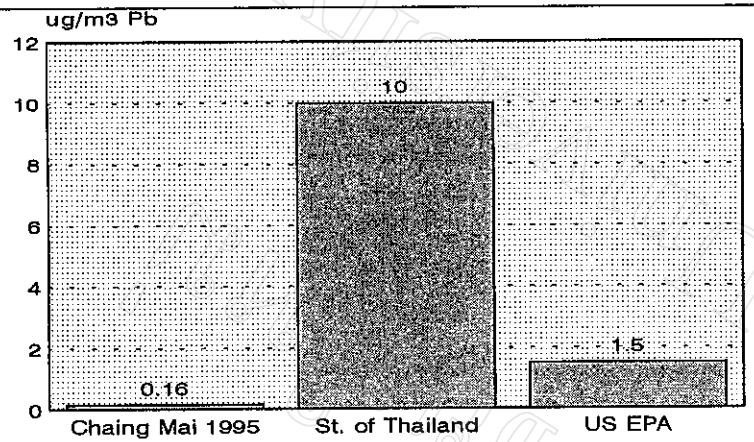


Figure 2.2B.5 The average lead level in the air of urban area and control sites in 1995

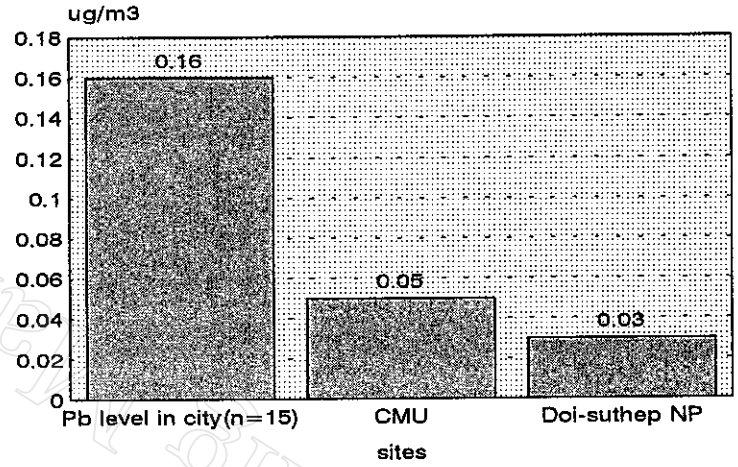


Figure 2.2B.6 SPMs levels in the air of Chiang Mai City in 1995 and standards

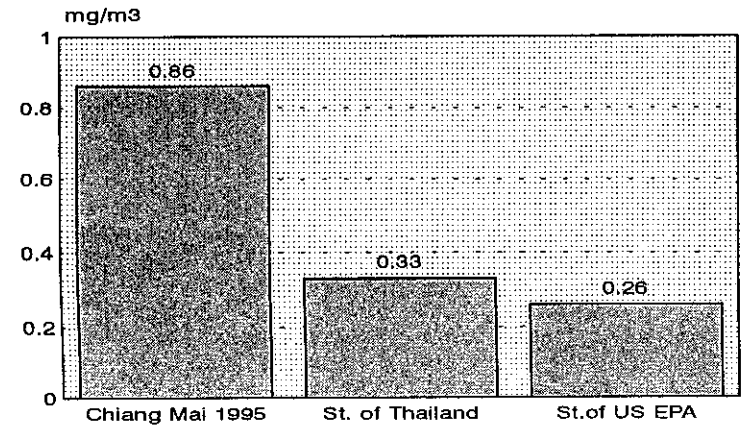
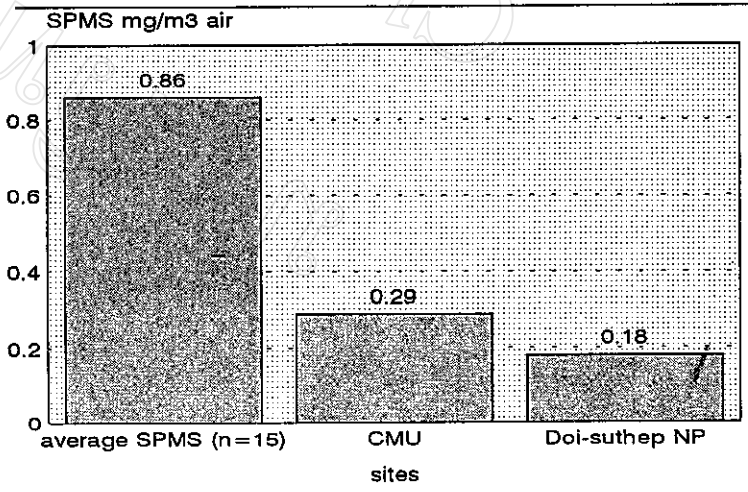


Figure 2.2B.7 SPMs level in the air of urban areas and control sites in 1995



time higher than the lead level in the air of the control site, taken from the residential area at the west of the Environmental Engineering Department, Chiang Mai University, and it was about 5 times higher than the other control site, taken from the National Park Headquarters on Doi-Suthep Mountain.

2. SPMs' levels in the air samples taken by the High Volume Air Sampler were also uneven with the range from 0.25 mg/m^3 to 1.71 mg/m^3. SPMs level at 14 out of 15 sties (93.3 %) exceeded both US EPA (0.26 mg / m^3) and Thailand standard (0.33 mg / m^3) (Table 2.2B.9) . The average of SPMs level was 0.864 mg/m^3 and also exceeded the levels from both standards for about 3 folds (Figure 2.2 B.6). Further more, the average of SPMs level in the air at roadsides of Chiang Mai City is 3 times of control sites in Chiang Mai University, and about 5 times of control site at the National Park Headquarters on Doi-Suthep Mountain (Figure 2.2 B.7) .

Table 2.2B.9 Lead and SPMs levels from the present study using High Volume Air Sampler and standard levels

Sources of data	LEAD, μg / m^3	SPMs, mg/m^3
Present study	0.155 ± 0.074	0.864 ± 0.419
Thailand, 24 Hours	10	0.33
US EPA, 24 Hours	1.5	0.26

3 Lead and SPMs levels in Chiang Mai from the present study, and in Bangkok and Chiang Mai reprted in 1993 [38] were in Table 2.2B.10 and Figure 2.2B.8). Lead level of Chiang Mai from the present study was lower than both in Chiang Mai and Bangkok reprted in 1993. Major reasons might be the reduction of

Figure 2.2B.8 Compare lead levels in air of Chiang Mai in 1995 with Chiang Mai and Bangkok in 1993

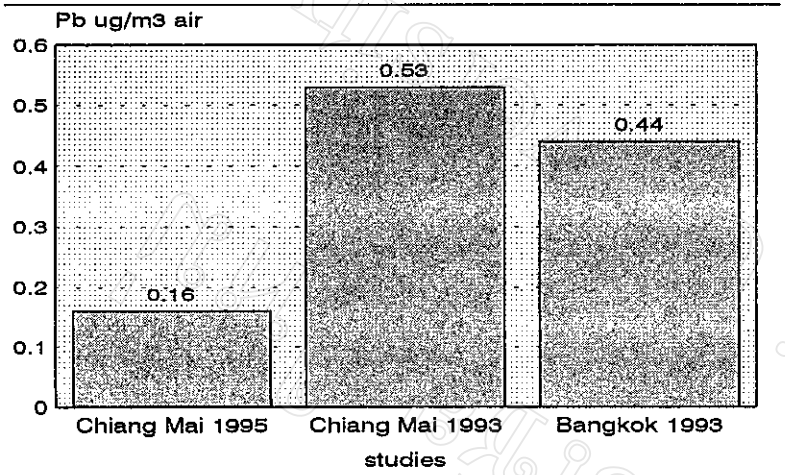


Figure 2.2B.9 Compare SPMs levels in air of Chiang Mai in 1995 with Chiang Mai and Bangkok in 1993

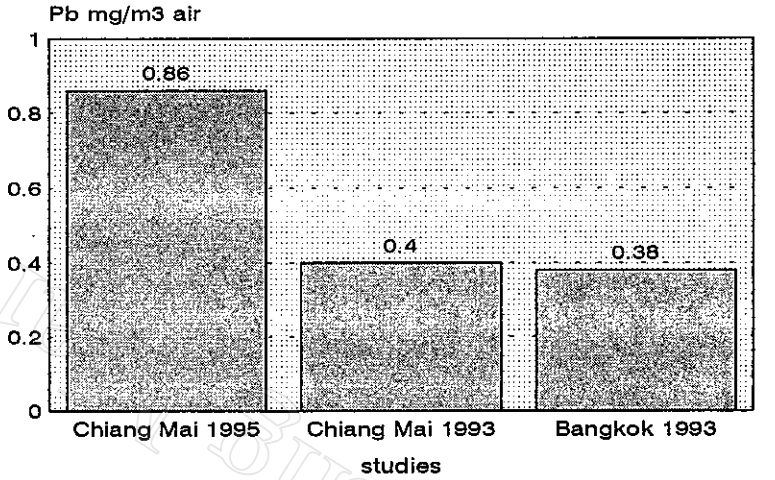


Figure 2.2B.10 Compare the monitoring lead level using mask filter and High Volume Air Sampler

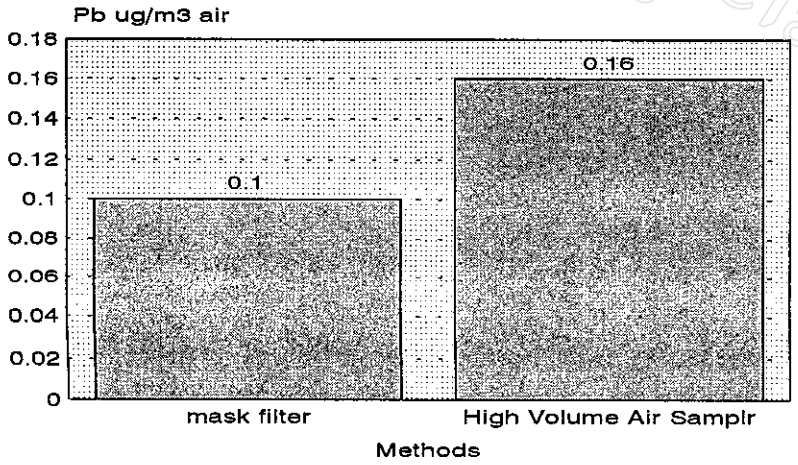
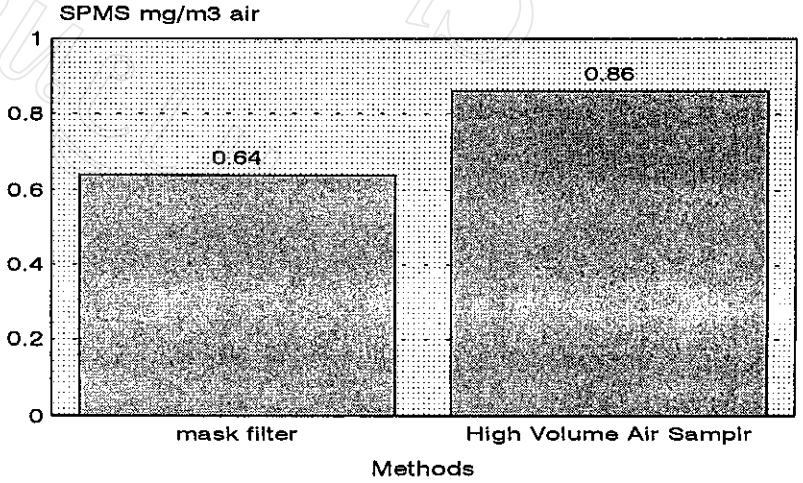


Figure 2.2B.11 Compare the monitoring SPMs level using mask filter and High Volume Air Sampler



lead content in gasoline and the increas of unleaded-gasoline (ULG) using in Thailand during recent years.

3 Lead and SPMs levels in Chiang Mai from the present study, and in Bangkok and Chiang Mai reprted in 1993 [38] were in Table 2.2B.10 and Figure 2.2B.8). Lead level of Chiang Mai from the present study was lower than both in Chiang Mai and Bangkok reprted in 1993. Major reasons might be the reduction of lead content in gasoline and the increas of unleaded-gasoline (ULG) using in Thailand during recent years.

Otherwise, the level of SPMs was almost double of the level detected in Chiang Mai and Bangkok two years ago (Figure 2.2B.9). Major reasons might be due to civil construction especially during our study period there were many buildings and road construction happening in Chiang Mai City for welcoming the SEA Games.

Table 2.2B.10 The levels of lead and SPMs in Chiang Mai City from present study, Bangkok and Chiang Mai in 1993 [38]

Studies (N)	Year	LEAD, $\mu g / m^3$	SPMs, mg/m^3
Chiang Mai, present study (15)	1995	0.155 ±	0.864 ± 0.419
Chiang Mai, 1993 (2)	1993	0.53	0.40
Bangkok, 1993 (15)	1993	0.44	0.38

Figure 2.2B.12 Lead levels in the air and rainfall amount in different month

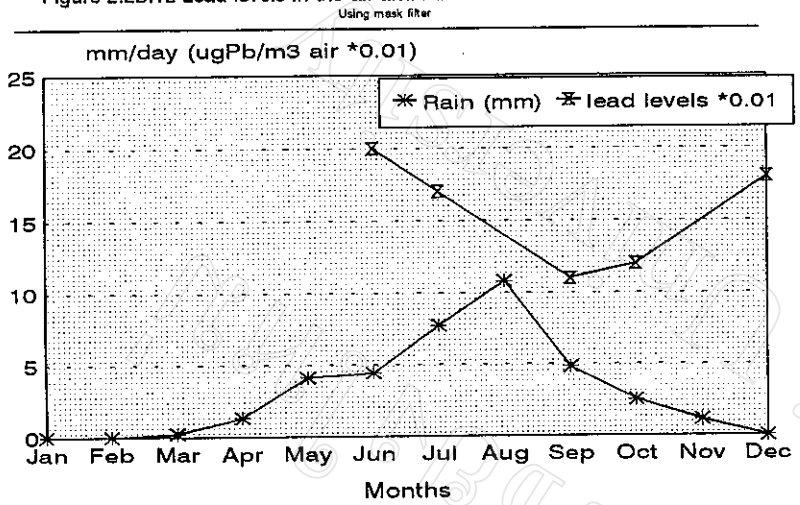


Figure 2.2B.13 Lead levels in the air in May-June & Sept.-Dec.and rain amount

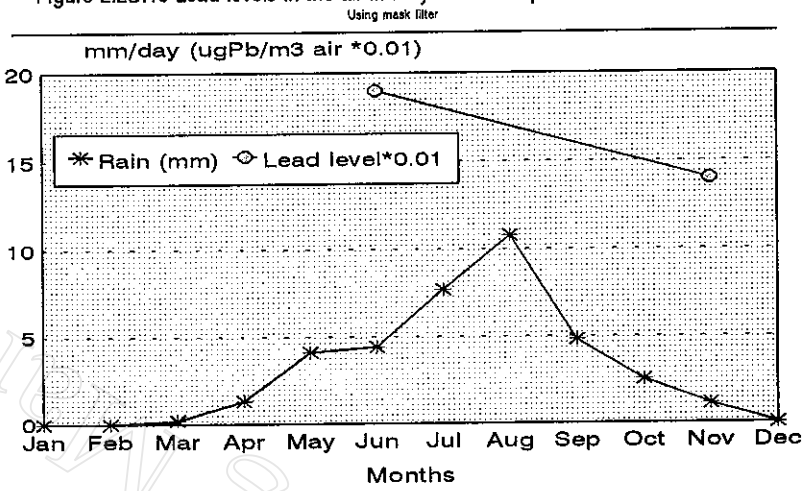


Figure 2.2B.14 SPMs levels in the air and rain amount in month

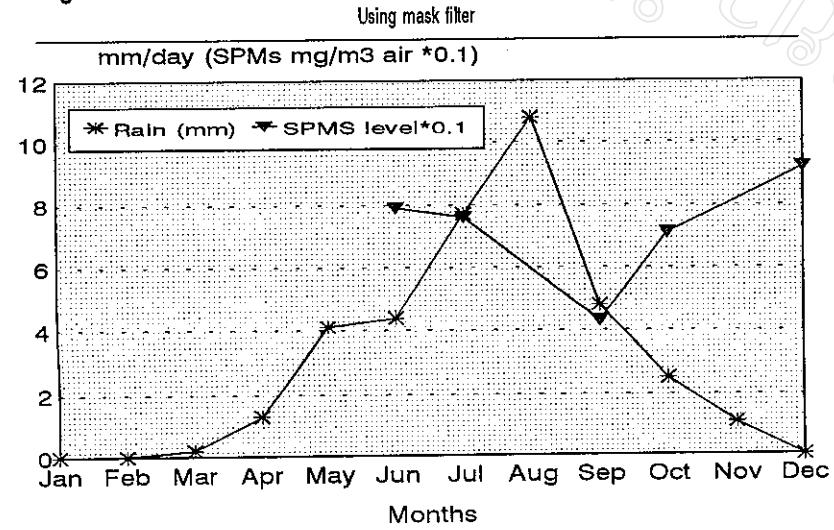
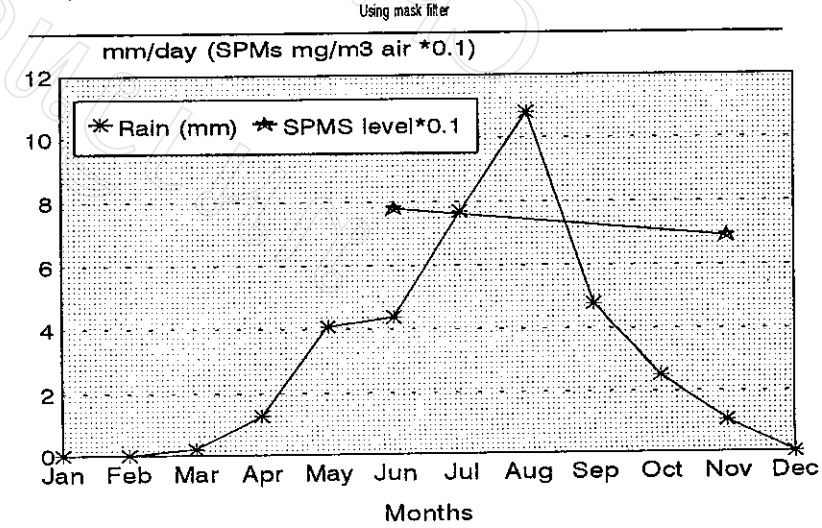


Figure 2.2B.15 SPMs levels in the air in May-June & Sept.-Dec.and rain amount



4. Considering the human hazards, results of monitoring using mask filter showed that people standing at the crossroads during rush hour without any protective measurement could intake lead about 0.16 μg per hour, and dust about 0.65 mg per hour from May to July 1995, and about 0.08 μg of lead per hour, and 0.53 mg of dust per hour from September to December 1995.

5. Comparing monitoring results using mask filter and high volume air sampler, both lead and SPMs levels using mask filter were lower than the level employed the High Volume Air Sampler (Table 2.2B.11; Figure 2.2B.10, 11). The ratio for the average level of lead is 0.1/0.16 = 0.645 , and the ratio of average of SPMs is 0 .64/0.86 = 0.74. The major reason for the difference might be due to different suckling power. Air monitoring using High Volume Air Sampler trends to reflect the total lead and SPMs levels, because it can suck bigger particles to the filter. However, air monitoring using mask filter trends to reflect the real human hazard of exposure to the air pollution.

Table 2.2B.11 Air monitoring using mask filter and High Volume Air Sampler

Sampling procedure	LEAD, μg / m^3	SPMs, mg/m^3
Mask filter N =29	0.10 ± 0.06	0.64 ± 0.50
High Volume Air Sampler N = 15	0.16 ± 0.07	0.86 ± 0.42

6. Lead and SPMs levels in different month in 1995 using the result of mask filter monitoring (Table 2.2B.12,13; Figure 2.2B.12,13,14 15)

Figure 2.2B-16 SPMs levels and construction

1st time monitoring with high volume air sampler

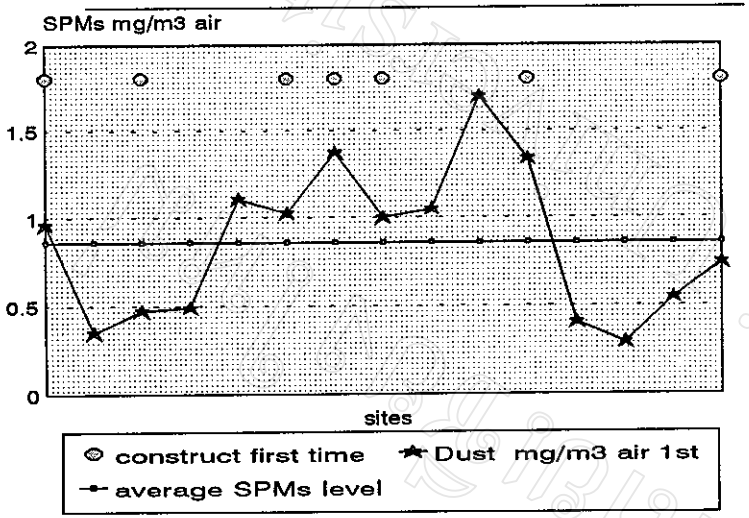


Figure 2.2B-17 SPMs levels and construction

2nd time monitoring with high volume air sampler

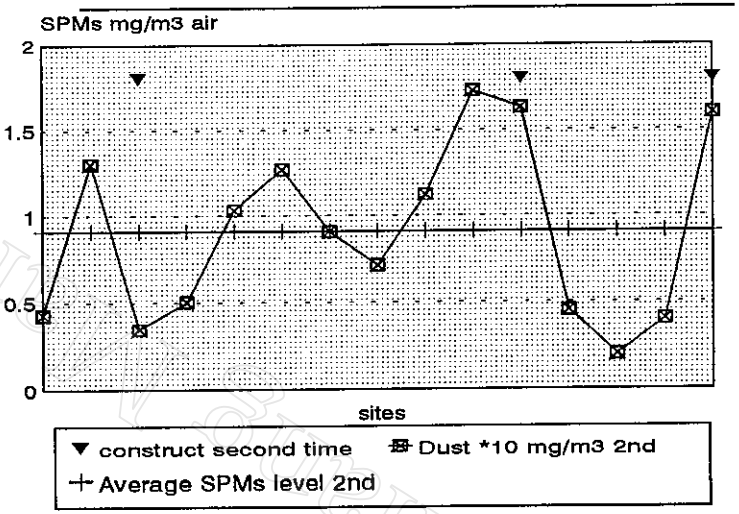


Figure 2.2B-18 Lead levels and traffic volume

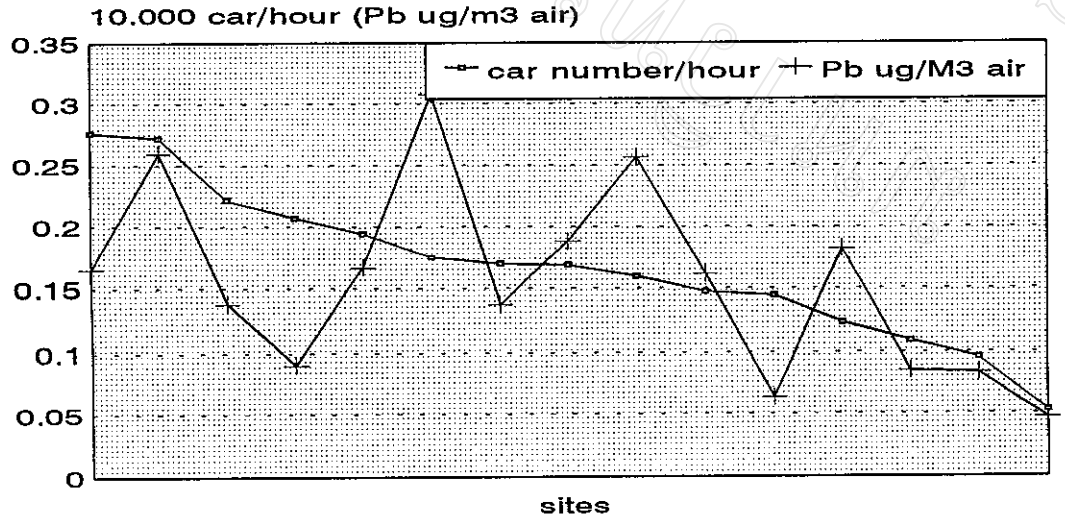


Table 2.2B.12 Lead and SPMs levels in time series monitoring using Mask filter worn by traffic policemen

Time	N	Average rainfall (mm/day)	Lead, μg / m^3 Mean ± SD	SPMs, mg/m^3 Mean ± SD
May - June	35	4.25	0.20 ± 0.14	0.79 ± 0.65
June - July	32	6.05	0.17 ± 0.18	0.76 ± 0.72
Sept.-Oct.	7	3.65	0.11 ± 0.06	0.43 ± 0.23
October	4	2.5	0.12 ± 0.05	0.71 ± 0.55
Nov. - Dec.	4	0.55	0.18 ± 0.02	0.92 ± 0.32

Table 2.2B.13 Lead and SPMs levels in the air of Chiang Mai City during the period May-July and September- December monitoring using mask filter worn by traffic policemen

Time	Average rainfall (mm/day)	Lead, μg / m^3	SPMs, mg/m^3
May - July	5.4	0.19 ± 0.17	0.78 ± 0.67
Sept. - Dec.	2.1	0.14 ± 0.06	0.69 ± 0.50

Our hypothesis and the actual monitoring results about the relation between lead and SPMs levels with rainfall amount was consistent. The lead and SPMs levels trend to be lower in the air with the increase of rainfall amount , due to the higher quantitative rainfall washing off the pollutants from the air. This conclusion showed clearly in the figure 2.2B.12,14, or Table 2.2B.10.

While the total changing trend of both lead and SPMs levels in the air in Chiang Mai City was higher in the period of May-July than the period of September - December were shown in Figure 2.2B.13,15, or Table 2.2B.11. These phenomenon might reveal that the major factors contributed to the air quality fluctuation in Chiang Mai City in 1995 besides the weather was human activities. The dramatical reduction of lead content in gasoline and increasing popularity of the ULG might be

responsible for the lower lead level in later period of 1995 monitoring (June-July) than in the earlier period of 1995 (Septmber-Deceber). Many road construction started during the early of 1995 and completed at the end of 1995 before the SEA Games might contribute to the abnormal SPMs fluctuation in rainy season and dry season. Traffic volume dramatically increased shortly before and during the SEA Games composed the increasing of lead and SPMs level during that time.

7. The relationship of SPMs level and road construction was shown in Figure 2.2B.16,17 and Table2.2B.14. During the sample collecting using Auto-Sampler machine, there were 7 sties in the first round, and 3 sites in the second round happened to construction. For the first round, SPMs level of 5 out of 7 study sites was above the mean level of 0.86 mg/m^3, and only 3 out of 8 sites with out underconstruction had SPMs over mean level. Therefore, the risk of having high level of SPMs from construction was 1.9 (Relative Risk ,RR = 1.9 ,95% Confidence Limits was 0.69 <RR< 5.23). For the second round, 2 out of 3 sites with underconstruction had SPMs level over the mean level of 0.91 mg/m^3 , and 5 out of 12 sites without underconstruction had SPMs above the mean level. Hence, RR was 1.6 (95% Confidence Limits for RR was 0.56<RR<4.54).

Table 2.2B.14 Road construction and SPMs level

Sampling round	Total No. of construct road	No. of const. sites above mean level	No. of non-const. above mean level
First	7	5/7 (>0.86 mg/m^3)	3/8
Second	3	2/3 (>0.91 mg/m^3)	5/12

8. Lead levels in the air seemed to have the trend that the higher the traffic volume , the higher the lead level. The correlation coefficient between traffic volume

and lead level in the present study was 0.46. There was a linear relationship between traffic volume and lead level (r-test at 0.05>P>0.02) (Figure 2.2B.18).

2.2B.4 Conclusion

The lead levels in roadside dust were unevenly distributed among the major crossroads in the urban area of Chiang Mai City, and the average lead level in roadside dusts collected in March which was representative month of dry months in Chiang Mai were significant higher than the average lead level in roadside dusts collected in August which was representative month of rainy months in 1995.

The average lead level in the air, monitoring using High Volume Air Sampler, of Chiang Mai City in 1995 was 0.16μg / m^3 , which much lower than air quality standards of Thailand and USEPA, and also lower than the lead level in air of Chiang Mai City conducted two years ago. This reducing trend of lead level mainly due to the reducing lead additive content in gasoline and using more unleaded gasoline (ULG) instead of leaded gasoline.

The average SPMs level in the air, monitoring using High Volume Air Sampler, in Chiang Mai City in 1995 was 0.86 mg / m^3 , which already exceeded the air quality standards of Thailand and USEPA, and also higher than the SPMs level in Chiang Mai City in 1993. Many road construction sites happening in Chiang Mai City before SEA Games might be the major factor responsible for the higher SPMs level in Chiang Mai 1995.

Both lead and SPMs levels in the air of urban areas were much higher than two control sites, which clearly showed the air pollution of urban areas. The air-borne lead and SPMs levels distributed unevenly among the individual sites among urban area of Chiang Mai City. The traffic volume variation along different roads

may partially responsible for the fluctuation lead level in the air, and the construction mainly responsible for the varied SPMs level in Chiang Mai City in 1995.

Air quality monitoring using mask filter trends to reflect the real human hazard of exposure to the air pollution. While monitoring using High Volume Air sampler trends to reflect the total Lead and SPMs levels in the air, lead and SPMs levels monitoring using mask filter were lower than High Volume Air Sampler. The ratio between monitoring using mask filter and High Volume Air Sampler in the present study was 0.65 for lead and 0.74 for SPMs.

RECOMMENDATION

In the process of human beings struggle with environmental pollution, many environmental factors have been shown to have an adverse effect on human health and well-being. This has been recognized for sometimes in different degrees in the various country, and over time the response have varied widely from place to place as well.

In the late 1950s and early 1960s, the more developed countries with large industrialized metropolitan areas, but to an extent many of the less developed ones as well, began concerned about the pollution issues and active in environmental protection because of the rise of a number of serious problems related to contamination. That period was characterized by disclosure of the serious adverse impact of pollution on health and well-being, identification of major sources of pollution, and increased perception its extent and trends. At the same time, there was also a growing emphasis on the developing technical capacity. This was followed by the promotion of public awareness, the establishment of environmental pollution control agencies and institutions as means of coping with the problems, regulatory legislation, and a recognition of the international and global nature of environmental degradation. These problems and effects to solve them have continued into the late 1970s and early 1980s during which time the list of pollutants, and hazardous substances affecting human and the environment has expanded at an alarming rate. Air pollution control has shown progress in some of the major municipal areas. Industrial and vehicle emissions continue , however to be a growing problem[39].

The cost of measures to remedy environmental degradation or to eliminate significant public health hazards has consistently been found to be greater than the cost preventive measures. Growing awareness of the socioeconomic consequences of a deteriorating environment is apparent in both industrialized and developing countries.

Air pollution has controlled with some success in developed countries[2]. with the control and dramatically reduce of some toxic substance in occupational and living environment, acute toxic cases quietly disappear in occupational and common

life. At the same time, techniques growing fast, lower and lower level of toxic substance and the subclinicl adverse effects of toxic substance are detectable. According to the trend in occupational and environmental health, experts pointed out that the chronic affects of trace amount of toxic substances and the coordination of multiple toxic substances need further study [40].

Growing interests in the environment and public health, and in the possible impact of both on the future of humanity and our planet become the conception of sustainble development. Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. The quest for sustainable development has come to focus on the interaction between health and the environment. Achieving supportive environments for health will require a new awareness of how health can be improved through environmental change. It will require stronger emphasis on the link between public health and sustainable development , especially in relation to long-term consequences[41].

ULG completely are being used in Thailand at present time. Inevitably, the lead level in the environment will continue reduce in the later years after the reduction of major sources of lead emission from burning leaded gasoline of motor vehicles. However, lead in the environment today will remain in the surrounding for a certain period of time.. Hence, the monitoring the lead level in the environment and the blood of human beings is still needed.

The number of motor vehicles in Chiang Mai City has been increasing rapidly in the past several years[42]. Besides the problem of lead contamination, our beautiful environment is also threatened by other adverse factors, such as noise, NO_x, SO_2, CO, CO_2 and other toxic organic matters caused by the dramatically increasing number of motor vehicles. In order to keep Chiang Mai's beautiful environment for its

inhabitants and continue to maintain its position on tourism , which is the major industry in Chiang Mai, some actions must be considered for future traffic development before the situation become critical. Such actions could be increasing of taxes and prices of motor vehicles and also gasoline; development of a public transportation system instead of personal cars; promotion of bicycles instead of motorcycles on university campus, etc. With public good cooperation as well as a genuine effort, Chiang Mai will be much more beautiful than she used to be and will attract more and more visitors from many countries of the world in the future.