CHAPTER 4

Result and Discussions

4.1 Concentrations of PM_{10}

The PM_{10} samples were collected using Mini Volume Air sampler (AIRmetric, USA) which located about 1.5 meters above the ground. The pumped volume flow rate was 5.0 L/min. The sampling period was in February to April for dry season and in May to July for wet season 2015. The field sampling duration in each month was divided in two days according to the lack of equipment. The field samplings of first day were included Lampang Meteorological Station (MS), Sa Det Subdistrict Administrative Organization (SD) and Tha Si Health Promotion Hospital (TS) sites. The field samplings of second day were included Mae Moh Wittaya School (MW) and Sob Pad Temple (SP) sites. The PM_{10} mass concentrations on a teflon fiber film filter was determined gravimetrically by weighing the filter before and after sampling using a five decimal places microbalance in a clean room at 25 ˚C and less than 40% relative humidity.

The field sampling and meteorological parameters of present study are shown in Table 4.1. The ambient average temperatures (T) ranged from 27.4 to 33.3 ^{0}C and average relative humidity (RH) ranged from 45 to 82%. During the sampling period the prevailing wind direction (WD) was primary impacted from southwest monsoon with maximum wind speeds (WS) ranging from 4 to 46 km/hr.

Table 4.1 Field sampling and meteorological parameters

Date	Sampling sites					T	WD	WS	RH
	TS	SP	MW	MS	SD	(^{0}C)	(degree)	(km/hr)	(%)
23-24/02/15 (24h)	Y	N	N	Y	Y	28.7	SSE/180	22	77
24-25/02/15 (24h)	N	Y	Y	N	N	28.7	S/270	17	75
16-17/03/15 (24h)	Y	N	N	Y	Y	27.4	S/180	13	55
17-18/03/15 (24h)	N	Y	Y	N	N	28.4	SW/220	4	58
20-21/04/15 (24h)	Y	N	N	Y	Y	32.6	S/180	13	50
21-22/04/15 (24h)	N	Y	Y	N	N	33.3	SSE/160	11	45
11-12/05/15 (24h)	Y	N	N	Y	Y	31.7	W/270	13	62
12-13/05/15 (24h)	N	Y	Y	N	N	32.7	S/180	41	55
15-16/06/15 (24h)	Y	N	N	Y	Y	28.7	S/180	22	77
16-17/06/15 (24h)	N	Y	Y	N	N	28.7	W/270	17	75
13-14/07/15 (24h)	Y	N	N	Y	Y	28.8	SSW/200	46	76
14-15/07/15 (24h)	N	Y	Y	N	N	28.6	S/180	43	82

Y: Sampling, N: No sampling

The thirty of PM_{10} samples were conducted once a month during February to July 2015. The 24 hour PM_{10} concentration varied from 18.98 to 174.07 µg/m^3 which relatively higher in February and March at every sampling sites. The summary of PM_{10} concentrations in each sampling site are showed in Table 4.2 and the result descriptions were given as follow.

Table 4.2 Summary of PM_{10} concentrations in each sampling sites

Month 2015	24 hour PM_{10} concentrations ($\mu g/m^3$) in each sites				
	TS	SP	MW	MS	SD
February	115.28	121.76	151.85	110.65	97.69
March	135.65	161.11	148.15	174.07	162.04
April	70.37	73.15	81.94	56.02	68.98
May	64.81	58.33	76.39	75.93	65.28
June	36.57	43.06	24.07	28.24	32.87
July	18.98	35.65	29.17	40.74	28.24
Average	73.61	82.18	85.26	80.94	75.85
SD	44.79	49.28	55.44	54.03	49.35

The average 24 hour PM_{10} concentrations observed at TS site was 73.61 ± 44.79 $\mu g/m^3$ which highest value of 135.65 $\mu g/m^3$ in March and lowest value of 18.98 $\mu g/m^3$ in July.

The average 24 hour PM_{10} concentrations observed at SP site was 82.18 ± 49.28 $\mu g/m^3$ which highest value of 161.11 $\mu g/m^3$ in March and lowest value of 35.65 $\mu g/m^3$ in July.

The average 24 hour PM_{10} concentrations observed at MW site was 85.26 ± 55.44 $\mu g/m^3$ which highest value of 151.85 $\mu g/m^3$ in February and lowest value of 24.07 $\mu g/m^3$ in June.

The average 24 hour PM_{10} concentrations observed at MS site was 80.94 ± 54.03 $\mu g/m^3$ which highest value of 174.07 $\mu g/m^3$ in March and lowest value of 28.24 $\mu g/m^3$ in June.

The average 24 hour PM_{10} concentrations observed at SD site was 75.85 ± 49.35 $\mu g/m^3$ which highest value of 162.04 $\mu g/m^3$ in March and lowest value of 28.24 $\mu g/m^3$ in July.

In present study, the lowest value of 18.98 μg/m^3 PM_{10} concentration was observed at TS site in July. Whereas, the highest of 174.07 μg/m^3 PM_{10} concentrations was observed at MS site on March which exceeded 24 hour PM_{10} standard (120 μg/m^3).

The seasonal maximum, minimum and mean of PM_{10} concentrations during dry and wet season are presented in Table 4.3.

Table 4.3 Comparison of PM_{10} concentrations between dry and wet season

Site	24 hour PM_{10} concentration (μg/m^3)					
	Dry season			Wet season		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
TS	107.10 ± 33.40[a]	70.37	135.65	40.12 ± 23.12[a]	18.98	64.81
SP	118.67 ± 44.06[a]	73.15	161.11	45.68 ± 11.56[a]	35.65	58.33
MW	127.31 ± 39.34[a]	81.94	151.85	43.21 ± 28.85[a]	24.07	76.39
MS	113.58 ± 59.08	56.02	174.07	48.30 ± 59.08	28.24	75.93
SD	109.57 ± 47.65	68.98	162.04	42.13 ± 20.18	28.24	65.28

[a] significantly different in $P < 0.05$

During dry season, the average 24 hour PM_{10} concentration were 107.10, 118.67, 127.31, 113.58 and 109.57 μg/m^3 at TS, SP, MW, MS and SD respectively. The maximum 24 hour PM_{10} concentrations at every sampling sites are exceeded 24 hour PM_{10} standard of 120 μg/m^3. The highest value of 174.07 μg/m^3 maximum 24 hour PM_{10} concentration in this study was observed at MS site where is located in the downtown, surrounded by airport, commercial and traffic area. The high emission from vehicular exhaust from dense traffic may be responsible for the highest levels of PM_{10} in this site. Moreover, the numbers of days that PM_{10} concentrations exceeded the Thailand's 24 hour PM_{10} standard has reported by PCD that AQM station (37T), where is located in the same area of MS site was also found to be significantly higher than those other stations (see Appendix, Table B6). This finding indicates the urgency for coresponsible authority in Lampang, especially in downtown area to develop more effective strategies to solve the particle pollution during the serious period.

During wet season, the average 24 hour PM_{10} concentrations were decreased due to the annual thunderstorms with 40.12, 45.68, 43.21, 48.30 and 42.13 μg/m^3 at TS, SP, MW, MS and SD sites, respectively. The maximum 24 hour PM_{10} concentrations at all

sampling site were decreased and accepted in the 24 hour PM_{10} standard. The influenced from meteorological condition such as high humidity (82%) and high wind speed (46 km/hr) were great effected on particles decreasing.

As the results, the 24 hour PM_{10} concentration at TS, SP and MW sites in dry season were statistically significantly higher than those in the wet season ($P < 0.05$) (see Appendix, Table C1-5), which is in agreement with previous study in Mae Moh area, Lampang province [3]. During dry season, the maximum 24 hour PM_{10} levels of all sampling sites are exceeded Thailand's 24 hour PM_{10} standard. These high levels of particulate matter in the dry season has been reported as a unique seasonal pattern in Northern Thailand [34] and may come influenced from several sources, temperature inversions and basin architecture in the area. However, the PM_{10} concentrations in the wet season were decreased according to the wind speeds and high relative humidity. The variation of PM_{10} concentrations during dry and wet season is shows in Figure 4.1.

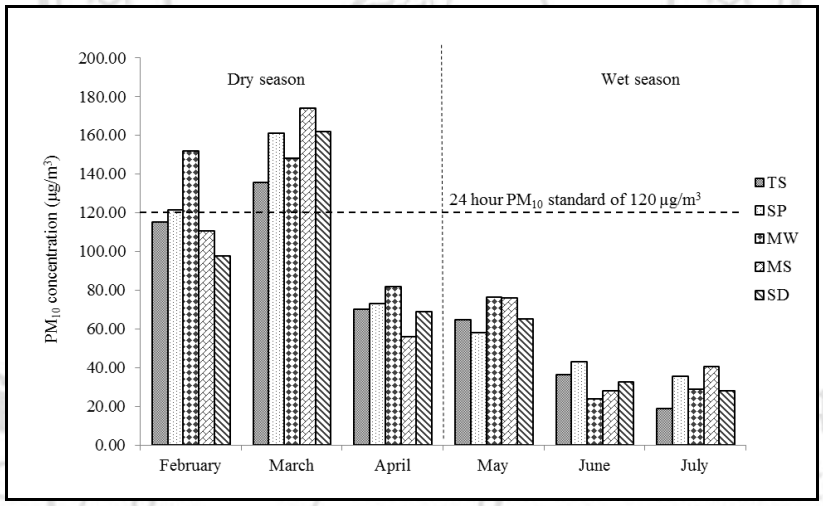

Figure 4.1 Variation of PM_{10} concentrations during dry and wet season

In addition, the 24 hour PM_{10} concentrations of this study were correlated with PM_{10} data obtained from AQM stations by PCD (see appendix, Table B7) between site MS and 37T ($r = 0.98$), site SP and 38T ($r = 0.97$) site TS and 39T ($r = 0.96$) and site MW and 40T ($r = 0.96$), respectively. The results of 24 hour PM_{10} concentrations in this study showed similar trend of the concentrations to their PCD data. It informed that PM_{10} sample can be used as the good representative for next analysis.

4.2 Analytical characteristics

In the present work, the method validation was presented in terms of precisions, repeatability, recovery, limit of detection (LOD) and limit of quantitation (LOQ).

4.2.1 Precision

The PAHs standard solution was spiked onto known filter sample. In meantime, fixed concentration of an internal standard (5 x 10^{-7} M of Pyr-d_{10}, 5 x 10^{-7} M of BaA-d_{10}, 1 x 10^{-6} M of BaP-d_{12}) was prepared by adding 15 µL onto the filters gave final concentration of 150 µL. The standards were extracted using same protocol of sample filters and then analyzed using the HPLC-FL. Precision is typically defined in terms of reproducibility and repeatability. Repeatability was done by 5 injections of 100 µL of each spiked PAHs samples. Mean, standard deviation (SD) and relative standard deviation (RSD) values were calculated and the result is shown in Table 4.4. The reproducibility of PAHs was done by calculating the RSD using means and SD from 5-batch analysis. The %RSD of 10 PAHs was ranged from 1.1-5.7% which in the acceptable range of 4-6%.

Table 4.4 Repeatability and reproducibility of 10 PAHs measurements

PAHs	Spiked conc. (ng/mL)	Concentrations (ng/mL)					Average	SD	%RSD
		1	2	3	4	5			
Flu	40.0	31.9	35.6	35.6	35.8	35.9	35.0	1.6	4.8
Pyr	20.0	17.0	18.9	16.9	17.1	18.9	17.8	1.0	5.7
BaA	20.0	19.1	18.2	18.8	18.5	18.4	18.6	0.3	1.9
Chr	20.0	18.9	18.3	18.8	18.6	18.4	18.6	0.2	1.3
BbF	40.0	37.5	36.4	37.0	36.8	36.8	36.9	0.4	1.1
BkF	20.0	17.9	17.0	17.3	17.2	17.1	17.3	0.3	2.0
BaP	20.0	24.0	23.4	23.9	23.5	23.4	23.6	0.2	1.1
DBA	40.0	44.2	42.8	43.1	41.9	41.8	42.8	1.0	2.3
BghiPe	40.0	49.3	45.5	45.7	46.9	44.7	46.4	1.8	3.8
IDP	20.0	25.6	25.8	26.1	25.1	25.4	25.5	0.4	1.7

4.2.2 Recovery

Five replications at each concentration of 10 PAHs were spiked onto known filter sample as above. The results showed recoveries acceptable ranging of 80-120% in the range of 82.2-108.8% as show in Table 4.5.

Table 4.5 Average recoveries of 10 PAHs spiked onto known filter sample

PAHs	% Recovery (Mean ± SD)
Flu	85.1 ± 4.1
Pyr	83.2 ± 4.3
BaA	87.8 ± 2.1
Chr	86.4 ± 1.3
BbF	87.0 ± 14
BkF	82.2 ± 1.8
BaP	106.9 ± 1.4
DBA	104.6 ± 2.4
BghiPe	104.1 ± 5.5
IDP	108.8 ± 2.5

4.2.3 Limit of detection (LOD)

In present work, LOD (limit of detection) and LOQ (limit of quantitation) were determined using the intercept of the regression line between the concentration of standard concentrations and SD which were derived from 5 replicates of each concentration. The LOD and LOQ results were reported in term of ng/m^3 which ranging from 0.0001-0.0021 and 0.0006-0.0063 ng/m3, respectively as show in Table 4.6.

Table 4.6 LOD and LOQ of 10 PAHs

PAHs	LOD (ng/m^3)	LOQ (ng/m^3)
Flu	0.0015	0.0045
Pyr	0.0003	0.0009
BaA	0.0003	0.0008
Chr	0.0002	0.0006
BbF	0.0005	0.0014
BkF	0.0001	0.0004
BaP	0.0001	0.0004
DBA	0.0012	0.0037
BghiPe	0.0011	0.0034
IDP	0.0021	0.0063

4.3 Concentration of PM_{10}-bound PAHs

The ten species of analyzed PAHs including fluoranthene (Flu), pyrene (Pyr), benz[*a*]anthracene (BaA), chrysene (Chr), benzo[*b*]fluoranthene (BbF), benzo[*a*]pyrene (BaP), benzo[*k*]fluoranthene (BkF), dibenz[*a,h*]anthracene (DBA), benzo[*g,h,i*]perylene (BghiPe) and indeno[1,2,3-*cd*]pyrene (IDP) were performed in PM_{10} sample which is recognized to be more appropriate indicator of adverse health effects than the total suspended particles (TSP). In present study, the total PAH concentration varied from 0.23 to 23.87 ng/m^3 (see appendix, Table B1-5). The average individual and total PAH concentrations (ng/m^3) in each sampling sites are presented in Table 4.7.

Table 4.7 Average individual and total PAH concentrations in each sampling site

PAHs	Average ± SD of PAHs concentrations (ng/m^3)				
	TS	SP	MW	MS	SD
Flu	0.17 ± 0.19	0.17 ± 0.23	0.17 ± 0.21	0.13 ± 0.13	0.12 ± 0.13
Pyr	0.11 ± 0.12	0.09 ± 0.09	0.10 ± 0.10	0.14 ± 0.11	0.11 ± 0.08
BaA	0.09 ± 0.10	0.13 ± 0.15	0.08 ± 0.09	0.09 ± 0.06	0.07 ± 0.04
Chr	0.07 ± 0.06	0.07 ± 0.04	0.05 ± 0.04	0.10 ± 0.09	0.08 ± 0.06
BbF	0.43 ± 0.72	0.46 ± 0.72	0.09 ± 0.07	0.40 ± 0.47	0.26 ± 0.28
BkF	0.29 ± 0.51	0.31 ± 0.47	0.25 ± 0.49	0.26 ± 0.029	0.18 ± 0.19
BaP	0.85 ± 1.48	0.96 ± 1.59	0.62 ± 1.22	0.77 ± 0.92	0.54 ± 0.67
DBA	N.D.	N.D.	N.D.	N.D.	N.D.
BghiPe	1.71 ± 2.50	2.47 ± 3.11	1.36 ± 2.25	2.09 ± 2.20	1.54 ± 1.54
IDP	1.69 ± 2.58	2.00 ± 2.54	1.32 ± 2.27	1.88 ± 2.09	1.46 ± 1.62
Total	5.47 ± 8.02	6.67 ± 8.86	4.06 ± 6.62	5.85 ± 6.27	4.35 ± 4.55

N.D. not detected

In present study, the average total PAH concentrations were 5.47, 6.67, 4.06, 5.85 and 4.35 ng/m^3 at TS, SP, MW, MS and SD sites, respectively. Among ten species of PAHs analyzed, Flu, Pyr, BaA and Chr which some of them are not carcinogenic (Flu and Pyr) were detected at low concentration at every sampling sites. This is due to it is high volatility especially at the high temperatures during the sampling period (27.4 – 33.3°C). Therefore, some of these compounds are commonly found in some part of gas phase. In the other hand, BbF, BkF, BaP, BghiPe and IDP that mostly absorb on small inhalable size particles were found in higher concentration on PM_{10} more than Flu, Pyr, BaA and Chr. However, DBA was not detected in any samples.

The seasonal maximum, minimum and mean of total PAH concentrations during dry and wet season are presented in Table 4.8.

Table 4.8 Comparison of total PAH concentrations between dry and wet season

Site	Total PAHs concentration (ng/m^3)					
	Dry season			Wet season		
	Average ± SD	Min	Max	Average ± SD	Min	Max
TS	10.18 ± 9.70	2.02	20.90	0.76 ± 0.23	0.50	0.93
SP	11.61 ± 11.01	2.59	23.87	1.74 ± 1.40	0.34	3.13
MW	7.34 ± 8.79	1.28	17.42	0.77 ± 0.33	0.42	1.06
MS	10.18 ± 6.35	2.86	14.19	1.52 ± 1.41	0.23	3.02
SD	7.57 ± 4.49	2.72	11.57	1.13 ± 0.75	0.45	1.93

During dry season, the average total PAHs concentration were 10.18, 11.61, 7.34, 10.18 and 7.57 ng/m^3 at TS, SP, MW, MS and SD sites, respectively. The lowest value of 1.28 ng/m^3 total PAH concentration was observed at MW site on April. While, the highest of 23.87 ng/m^3 PAHs concentrations was observed at SP site on February. In the other hand, the total PAHs concentration in wet season were decreased with 0.76, 1.74, 0.77, 1.52 and 1.13 ng/m^3 at TS, SP, MW, MS and SD sites respectively. The lowest value of 0.23 ng/m^3 PAHs concentration was observed at MS site on June. While, the highest of 3.13 ng/m^3 PAHs concentrations was observed at SP site on July.

The higher PAHs levels in dry season were mainly due to the high emission from many sources such as forest fires and agricultural burning. Additionally, the temperature inversions are trend to accumulation of these pollutants. On the contrary, the lower PAHs levels in wet season were likely attributed to the combining effects of quick atmospheric dispersion with monsoon, precipitate effect of rain, more relative humidity and high wind speed also leads to more dilution of pollutants in the ambient air. These results indicating that the PAHs concentration in the Mae Moh area was seasonal variation. However, there are no significant different between the total PAHs concentration between dry and wet season ($P > 0.05$) at every sampling site.

From the above discussion, the concentration of total PAHs and PM_{10} showed similar variation in the study. Therefore, it is necessary to investigate the relationship between PAHs and PM_{10}. Figure 4.2 shows the positive correlation between the PAHs and PM_{10} concentration in present study. The strong relationship of PAHs and PM_{10}

(Pearson correlation coefficients: r = 0.704, P-value = 0.000), illustrated that PAHs tend to absorbed on the PM_{10}.

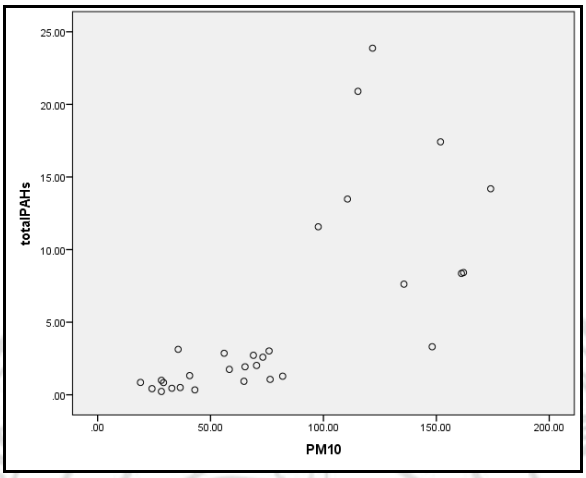

Figure 4.2 Correlation between total PAHs and PM_{10} concentrations

The comparison of average total PAHs concentration in this study with the published data in other studies was show in Table 4.9. The total of ten species PAH were included Flu, Pyr, BaA, Chr, BbF, BaP, BkF, DBA, BghiPe and IDP. The results indicating that the average total PAH concentrations in this study are lower than those in Tiajin which is an important industrial city in China. Additionally, the average total PAHs concentration in this study are comparable to those reported in Metropolitan area, Bangkok with dense heavy traffic, but are higher than those in Chiang Mai and Kozani Basin, Greece.

Table 4.9 Average total PAHs concentration in present and other studies

Source	Sample type	Average total PAHs (ng/m^3)	Reference
Mae Moh Basin, Lampang*	PM_{10}	5.26	This study
Chiang Mai*	TSP	1.73	Chuesaard *et al*., 2014 [34]
Metropolitan area, Bangkok*	PM_{10}	9.79	Norramit *et al*., 2005 [41]
Kozani Basin, Greece	PM_{10}	2.27	Tolis *et al*., 2014 [43]
Industrial area, Tiajin city, China	PM_{10}	91.63	Shi *et al*., 2010 [31]

*Thailand

4.4 Characterization of PM_{10}-bound PAHs

Specific PAHs have been suggested as being indicative for certain processes that release PAHs into the environment. These PAHs are typically called chemical markers. The individual PAHs profile can be used to determine the abundant species of different sources to PAHs concentration in particulates as showed in Figure 4.3-4.7.

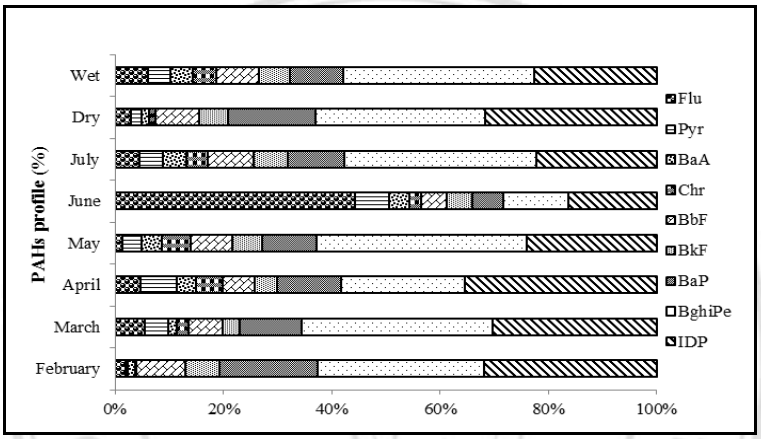

Figure 4.3 PAHs profile surrounding TS site

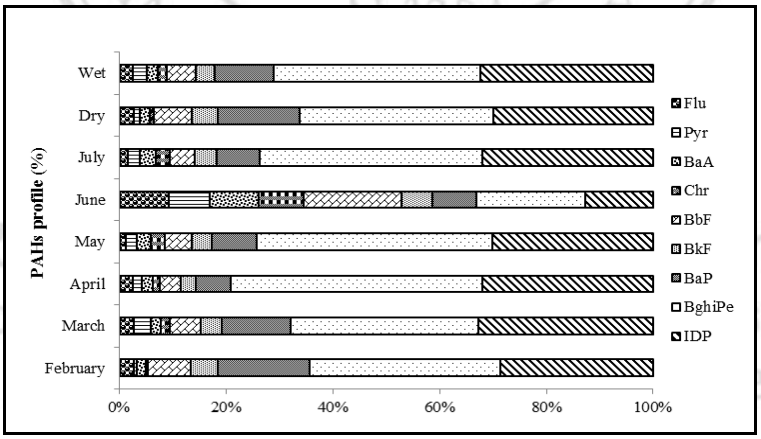

Figure 4.4 PAHs profile surrounding SP site

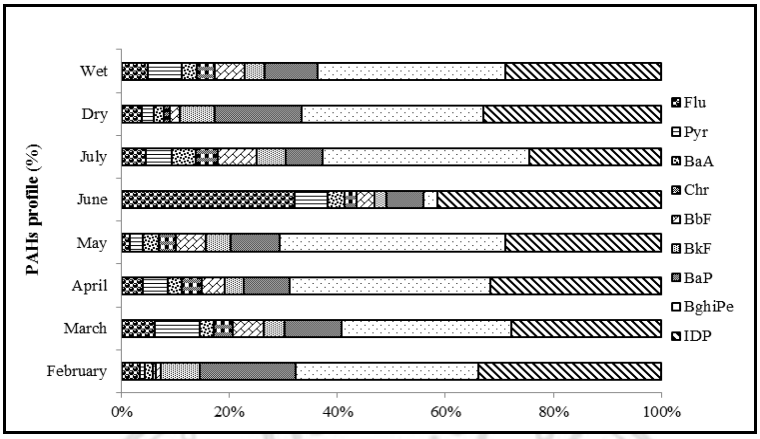

Figure 4.5 PAHs profile surrounding MW site

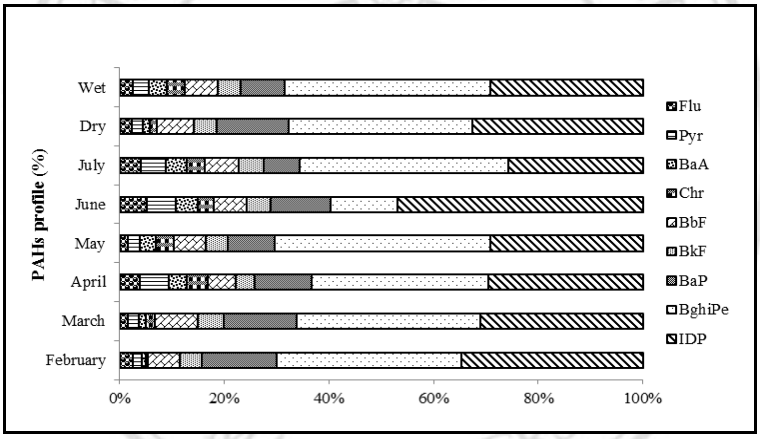

Figure 4.6 PAHs profile surrounding MS site

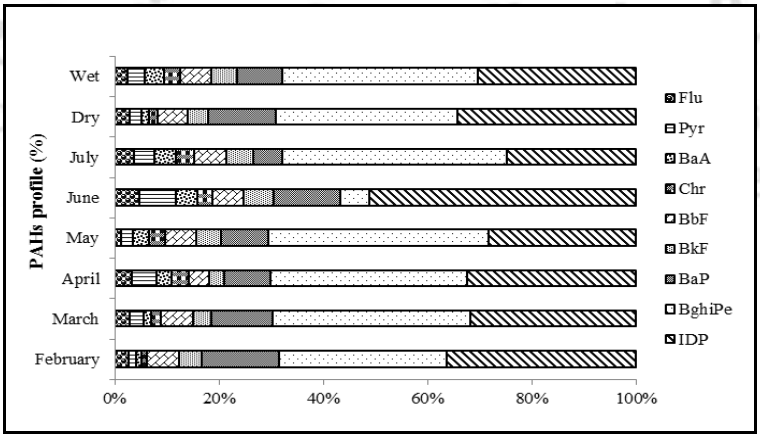

Figure 4.7 PAHs profile surrounding SD site

The PAHs profiles in TS site were similar trend in both of dry and wet season. The highest percentage of PAHs species observed were BghiPe with 31.5% following by IDP, BaP, BbF and BkF with 31.2, 15.7, 8.0 and 5.4% respectively.

The PAHs profiles in SP site were similar trend in both of dry and wet season. The highest percentage of PAHs species observed were BghiPe with 37.0% following by IDP, BaP, BbF and BkF with 30.0, 14.5, 6.9 and 4.6% respectively.

The PAHs profiles in MW site were similar trend in both of dry and wet season. The highest percentage of PAHs species observed were BghiPe with 33.7% following by IDP, BaP, BbF and Flu with 32.6, 15.4, 6.2 and 4.2% respectively.

The PAHs profiles in MS site were similar trend in both of dry and wet season. The highest percentage of PAHs species observed were BghiPe with 35.7% following by IDP, BaP, BbF and BkF with 32.1, 13.1, 6.9 and 4.4 % respectively.

The PAHs profiles in SD site were similar trend in both of dry and wet season. The highest percentage of PAHs species observed were BghiPe with 35.3% following by IDP, BaP, BbF and BkF with 33.7, 12.3, 5.9 and 4.0% respectively.

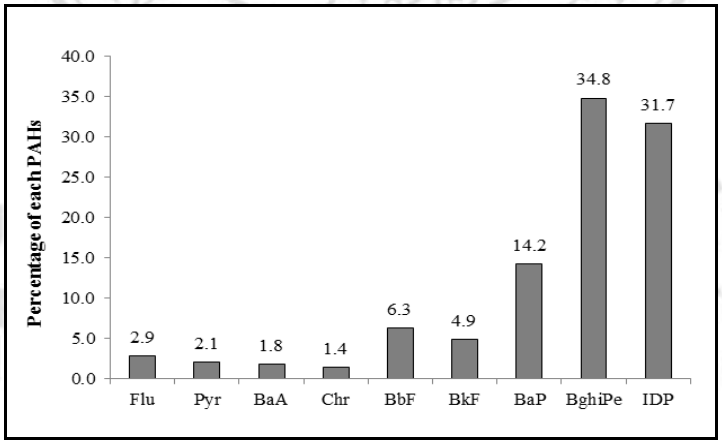

Figure 4.8 Percentage of individual PAHs in this study

Figure 4.8 gives the individual PAHs in this study with the percentage from 1.4-34.8% that the predominant PAH species were found in BghiPe with percentage of 34.8% following by IDP, BaP and BbF with percentage of 31.7, 14.2 and 6.3%, respectively. In comparison to previous studies, the predominant PAHs species of DBA, BaP, BbF and BghiPe are significant high, which indicates fuel consumption of power

plant, gasoline vehicle and biomass burning and soil dust in Ratchaburi [40]. Additionally, IDP and BghiPe are usually considerate to be indicators of traffic emissions. Oil combustion is associated with high loading of the more BbF in Harrison studies [45]. Therefore, the possible sources of PAHs in this study may come from different sources according to their different sampling locations.

4.5 Distribution patterns of PAHs in Different Rings

To assess PAH homolog distribution patterns for each sampling sites, the analyzed PAHs could be classified according to their number of aromatic rings into three categories as following: 4-rings PAHs including Flu, Pyr, BaA and Chr, 5-rings PAHs including BbF, BkF, BaP and DBA, 6-rings PAHs including BghiPe and IDP. Moreover, they can be further classified into middle molecular weight (MMW, 4-rings PAHs) and high molecular weight (HMW, 5- and 6-rings PAHs) according to their molecular weights as show in Table 4.10.

Table 4.10 PAHs concentration based on their rings number and molecular weight

Molecular weight	Rings	PAHs concentration (ng/m^3) in each site				
		TS	SP	MW	MS	SD
MMW	4-rings	0.44	0.47	0.40	0.46	0.38
	Total	0.44	0.47	0.40	0.46	0.38
HMW	5-rings	1.58	1.74	0.97	1.43	0.97
	6-rings	3.39	4.47	2.69	3.97	3.00
	Total	4.97	6.21	3.65	5.39	3.97
Total		5.41	6.67	4.05	5.85	4.35

[4-rings PAHs] = [Flu] + [Pyr] + [BaA] + [Chr]

[5-rings PAHs] = [BbF] + [BkF] + [BaP] + [DBA]

[6-rings PAHs] = [BghiPe] + [IDP]

This study revealed that middle molecular weight PAHs (4-rings) represented only a small portion of the total PAHs concentration with 0.46, 0.38, 0.44, 0.40, 0.40.44, 0.47, 0.40, 0.46, 0.38 ng/m^3 at TS, SP, MW, MS and SD sites, respectively. The most PAHs being of high molecular weight with 4.97, 6.21, 3.65, 5.39 and 3.97 ng/m^3 at TS, SP, MW, MS and SD sites respectively. The percentage of ring number distribution pattern of PAHs in each sampling sites are presented in Figure 4.9-4.13.

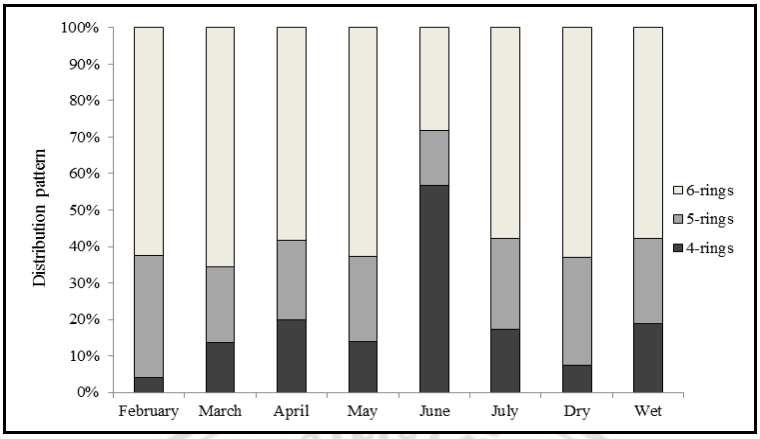

Figure 4.9 Distribution patterns of PAHs surrounding TS site

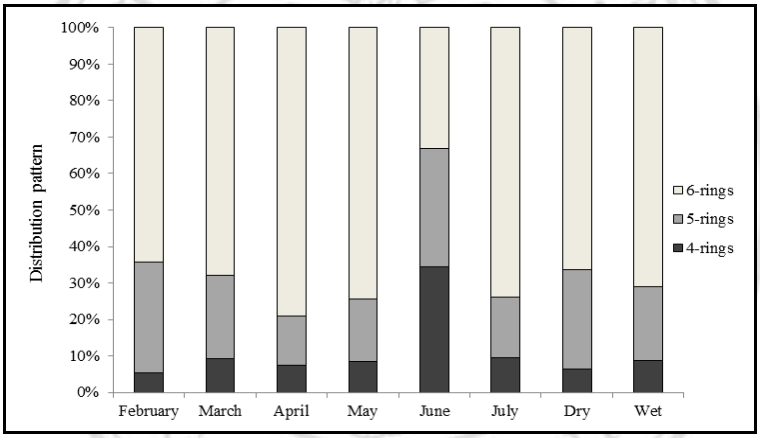

Figure 4.10 Distribution patterns of PAHs surrounding SP site

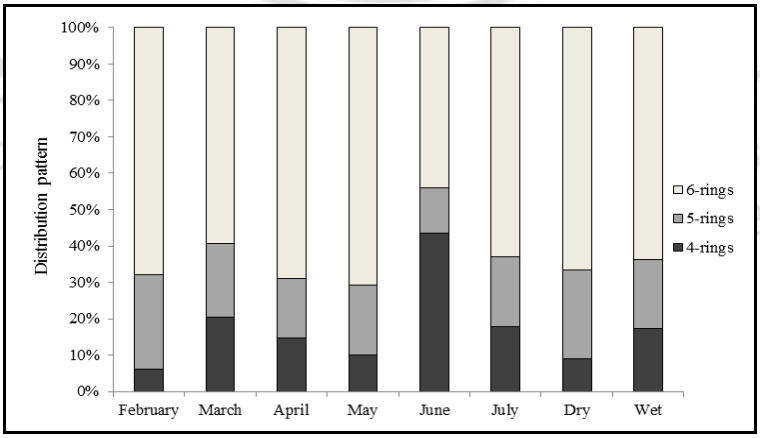

Figure 4.11 Distribution patterns of PAHs surrounding MW site

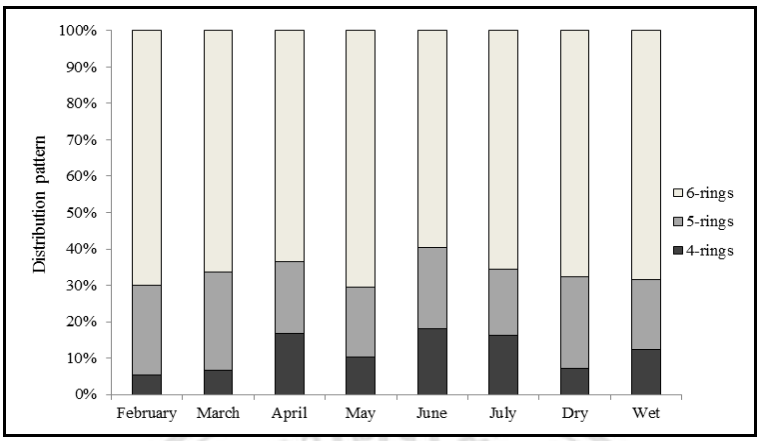

Figure 4.12 Distribution patterns of PAHs surrounding MS site

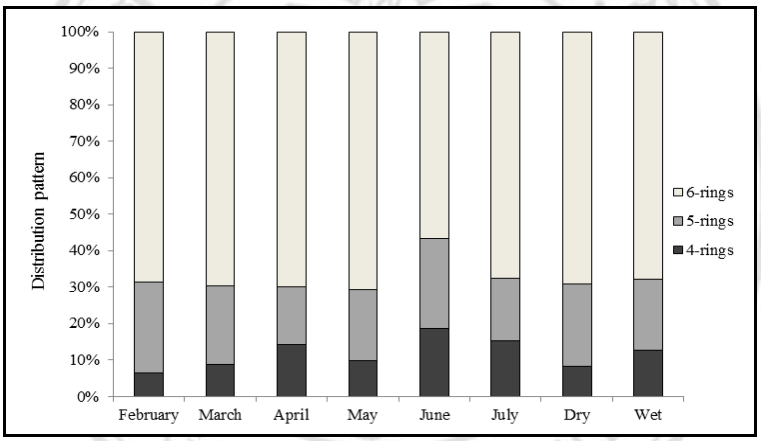

Figure 4.13 Distribution patterns of PAHs surrounding SD site

It can be found similar patterns that the PAHs with 5- and 6-ring are dominant in PM_{10} during sampling period. Although, the results show that mostly their percentage ranged in 28.3 – 79.2% of 5- and 6-ring PAHs and it may be associated with vehicles emission, and can be regards as tracers for this source, which is inconsistent with the results of Pengchai and group in 2009. However, it's interesting to find that the percentage of 4-ring PAHs (56.6, 43.4 and 34.4%) were higher in 5- and 6-rings PAH during June at TS, MW and SP where is all of these sampling sites was located in different part of Mae Moh district and closed the power plant than other sites. This may be due to different emission sources of PAHs as well as physical and chemical transformation of the compounds in the air. Additionally, Ravindra and group in 2008 have been indicated that the major source for 4-ring PAHs are usually associated with wood and coal combustion and can be identified from this source [46].

Compared to previous study, Phuthiwat and Junyaporn were studied the size distribution of PAHs during haze period in Hangchat district, Lampang province. The results found the most 5- and 6-rings PAHs are observed during haze period while the 3-and 4-rings PAHs are presented in rice straw burning period [14]. Moreover, Keshtkar and Ashbaugh (2007) reported that high molecular weight PAHs (5- and 6-rings PAHs) are more carcinogenic potential than low molecular weight PAHs [47].