CHAPTER 4

RESULTS

4.1 Samples Integrity and Analytical Quality

Ambient air samples were collected every 6 days at 4 stations during July 2003 to February 2004 covering both the southwest (SW) and northeast (NE) monsoon seasons. Seventy-eight ambient air samples were collected (Table 4.1). However, due to initial problems on GC equipment, only 68 samples were completely analyzed. Air samples were collected at one station each day because there was only one set of sampling train. The sequence of collection was Din Daeng (DD), Chandrakasem (JK), Ban Somdej Chao Praya (BS), and Ratburana (RB). The analytical work was performed on the 2 days when there was no sampling work. Table 4.2 shows the detail of the sample collection plan and the actual sampling dates. When there was a problem on the GC facility the sampling work stopped, because the sorbent tubes could not be cleaned for reuse. When there was heavy rain from early morning and it continued into late morning, the sampling work was not done because high humidity inhibits the ability of the sorbent tube. Table 4.3 summarizes the number of analyzed samples with wind direction. Wind direction data was obtained from PCD stations. Wind direction at each station was summarized.

Table 4.1 The Number of Samples Collected and Analyzed

Stations	Number of samples			
	July 03 –October 03		November 03-February 04	
	Sampled	Analyzed	Sampled	Analyzed
Din Daeng	9	6	10	10
Chandrakasem	11	9	10	8
Ban Somdej	9	8	10	10
Ratburana	9	7	10	10
Total	**38**	**30**	**40**	**38**

Table 4.2 Detail of the Sampling Plan and Actual Sampling Dates

Day	July, 03	Aug, 03	Sep, 03	Oct, 03	Nov, 03	Dec, 03	Jan, 04	Feb, 04
Mon			1 DD			1 JK		
Tue	1		2 JK			2 RB		
Wed	2		3 RB	1 DD*		3 BS		
Thru	3		4 BS	2 JK		4	1 RB	
Fri	4	1	5	3 RB		5	2 BS	
Sat	5	2 DD	6	4 BS	1	6 DD	3	
Sun	6	3 JK	7 DD	5	2	7 JK	4	1 BS
Mon	7	4 RB	8 JK	6	3	8 RB	5 DD	2
Tue	8	5 BS	9 RB	7 DD	4	9 BS	6 JK	3
Wed	9 DD	6	10 BS	8 JK	5	10	7 RB	4 DD
Thru	10 JK	7	11	9 RB	6 DD	11	8 BS	5 JK
Fri	11 RB	8 DD	12	10 BS	7 JK	12 DD	9	6 RB
Sat	12 BS	9 JK	13 DD	11	8 RB	13 JK	10	7 BS
Sun	13	10 RB	14 JK	12	9 BS	14 RB	11 DD	8
Mon	14	11 BS	15 RB	13 DD	10	15 BS	12 JK	9
Tue	15 DD	12	16 BS	14 JK	11	16	13 RB	10 DD
Wed	16 JK	13	17	15 RB	12 DD	17	14 BS	11 JK
Thru	17 RB	14 DD	18	16 BS	13 JK	18 DD	15	12 RB
Fri	18 BS	15 JK	19 DD*	17	14 RB	19 JK	16	13 BS
Sat	19	16 RB	20 JK	18	15 BS	20 RB	17 DD	14
Sun	20	17 BS	21 RB*	19 DD	16	21 BS	18 JK	15
Mon	21 DD	18	22 BS	20 JK	17	22	19 RB	16 DD
Tue	22 JK	19	23	21 RB	18 DD	23	20 BS	17 JK
Wed	23 RB	20 DD	24	22 BS	19 JK	24 DD	21	18 RB
Thru	24 BS	21 JK	25 DD	23	20 RB	25 JK	22	19 BS
Fri	25	22 RB	26 JK	24	21 BS	26 RB	23 DD	20
Sat	26	23 BS	27 RB	25	22	27 BS	24 JK	21
Sun	27 DD	24	28 BS	26	23	28	25 RB	22 DD
Mon	28 JK	25	29	27	24 DD	29	26 BS	23 JK
Tue	29 RB	26 DD	30	28	25 JK	30 DD	27	24 RB
Wed	30 BS	27 JK		29	26 RB	31 JK	28	25 BS
Thru	31	28 RB		30	27 BS		29 DD	26
Fri		29 BS		31	28		30 JK	27
Sat		30			29		31 RB	28
Sun		31			30 DD			29

Note: * Heavy rain from early morning

During July, August to September and October to January, there were problems on the GC facility

[shaded box] Actual sampling dates

Table 4.3 Day of Analyzed Samples and Wind Direction

Day	July, 03	Aug, 03	Sep, 03	Oct, 03	Nov, 03	Dec, 03	Jan, 04	Feb, 04
Mon			1			NE		
Tue	1		2			NE		
Wed	2		3	1		NE		
Thru	3		4	SW-NE		4	1	
Fri	4	1	5	SW-NE		5	2	
Sat	5	2 DD	6	SW-NE	1	NE	3	
Sun	6	SW	7	5	2	7 JK	4	1
Mon	7	SW	8	6	3	NE	5	2
Tue	8	SW	9	SW-NE	4	NE	6	3
Wed	9 DD	6	10	SW-NE	5	10	7	SW-NE
Thru	10 JK	7	11	SW-NE	NE	11	8	SW-NE
Fri	11 RB	SW	12	SW-NE	NE	NE	9	SW-NE
Sat	12 BS	SW	13	11	NE	NE	10	SW-NE
Sun	13	10	14	12	NE	NE	11	8
Mon	14	11	15	SW-NE	10	NE	12	9
Tue	15 DD	12	16	SW-NE	11	16	13	10
Wed	16 JK	13	17	SW-NE	NE	17	14	11
Thru	17 RB	14	18	SW-NE	NE	18	15	12
Fri	18	15	19	17	NE	19	16	13
Sat	19	16	SW	18	NE	20	17	14
Sun	20	17	21	SW-NE	16	21	18	15
Mon	21	18	SW	SW-NE	17	22	19	SW-NE
Tue	22	19	23	SW-NE	SW-NE	23	20	SW-NE
Wed	23	20	24	SW-NE	SW-NE	24	21	SW-NE
Thru	24	21	SW-NE	23	SW-NE	25	22	SW-NE
Fri	25	22	SW-NE	24	NE	26	23	20
Sat	26	23	SW-NE	25	22	27	24	21
Sun	SW	24	SW-NE	26	23	28	25	SW-NE
Mon	SW	25	29	27	NE	29	26	SW-NE
Tue	SW	26	30	28	25 JK	30	27	SW-NE
Wed	SW	27		29	NE	31	28	SW-NE
Thru	31	28		30	NE		29	26
Fri		29		31	28		30	27
Sat		30			29		31	28
Sun		31			NE			29

(shaded) Wind direction on days with analyzed samples

The analytical results of 3 replications of mixed standard gases showed the RSD of around 8.2% (Table 4.3). The percentage of VOCs recovery with thermal desorption varied from species to species. The mean value of the recovery was 95.0 ± 7.9%.

Table 4.4 Analytical Results of the Mixed Standard Gases

VOC species	Concentration, ppbC	Retention time, min			Area			% Recovery
		Mean	SD	%RSD	Mean	SD	% RSD	
1- Pentene	540	5.145	0.005	0.098	8867886	2514292	28.4	101.2
n-Pentane	545	5.286	0.005	0.097	11731493	2558577	21.8	93.7
trans-2-Pentene	545	5.629	0.006	0.099	7193721	927550	12.9	91.4
Isoprene	555	5.845	0.006	0.105	5224393	628260	12.0	77.3
2-Methylpentane	654	7.683	0.006	0.078	11789451	377545	3.2	96.5
Cyclopentane	535	7.771	0.006	0.071	9239334	617805	6.7	91.7
3-Methylpentane	654	8.351	0.010	0.122	9336678	242405	2.6	96.1
n-Hexane	654	9.159	0.008	0.082	10634903	334092	3.1	99.6
Cyclohexane	648	12.995	0.010	0.077	9368257	223613	2.4	93.8
Benzene	648	14.055	0.011	0.078	9068236	1303968	14.4	110.6
2,2,4-Trimethylpentane	872	14.381	0.012	0.083	26824614	2173556	8.1	93.3
n-Heptane	749	15.122	0.013	0.086	14670123	737054	5.0	102.9
Toluene	749	21.211	0.018	0.084	9775207	143015	1.5	104
n-Octane	856	21.896	0.016	0.072	17939870	785800	4.4	98.7
m/p-Xylene	840	28.249	0.019	0.068	11343398	477239	4.2	93.9
n-Nonane	945	28.625	0.017	0.058	23448630	410511	1.8	92.1
1,3,5-Trimethylbenzene	972	34.692	0.018	0.053	12590553	656699	5.2	89.6
n-Decane	1050	35.028	0.023	0.064	29040087	3049015	10.5	83.7
Average							**8.2**	**95.0**

Note: The percentage of VOC recovery with thermal desorption was checked by Dr. Ian Weeks

4.2 VOC Concentrations in Bangkok Ambient Air

4.2.1 VOC Concentrations during the Southwest Monsoon Season

Thirty samples were completely analyzed during the southwest monsoon season (SW). The average concentrations of 18 VOC species are shown in Table 4.5. The three highest concentrations of VOC species in alkane, alkene and aromatic groups can be described as follows:

Stations	C5-C10 Alkanes	C5-Alkenes	Aromatics
Din Daeng (DD)	n-Pentane n-Nonane 3-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene m/p-Xylene 1,3,5-Trimethylbenzene
Chandrakasem (JK)	n-Decane n-Nonane 2-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene 1,3,5-Trimethylbenzene m/p-Xylene
Ban Sondej (BS)	n-Decane n-Nonane 2-Methylpentane	Isoprene 1-Pentene trans-2-Pentene	Toluene 1,3,5-Trimethylbenzene m/p-Xylene
Ratburana (RB)	n-Decane Cyclohexane n-Nonane	Isoprene 1-Pentene trans-2-Pentene	Toluene 1,3,5-Trimethylbenzene m/p-Xylene

The data of VOC concentrations on each day and at each station are shown in Appendix B. Figure 4.1 to Figure 4.4 show the 18 VOC concentrations at each station during the SW monsoon season (July-October 2003) and Figure 4.5 compares average VOC concentrations found at each station.

Table 4.5 VOC Concentrations at 4 Stations during the Southwest Monsoon

Unit : ppbC

VOC species	Average VOC Concentrations			
	Din Daeng	Chandrakasem	Ban Somdej	Ratburana
Alkanes				
n-Pentane, C5	**68.8**	23.8	13.7	14.1
2-Methylpentane, C6	33.7	**25.9**	**14.1**	15.1
Cyclopentane, C5	33.8	4.4	7.8	8.0
3-Methylpentane, C6	**58.4**	22.9	13.1	14.0
n-Hexane, C6	31.7	14.2	8.9	23.3
Cyclohexane, C6	52.3	1.5	2.0	**67.5**
n-Heptane, C7	19.2	7.2	11.3	6.7
n-Octane, C8	13.2	12.5	12.4	7.0
2,2,4-Trimethylpentane, C8	5.7	2.8	1.8	1.2
n-Nonane, C9	**60.4**	**62.4**	**62.1**	**36.3**
n-Decane, C10	23.3	**146.7**	**153.1**	**91.5**
Alkenes				
1- Pentene, C5	**9.5**	**3.7**	**2.8**	**2.1**
trans-2-Pentene, C5	**14.6**	**5.6**	**1.9**	**1.8**
Isoprene, C5	**17.9**	**13.2**	**8.3**	**7.2**
Aromatics				
Benzene, C6	56.8	38.8	35.0	48.1
Toluene, C7	**222.8**	**210.0**	**200.6**	**134.6**
m/p-Xylene, C8	**181.7**	**146.0**	**161.7**	**86.7**
1,3,5-Trimethylbenzene, C9	**68.8**	**150.4**	**181.7**	**101.1**
Total Identified VOCs	972.6	892.2	892.2	666.5

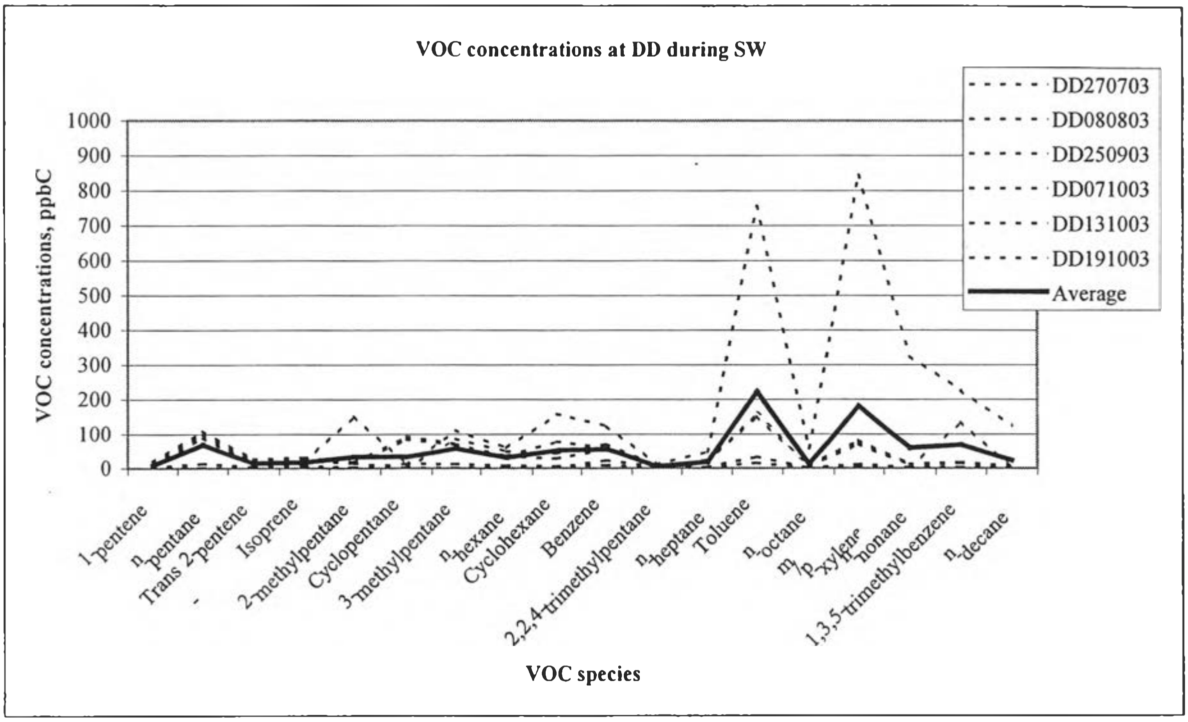

Figure 4.1 VOC Concentrations at DD Station during the SW Monsoon

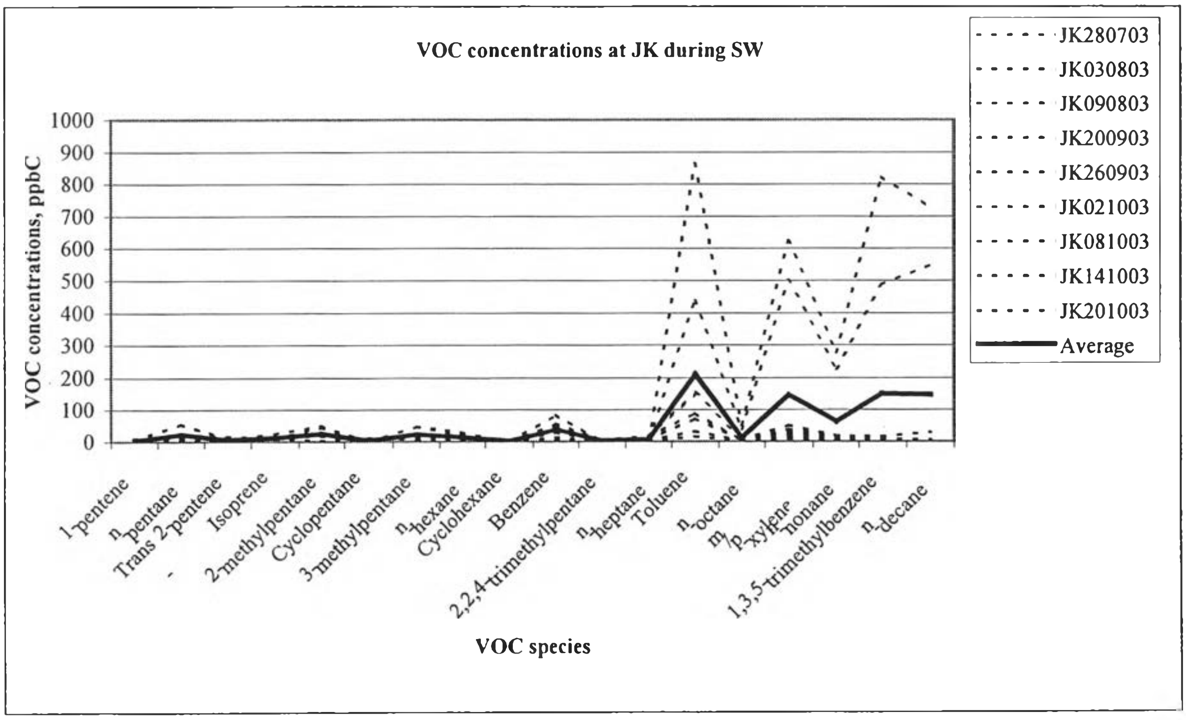

Figure 4.2 VOC Concentrations at JK Station during the SW Monsoon

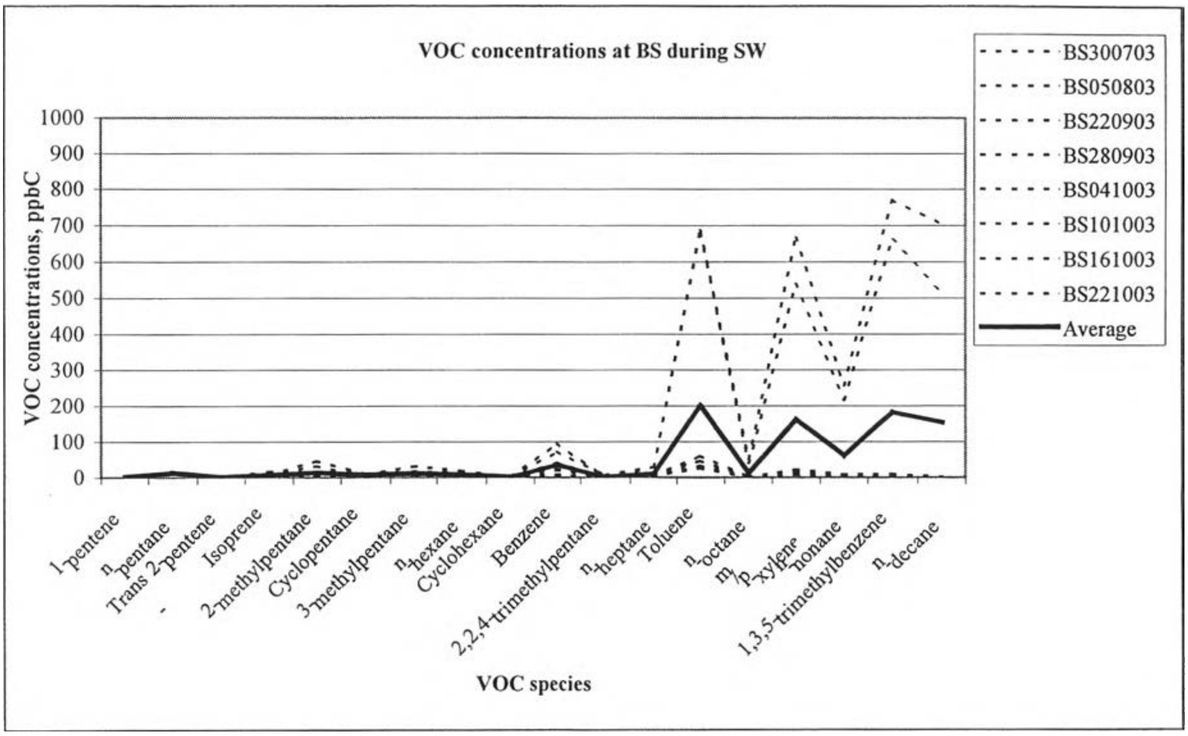

Figure 4.3 VOC Concentrations at BS Station during the SW Monsoon

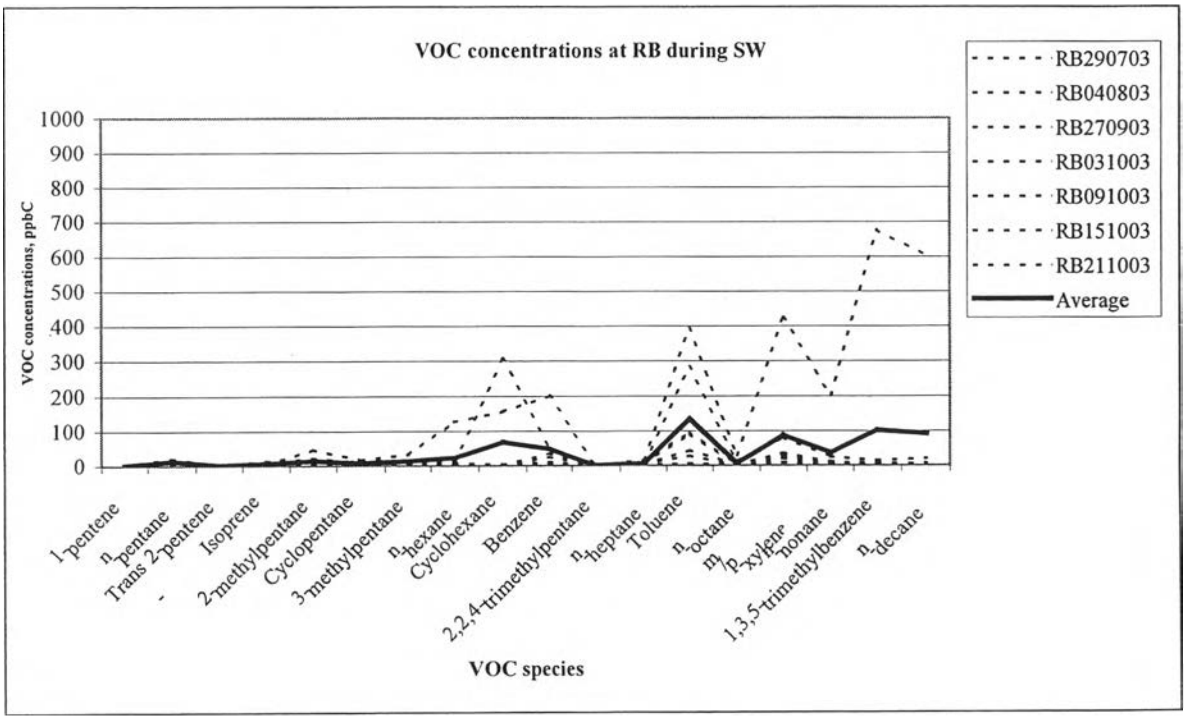

Figure 4.4 VOC Concentrations at RB Station during the SW Monsoon

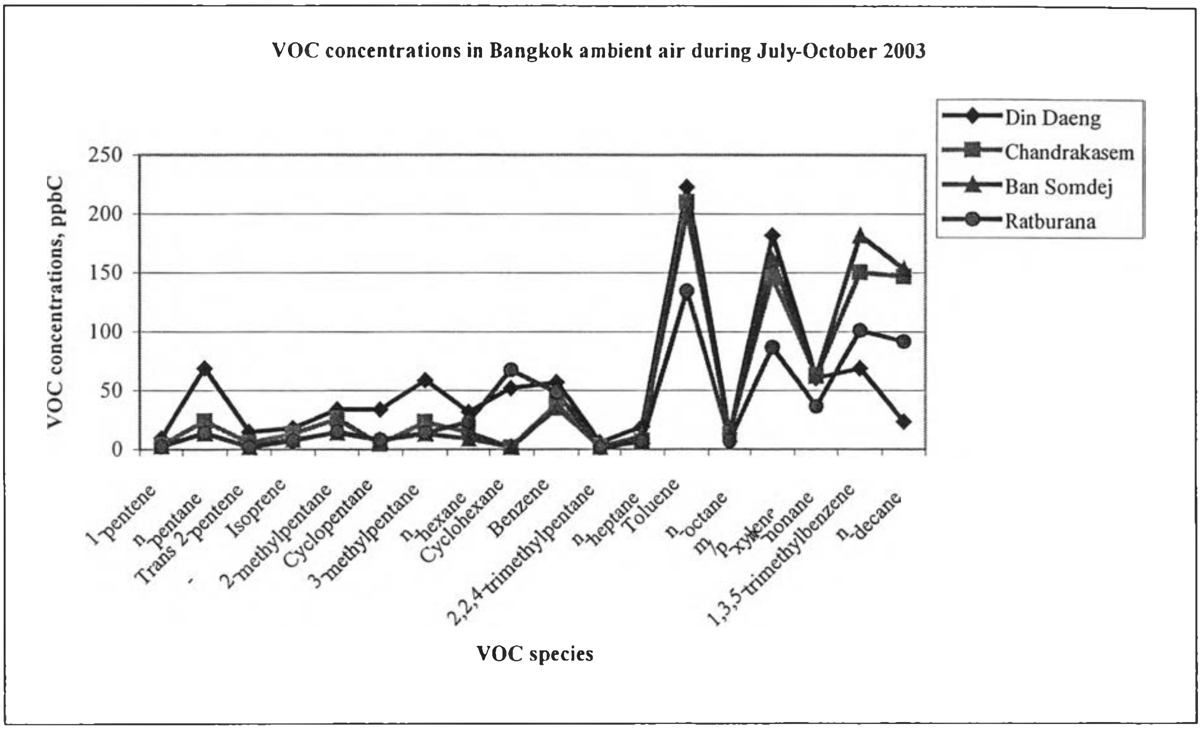

Figure 4.5 VOC Concentrations at the 4 Stations during the SW Monsoon

4.2.2 VOC Concentrations during the Northeast Monsoon Season

Thirty-eight samples were completely analyzed. The average concentrations of 18 VOC species are shown in Table 4.6. The three highest concentrations of VOC species in alkane, alkene and aromatic groups can be described as follows:

Stations	C5-C10 Alkanes	C5-Alkenes	Aromatics
Din Daeng (DD)	Cyclopentane n-Pentane 3-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene m/p-Xylene Benzene
Chandrakasem (JK)	3-Methylpentane n-Pentane 2-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene m/p-Xylene Benzene
Ban Sondej (BS)	3-Methylpentane n-Pentane 2-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene Benzene m/p-Xylene
Ratburana (RB)	n-Pentane 3-Methylpentane 2-Methylpentane	Isoprene trans-2-Pentene 1-Pentene	Toluene m/p-Xylene Benzene

The data of VOC concentrations on each day and at each station are shown in Appendix B. Figure 4.6 to Figure 4.9 show the 18 VOC concentrations at each station during the NE monsoon season (November 2003 to February 2004) and Figure 4.10 compares average VOC concentrations found at each station.

Table 4.6 VOC Concentrations at 4 Stations during the Northeast Monsoon

Unit : ppbC

VOC species	Mean VOC Concentrations			
	Din Daeng	Chandrakasem	Ban Somdej	Ratburana
Alkanes				
n-Pentane, C5	**39.9**	**19.0**	**14.0**	**9.6**
2-Methylpentane, C6	21.7	**18.8**	**12.0**	**8.2**
Cyclopentane, C5	**40.8**	11.3	8.7	4.8
3-Methylpentane, C6	**38.7**	**19.4**	**14.2**	**8.5**
n-Hexane, C6	21.5	11.5	8.5	5.4
Cyclohexane, C6	19.5	10.9	6.9	4.8
n-Heptane, C7	11.0	6.6	5.4	3.6
n-Octane, C8	2.9	1.6	1.4	1.4
2,2,4-Trimethylpentane, C8	1.5	1.0	1.4	0.9
n-Nonane, C9	3.4	2.6	2.9	3.0
n-Decane, C10	3.0	2.9	2.6	3.7
Alkenes				
1- Pentene, C5	**4.2**	**3.3**	**1.9**	**1.7**
trans-2-Pentene, C5	**6.8**	**6.3**	**2.0**	**3.0**
Isoprene, C5	**11.8**	**8.2**	**7.4**	**6.8**
Aromatics				
Benzene, C6	**30.3**	**15.9**	**14.0**	**9.5**
Toluene, C7	**101.4**	**73.4**	**50.3**	**40.3**
m/p-Xylene, C8	**32.9**	**18.3**	**13.7**	**11.1**
1,3,5-Trimethylbenzene, C9	8.7	3.9	3.0	2.3
Total Identified VOCs	400.0	235.0	170.3	128.6

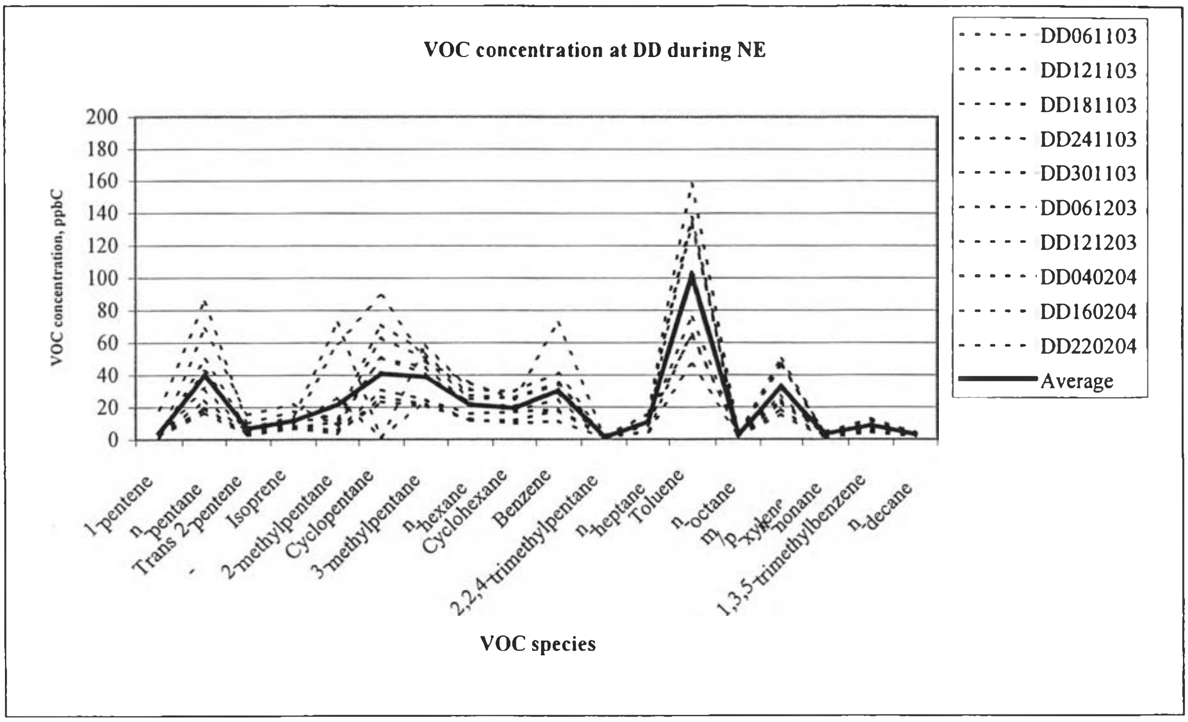

Figure 4.6 VOC Concentrations at DD Station during the NE Monsoon

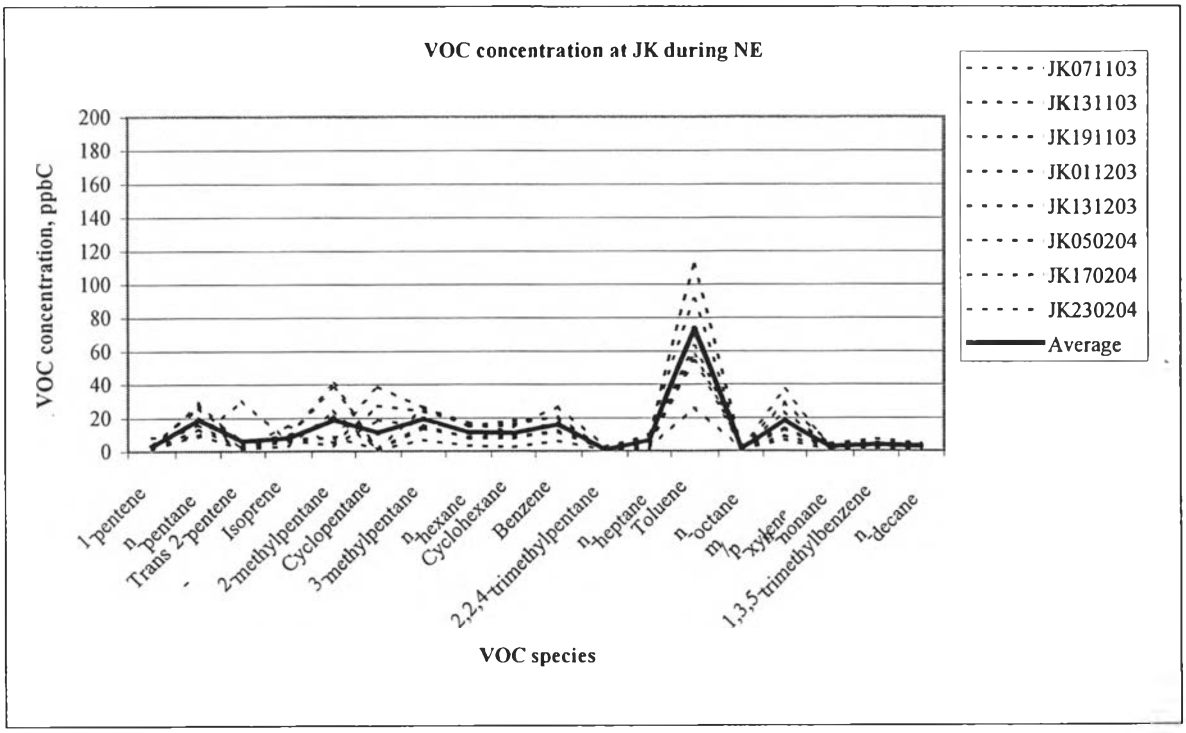

Figure 4.7 VOC Concentrations at JK Station during the NE Monsoon

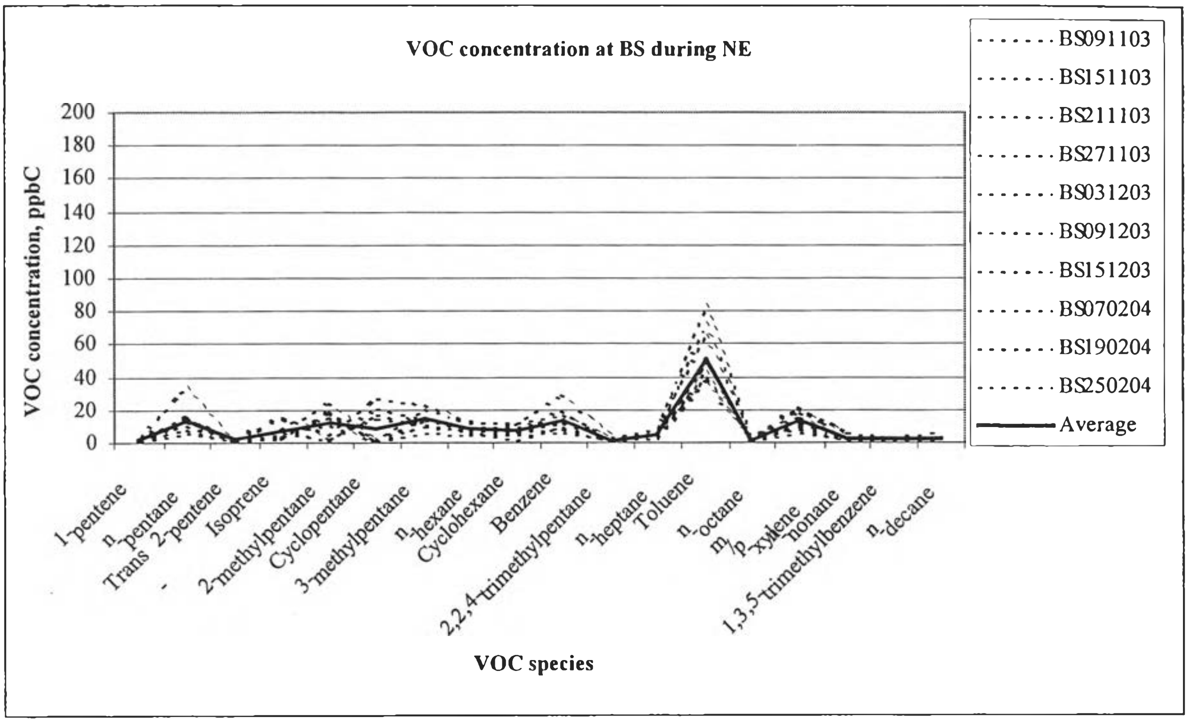

Figure 4.8 VOC Concentrations at BS Station during the NE Monsoon

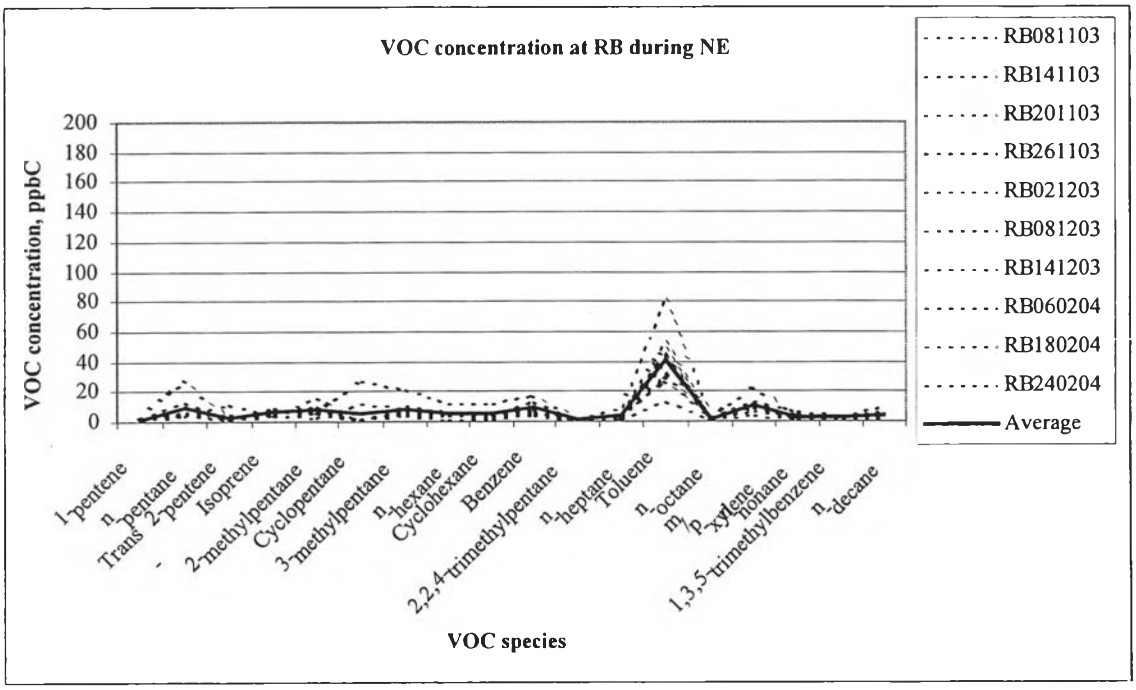

Figure 4.9 VOC Concentrations at RB Station during the NE Monsoon

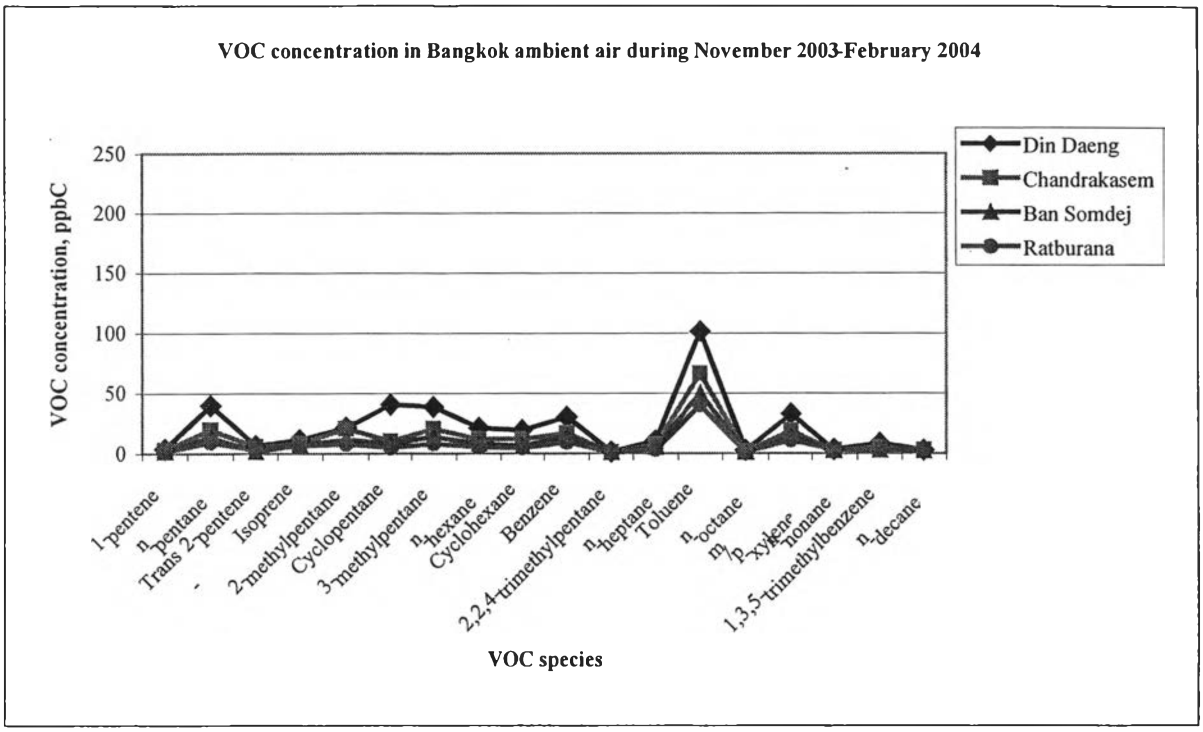

Figure 4.10 VOC Concentrations at the 4 Stations during the NE Monsoon

4.2.3 VOC Concentrations during the SW & NE Monsoons

The results of VOC concentrations in Bangkok ambient air showed higher concentrations during the SW monsoon season than during the NE monsoon season. Figures 4.11 - 4.14 show the comparison of VOC concentrations during the SW and NE monsoons at the 4 sampling stations.

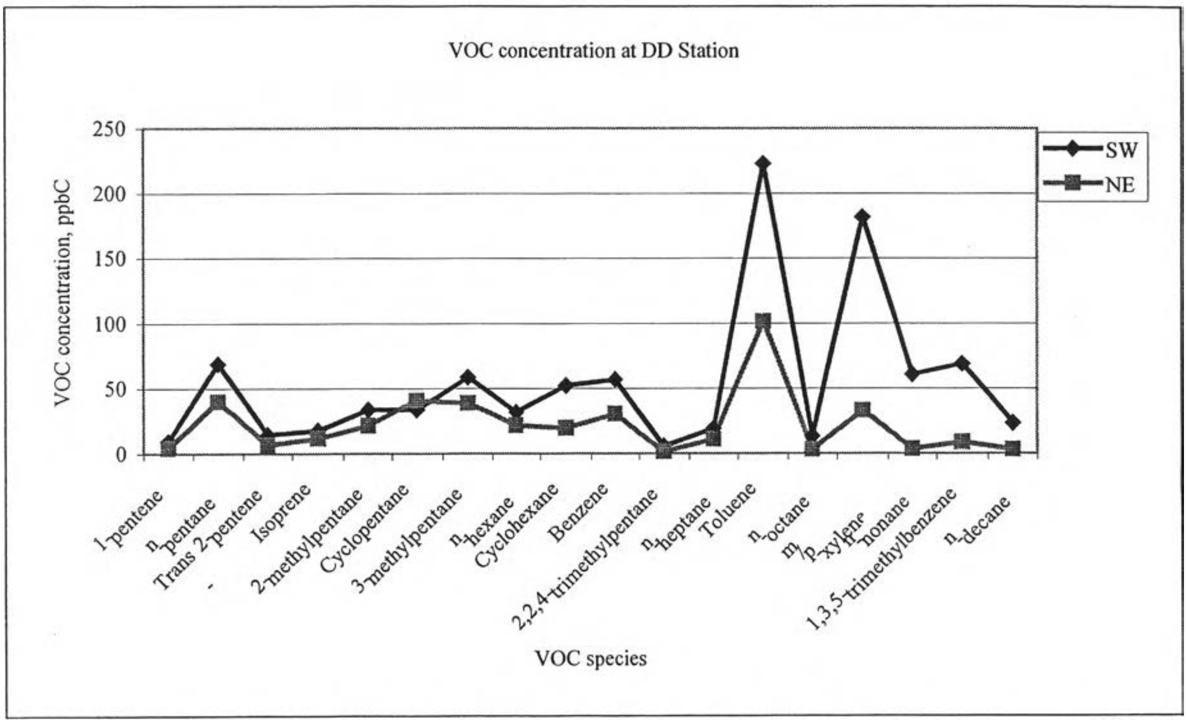

Figure 4.11 Seasonal VOC Concentrations at DD Station

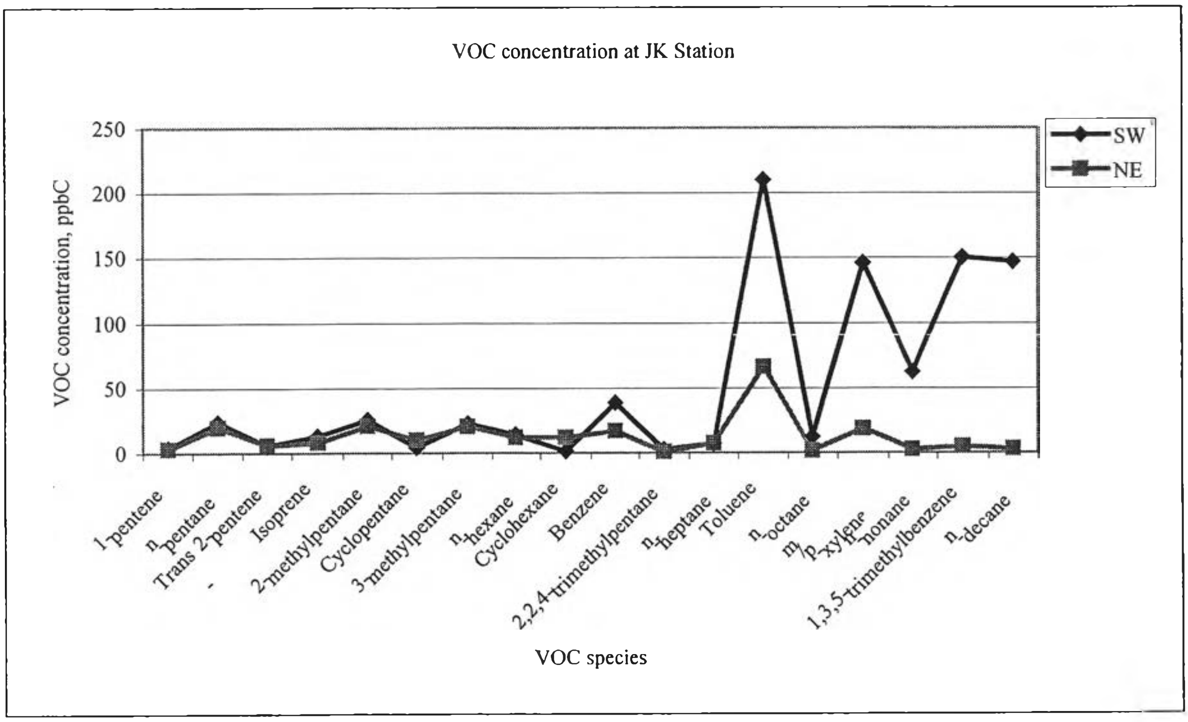

Figure 4.12 Seasonal VOC Concentrations at JK Station

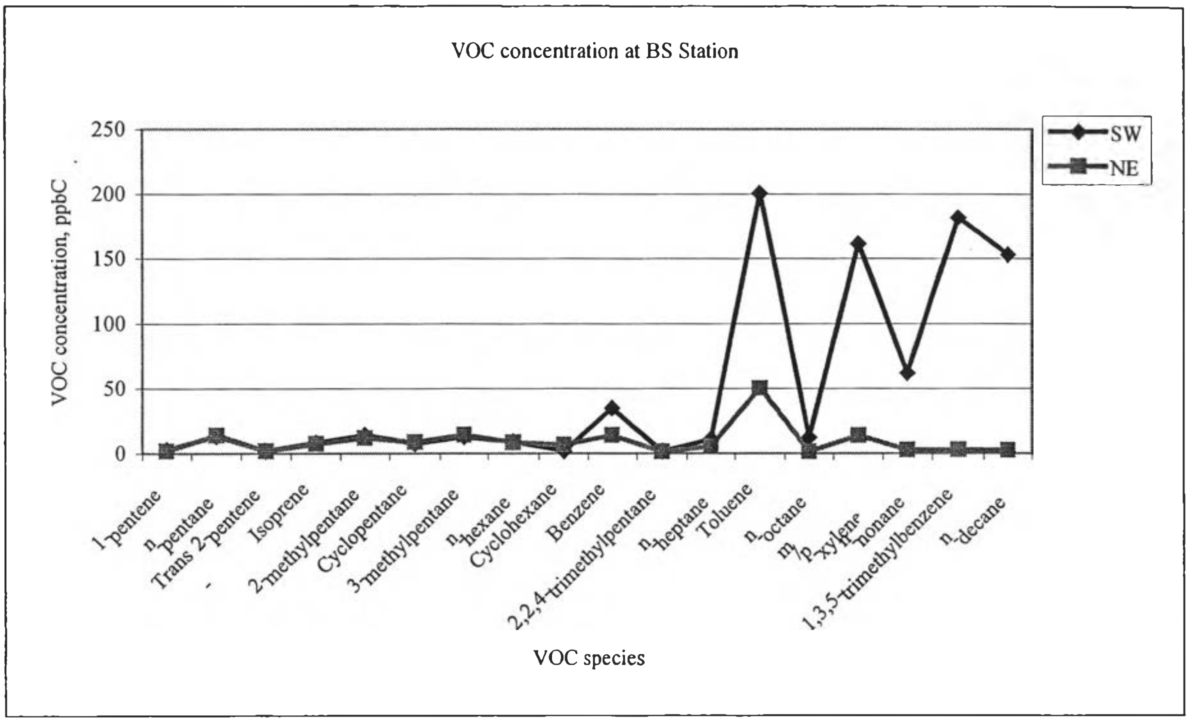

Figure 4.13 Seasonal VOC Concentrations at BS Station

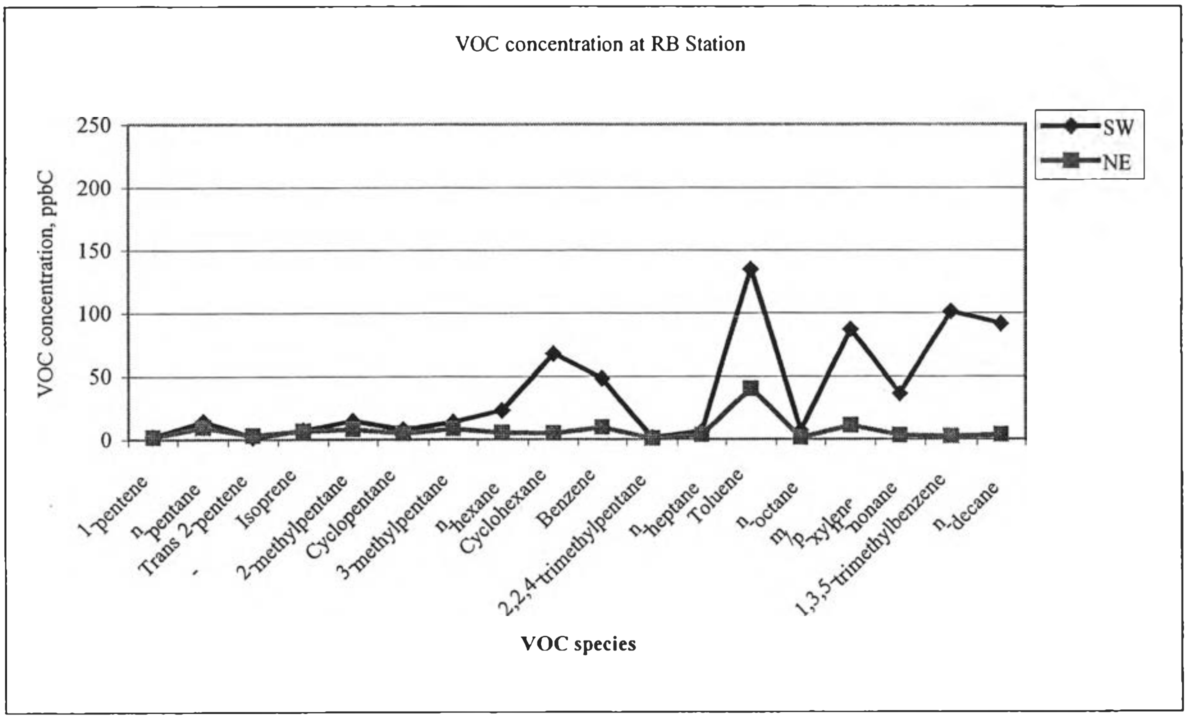

Figure 4.14 Seasonal VOC Concentrations at RB Station

4.3 Total Identified VOCs (TVOC) in Bangkok Ambient Air

TVOC concentrations during the SW monsoon at all stations were higher than the concentrations during the NE monsoon. TVOC during the SW monsoon had an average range of 666.5 – 972.6 ppbC and during the NE monsoon had an average range of 128.6 - 400.0 ppbC.

DD station had the highest concentrations. JK and BS stations had similar concentrations and RB station recorded the lowest. Table 4.7 shows TVOC concentrations at each station during the 2 monsoon seasons.

Table 4.7 TVOC Concentrations at Each Station during the 2 Monsoon Seasons

Unit: ppbC

Day	SW				NE			
	DD	JK	BS	RB	DD	JK	BS	RB
Monday	794.4	453.8 99.1*	158.0	2,799.1	498.4 604.6	256.7 177.3	144.3	99.2
Tuesday	840.1	240.9	3,351.0	1,046.2 96.2*	559.2	173.8	123.1	116.1 92.1
Wednesday	-	285.0	2,908.5 104.4*	64.4	435.1 271.4	340.8	218.1 100.0	123.7 140.7
Thursday	723.1	463.6	107.2	155.4	581.3	170.5 339.1	134.0 200.2	100.6
Friday	204.2	442.3	141.2	225.3	382.6	299.3	146.6	151.2 130.2
Saturday	-	3,534.0 106.0	195.8	278.8	250.7	122.2	173.6 163.7	267.6
Sunday	3,138.4 135.2*	2,405.0	171.5	-	224.5 192.3	-	299.5	63.6
Maximum	3,138.4	3,534.0	3,351.0	2,799.1	604.6	340.8	299.5	267.6
Average	**972.6**	**892.2**	**892.2**	**666.5**	**400.0**	**235.0**	**170.3**	**128.6**
Minimum	135.2	99.1	107.2	64.4	192.3	122.2	100.0	63.6

* During declared holidays for the APEC Conference

4.4 Emission Source Profiles

There are nine emission source profiles of VOCs included in the study: (1) the exhaust gas from tailpipes of gasoline vehicles, (2) the exhaust gas from tailpipes of diesel vehicles, (3) the vapor of gasoline, (4) flue gas from fuel oil boilers, (5) the vapor of solvent-based paints, (6) liquid thinners, (7) smoke from biomass burning, (8) smoke from food barbequing on charcoal stoves, and (9) air samples from a municipal waste disposal site.

Four emission source profiles of exhaust gas of gasoline vehicles, exhaust gas of diesel vehicles, flue gas from fuel oil boilers, and smoke from biomass burning are existing source profiles (Limpaseni et al., 2003).

Five new emission source profiles were made in this study. These were the vapor of gasoline, the vapor of solvent-based paints, liquid thinners, smoke from food barbequing on charcoal stoves, and air samples from municipal waste disposal sites. Table 4.8 shows the fraction of VOCs in each source.

Table 4.8 Emission Source Profiles of VOC Species

VOC species	Fraction								
	GV	VG	DV	FB	BB	BBQ	LT	VP	MW
1- Pentene	0.0068	0.0125	0.0855	0.0014	0.0163	0.0930	0.0000	0.0000	0.0000
n-Pentane	0.0746	0.1892	0.0348	0.0079	0.0214	0.1028	0.0000	0.0000	0.0184
trans-2-Pentene	0.0169	0.0200	0.0155	0.0043	0.0117	0.0164	0.0000	0.0000	0.0000
Isoprene	0.0016	0.0000	0.0003	0.0000	0.0487	0.0151	0.0000	0.0000	0.0019
2-Methylpentane	0.0832	0.2275	0.0995	0.0470	0.0457	0.0089	0.0000	0.0000	0.0032
Cyclopentane	0.0032	0.0000	0.0027	0.0003	0.0008	0.0828	0.0000	0.0000	0.0000
3-Methylpentane	0.0572	0.1299	0.0347	0.0682	0.0095	0.0068	0.0000	0.0000	0.0049
n-Hexane	0.0572	0.1274	0.0347	0.0616	0.0157	0.0848	0.0000	0.0000	0.0149
Cyclohexane	0.0516	0.0234	0.0385	0.0312	0.0118	0.0359	0.0000	0.0000	0.0425
Benzene	0.1093	0.0544	0.2677	0.0464	0.3949	0.1901	0.0000	0.0000	0.0000
2,2,4-Trimethylpentane	0.0000	0.0038	0.0000	0.0086	0.0000	0.0298	0.0000	0.0000	0.0259
n-Heptane	0.0280	0.0299	0.0176	0.0343	0.0172	0.0985	0.0000	0.0000	0.0332
Toluene	0.3103	0.1731	0.1939	0.3454	0.3108	0.1033	0.9669	0.0635	0.7400
n-Octane	0.0119	0.0000	0.0148	0.0278	0.0044	0.0934	0.0000	0.2455	0.0256
m/p-Xylene	0.1841	0.0088	0.0629	0.2201	0.0583	0.0000	0.0230	0.2964	0.0644
n-Nonane	0.0052	0.0000	0.0245	0.0272	0.0049	0.0757	0.0000	0.2306	0.0146
1,3,5-Trimethylbenzene	0.0268	0.0000	0.0252	0.0433	0.0202	0.0000	0.0101	0.0000	0.0031
n-Decane	0.0033	0.0000	0.0598	0.0250	0.0076	0.0433	0.0000	0.1640	0.0075
Total	1	1	1	1	1	1	1	1	1

Note: GV, DV, FB, and BB source profiles were tabulated from Limpaseni, et al. (2003)

The 4 Existing Source Profiles

1) The Exhaust Gas from Tailpipes of Gasoline Vehicles (GV)

The emission source profile of gasoline vehicles composes of VOCs from light duty gasoline vehicles without a catalytic converter, with a catalytic converter, 2-stroke motorcycles, and 4-stroke motorcycles. All vehicles were tested on a chassis dynamometer. Figure 4.15 shows the fraction of VOCs in exhaust gas from tailpipes of gasoline vehicles profile. In this gasoline profile, the fractions of VOCs which have a value of more than 0.1000 are toluene, xylene, and benzene.

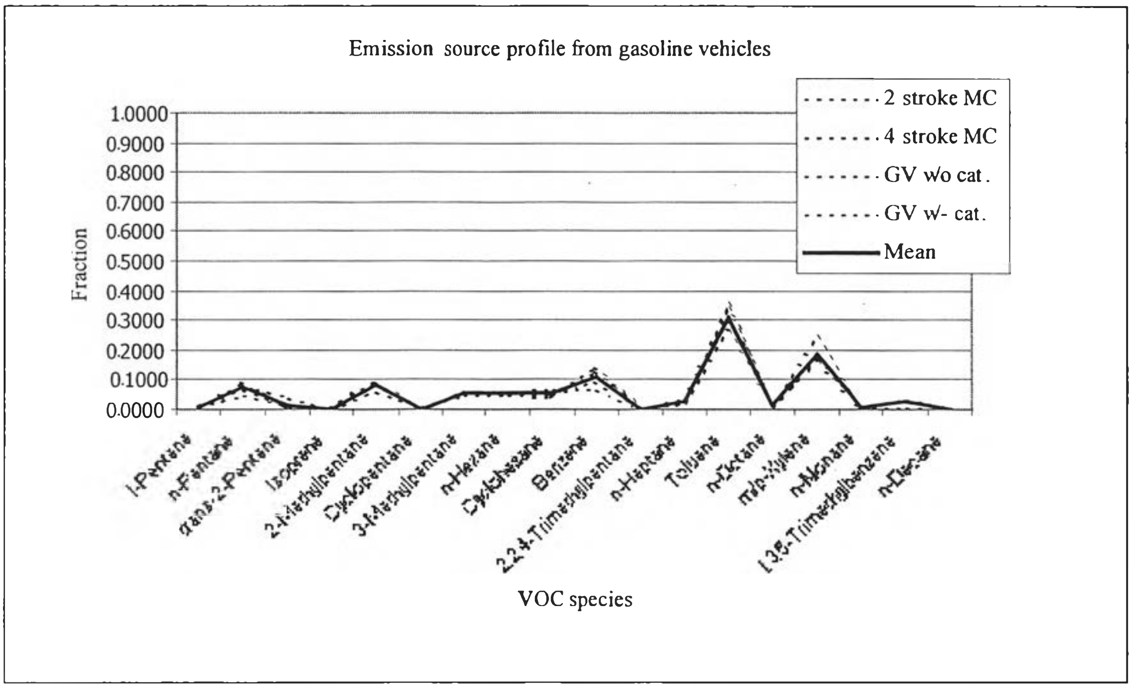

Figure 4.15 Emission Source Profile of Exhaust Gas from Gasoline Vehicles

2) The Exhaust Gas from Tailpipes of Diesel Vehicles (DV)

The emission source profile of diesel vehicles composes of VOCs from light duty diesel vehicles and heavy duty diesel vehicles. All vehicles were tested on a chassis dynamometer. Figure 4.16 shows the fraction of VOCs in exhaust gas from tailpipes of diesel vehicles. In this diesel vehicle profile, the fractions of VOCs which have a value of more than 0.1000 are benzene, and toluene.

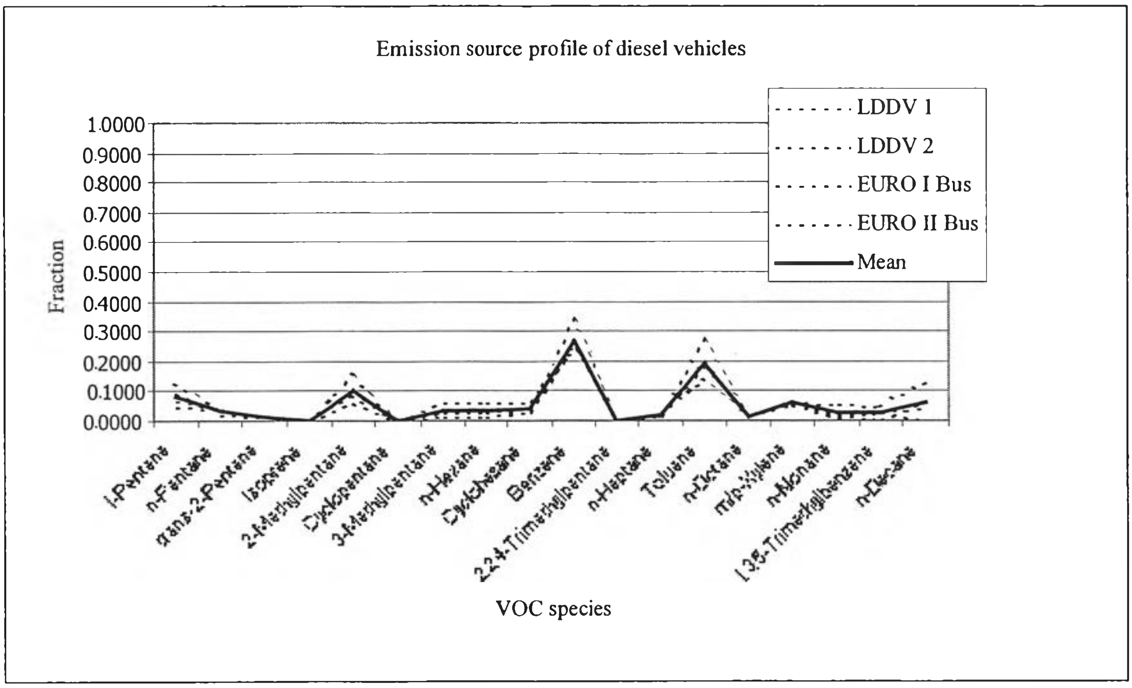

Figure 4.16 Emission Source Profile of Exhaust Gas from Diesel Vehicles

3) Flue Gas from Fuel Oil Boilers (FB)

The emission source profile of flue gas from fuel oil boilers composes of VOCs from 7 fuel oil boilers in 3 factories. Figure 4.17 shows the fraction of VOCs in flue gas of fuel oil boilers. The fraction of VOCs which have a value of more than 0.1000 are toluene, and xylene.

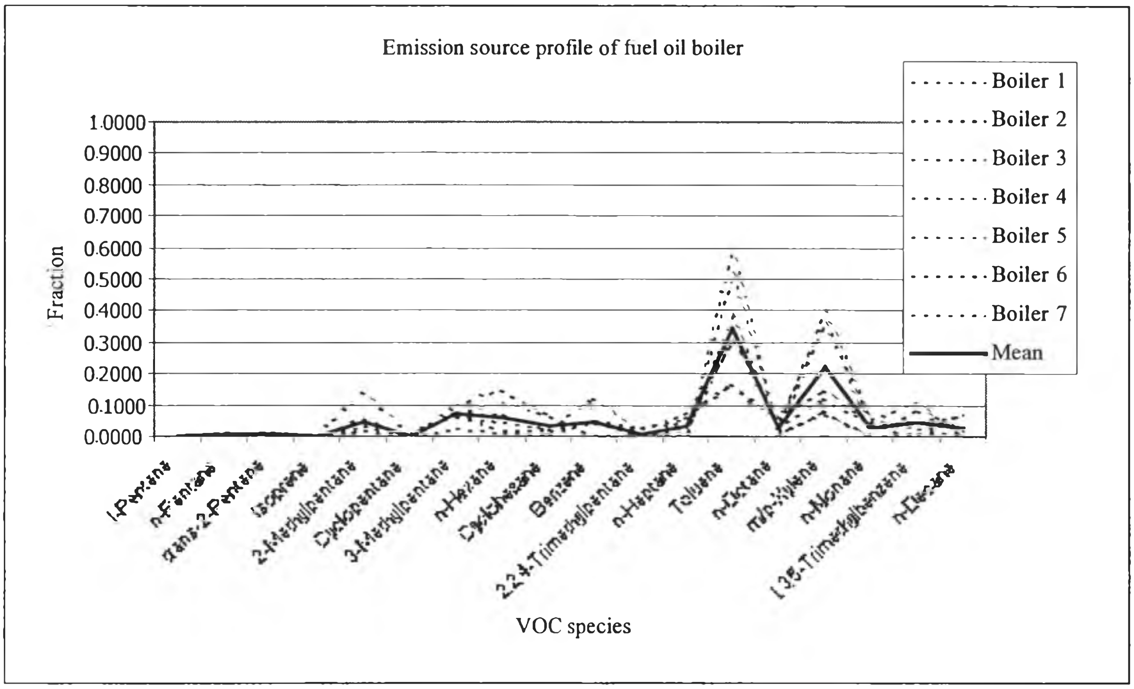

Figure 4.17 Emission Source Profile of Flue Gas from Fuel Oil Boilers

4) Smoke from Biomass Burning (BB)

The emission source profile of smoke from biomass burning composes of VOCs from smoke during the flaming and smouldering stages of grass burning in suburban Bangkok. Figure 4.18 shows the fraction of VOCs in smoke of biomass burning. The fraction of VOCs which have a value of more than 0.1000 are benzene and toluene.

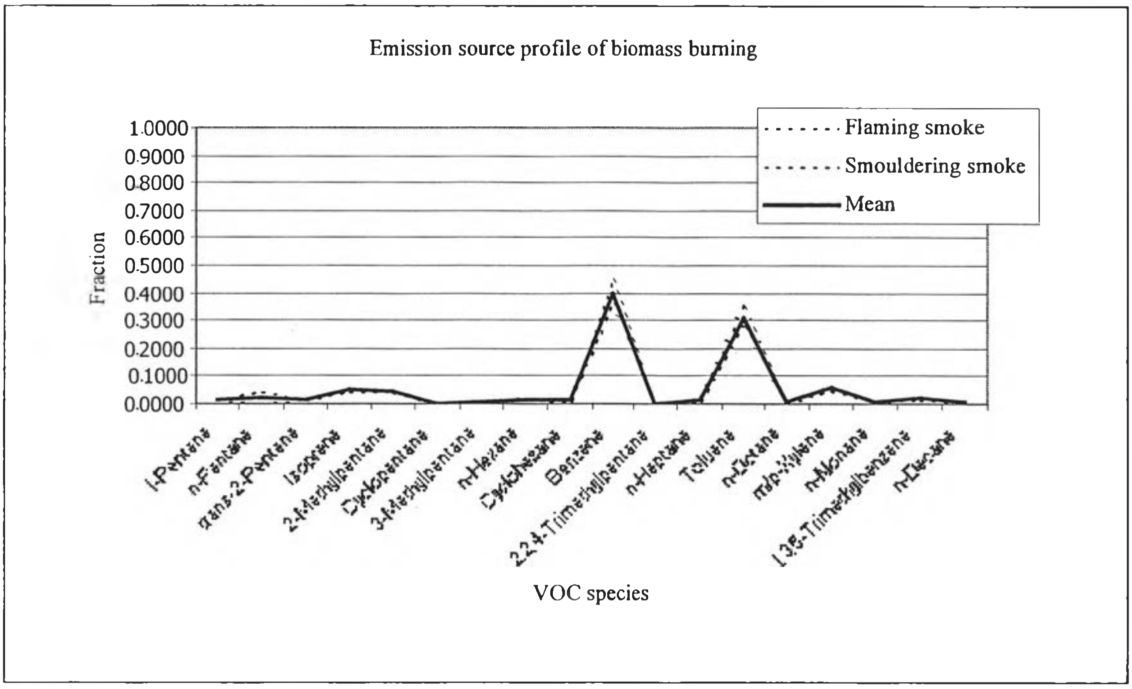

Figure 4.18 Emission Source Profile of Biomass Burning

The 5 New Source Profiles

1) The Vapor of Gasoline (VG)

The emission source profile of the vapor of gasoline composes of VOCs in the vapor of the 5 major brands of gasoline. Figure 4.19 shows the fraction of VOCs from the vapor of gasoline. The fraction of VOCs which have a value of more than 0.1000 are 2-methylpentane, n-pentane, toluene, 3-methylpentane, and n-hexane.

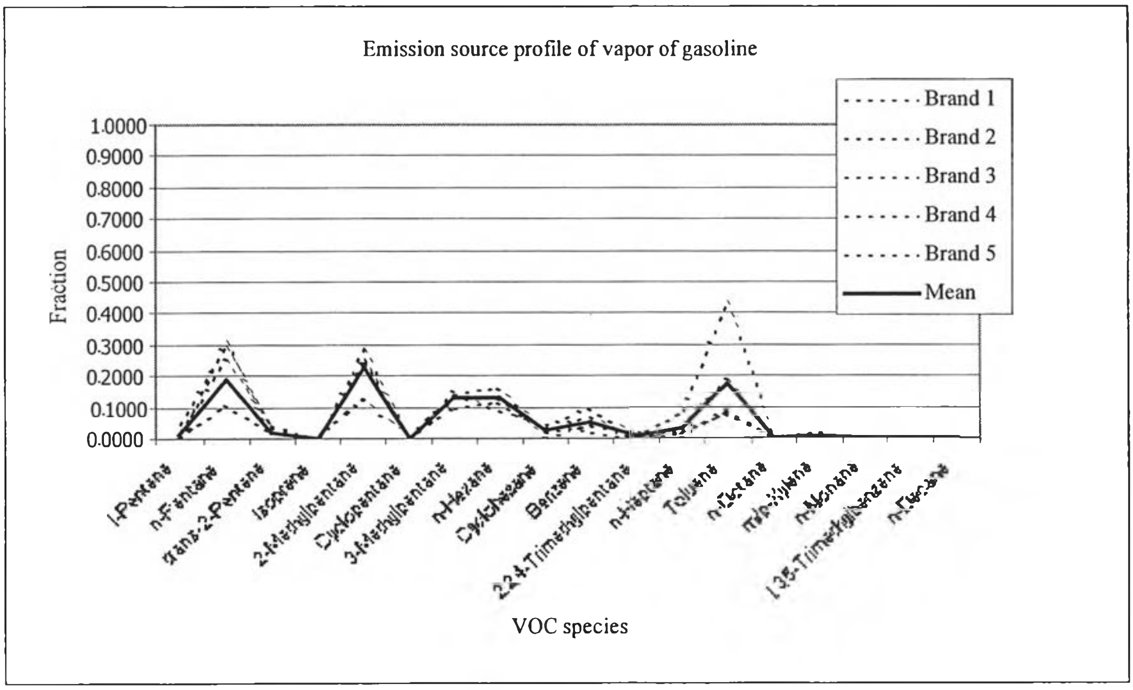

Figure 4.19 Emission Source Profile of the Vapor of Gasoline

2) Smoke from Food Barbequing on Charcoal Stoves (BBQ)

The emission source profile of smoke from food barbequing composes of VOCs from 3 food vendors. Figure 4.20 shows the fraction of VOCs from barbequing food. The fraction of VOCs which have a value of more than 0.1000 are benzene, toluene, and n-pentane.

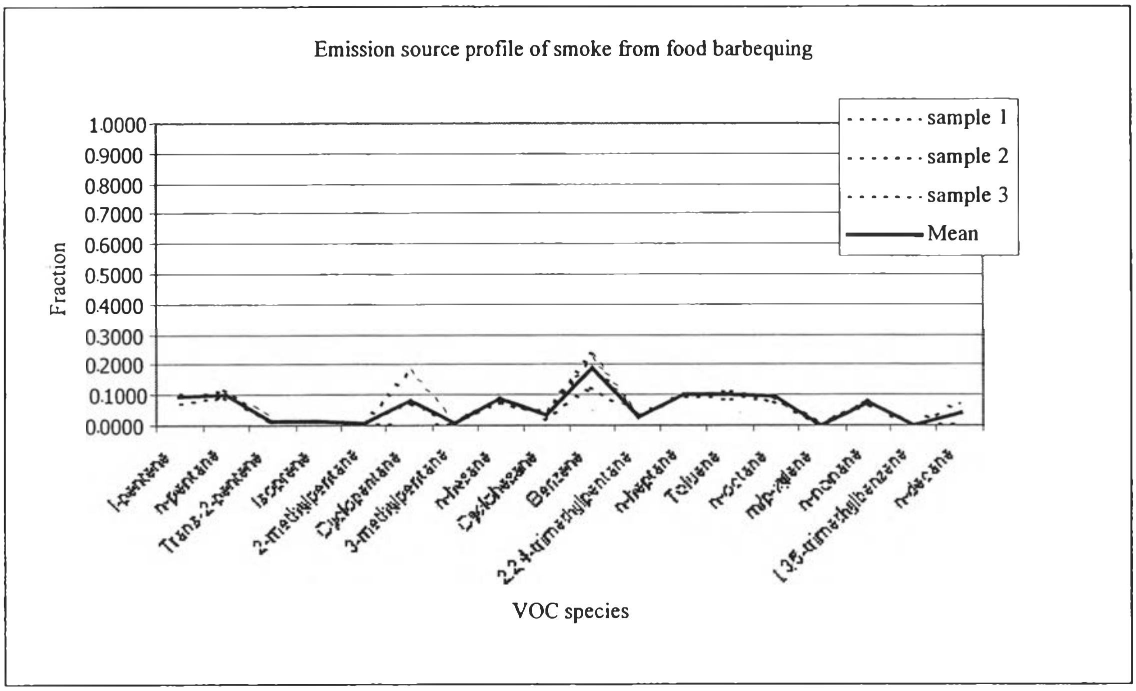

Figure 4.20 Emission Source Profile of Smoke from Food Barbequing

3) Liquid Thinners (LT)

The emission source profile of liquid thinners composes of VOCs from the 5 brands of thinners obtained from 5 auto-body repair shops. Figure 4.21 shows the fraction of VOCs from thinners. The major VOC species in this profile is toluene.

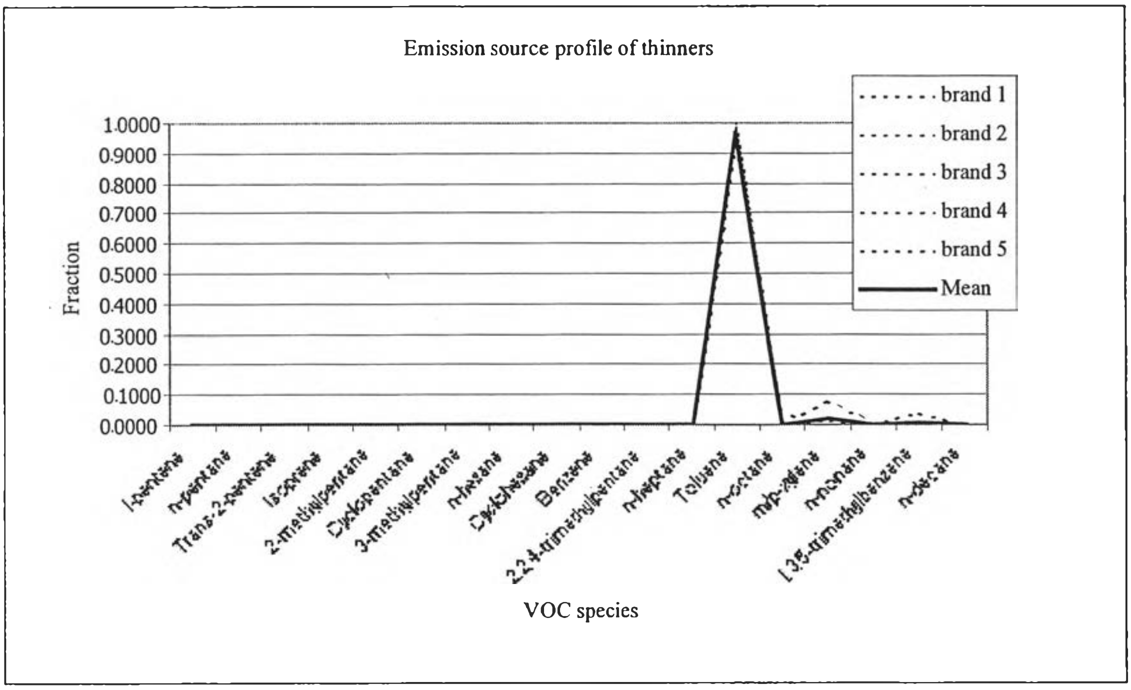

Figure 4.21 Emission Source Profile of Liquid Thinners

4) The Vapor of Solvent-based Paints (VP)

The emission source profile of the vapor from solvent-based paints was obtained from the 5 leading brands of paints. Figure 4.22 shows the fraction of the vapor of solvent-based paint. The fraction of VOCs which have a value of more than 0.1000 are xylene, n-octane, n-nonane and n-decane.

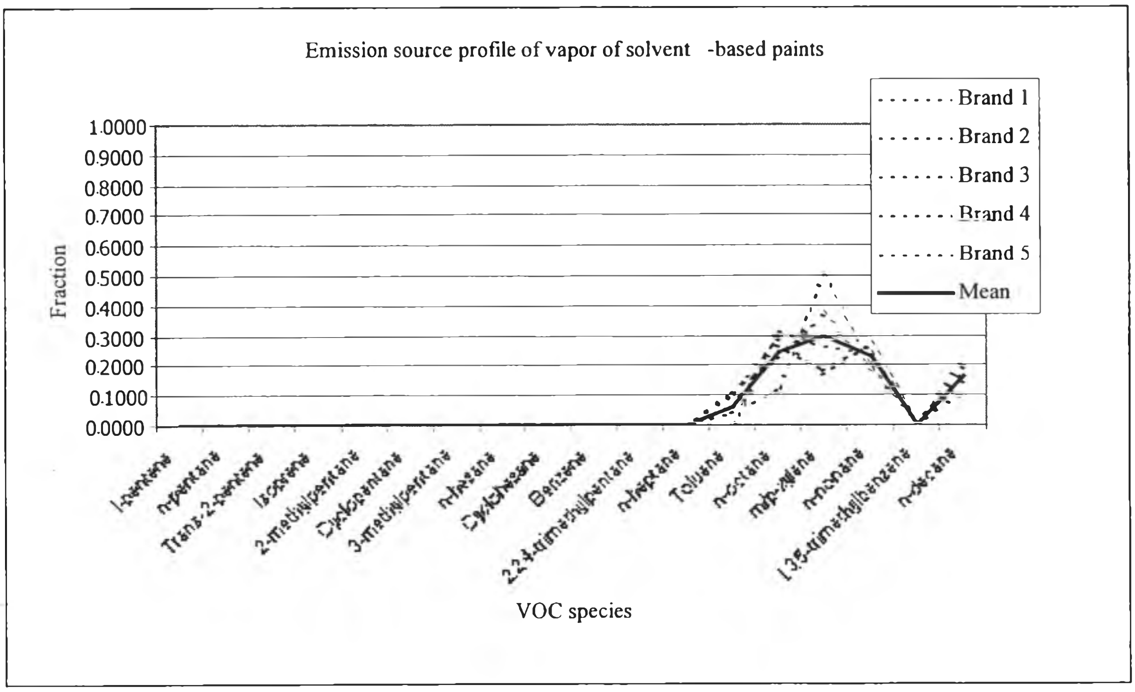

Figure 4.22 Emission Source Profile of Vapor of Solvent-based Paints

5) Air samples from the Municipal Waste Disposal (MW)

The emission source profile of air samples from the municipal waste disposal site at On-nuch consists of the 3 separate samples. Figure 4.23 shows the fraction of VOCs of air from the municipal waste disposal site. The major VOC species in this profile is toluene.

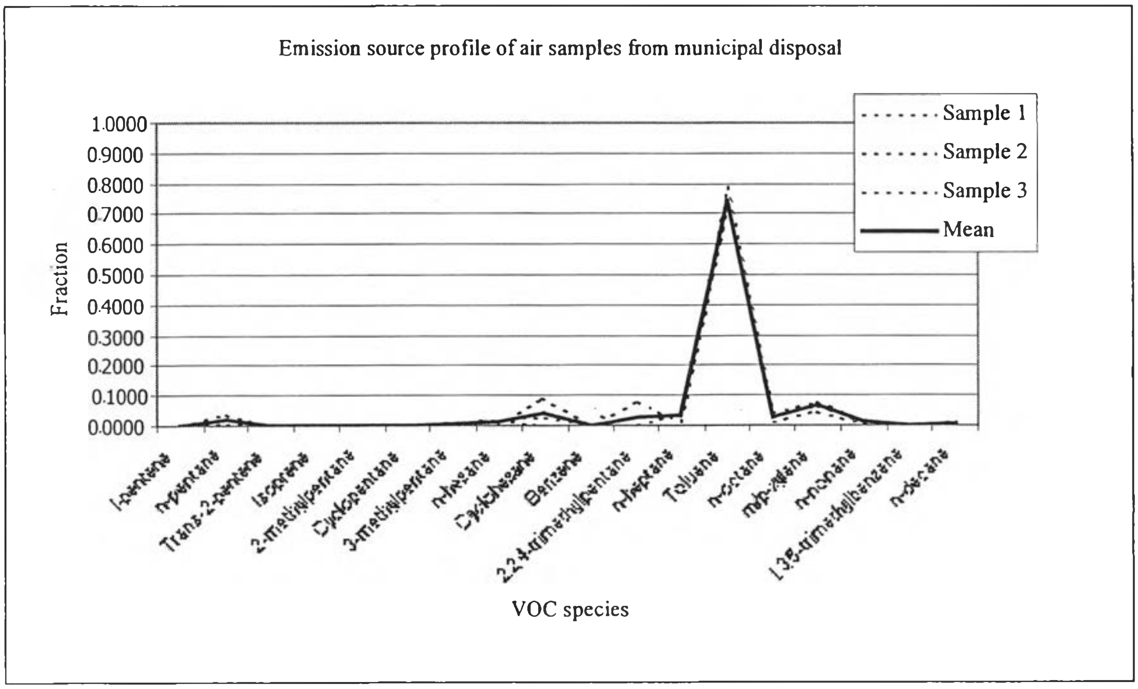

Figure 4.23 Emission Source Profile of Air Samples from the Municipal Waste Disposal

4.5 Source Contribution

4.5.1 During SW and NE Wind Directions

The U.S. EPA chemical mass balance receptor model, CMB7, was run by using a set of ambient air data outlined in section 4.2 and the emission source profiles from section 4.4. Sixty-eight ambient air samples were analyzed but only 34 were selected to examine the source contribution of VOCs by choosing only the dates on which the wind direction was from the southwest and the northeast in order to compare the major emission sources during specific southwest and northeast winds (Table 4.12). Due to the changing season at period, on some days in September, October, November and February, wind direction changed between SW and NE.

The ambient air samples were modeled each day (day by day) in a process of trial and error. The example of CMB modeling from the first step until the final results is shown in Appendix D. Table 4.9 shows the number of samples which were analyzed and used in CMB modeling.

Table 4.9 Number of Samples Collected, Analyzed and Used in CMB Modeling

Stations	Number of samples			
	SW (July 03 –October 03)			
	Sampled	Analyzed	Wind direction: SW	Other wind direction
Din Daeng	9	6	2	4
Chandrakasem	11	9	4	5
Ban Somdej	9	8	3	5
Ratburana	9	7	2	5
Total	38	30	11	19
	NE (November 03-February 04)			
	Sampled	Analyzed	Wind direction: NE	Other wind direction
Din Daeng	10	10	6	4
Chandrakasem	10	8	4	4
Ban Somdej	10	10	7	3
Ratburana	10	10	6	4
Total	40	38	23	15

Tables 4.10 - 4.13 show the results of CMB modeling on the dates chosen strictly on wind direction. Although the values of R^2, chi-square, and TSTAT comply with the criteria summarized in Table 3.4, some samples showed percent mass contribution as too low. Those samples were not included in the source contribution results.

At DD station during the SW monsoon, there were only 2 samples collected under SW wind conditions but for one of these the percent mass contribution was lower than 80%. Although R^2 was 0.97, and chi-square was 1.22, the percent mass contribution was only 30%. Thus, there was only one sample meeting the criteria for source apportionment estimation. The identified sources of VOCs were from GV, FB and VP. In NE monsoon conditions 7 samples were modeled. All samples had the parameters complying to the goodness of fit criteria. The identified sources of VOCs were from GV, DV, VG and MW (Table 4.10).

Table 4.10 Source Contribution of VOCs at DD Station (Specific Wind Direction)

Southwest Wind Direction

Sources	Source contribution, ppbC	
	27 Jul 03	8 Aug 03
GV	21,795.0 ± 3,042.4	-
FB	28,090.3 ± 4,459.2	364.3 ± 89.4
VP	17,884.2 ± 3,905.6	-
BB	-	895.0 ± 287.8
BBQ	-	269.9 ± 62.1
Unexplained	10,689.4	3,576.0
R^2	0.96	0.97
Chi-square	1.68	1.22
Percent mass	86.4	30.0*
DF	8	6

Northeast Wind Direction

Sources	Source contribution, ppbC						
	6 Nov 03	12 Nov 03	18 Nov 03	24 Nov 03	30 Nov 03	6 Dec 03	12 Dec 03
GV	4,423.0 ± 827.5	3,213.5 ± 613.7	8,766.9 ± 801.9	4,032.8 ± 820.7	1,688.5 ± 369.5	2,444.1 ± 435.9	2,882.2 ± 566.1
DV	756.3 ± 213.5	798.9 ± 205.8	-	1,234.2 ± 308.4	821.2 ± 184.7	644.1 ± 162.4	571.1 ± 154.5
VG	7,151.7 ± 1,182.4	4,999.4 ± 975.9	3,243.7 ± 744.6	5,823.0 ± 1,056.1	2,156.8 ± 432.1	2,729.3 ± 539.1	4,882.6 ± 813.4
MW	1,051.5 ± 331.2	743.4 ± 246.6	855.0 ± 246.5	1,199.0 ± 317.4	542.6 ± 136.6	446.9 ± 141.8	899.9 ± 244.8
Unexplained	1,149.6	1,122.2	1,115.6	170.9	404.0	2.4	329.9
R^2	0.99	0.98	0.97	0.98	0.98	0.97	0.99
Chi-square	0.76	1.45	1.05	1.28	1.46	1.69	0.94
Percent mass	92.1	89.7	92.0	98.6	92.8	100.0	96.6
DF	5	4	10	5	5	5	5

* Not accepted

At JK station during the SW monsoon, 4 samples were modeled. However 3 of these samples had the percent mass contribution not meeting the criteria. Those 3 samples had R^2 of 0.96 - 0.98, and a chi-square of 0.71 - 0.74, but the percent mass contribution values were only 68.6 - 72.1%. There was only one sample meeting the criteria for source apportionment estimation. The identified sources of VOCs were from VG, FB, VP and BB. During the NE monsoon 4 samples were modeled although one sample had R^2 equal to 1.00, and a chi-square of 0.08, but the percent mass contribution was only 50.7% which did not meet the criteria. Three samples were suitable for the estimation of VOCs source apportionment. The identified sources of VOCs were from GV, LT and BBQ (Table 4.11).

At BS station during the SW monsoon, 3 samples were modeled. Two samples had R^2 of 1-0.91, and a chi-square of 0.21 - 2.89, but the percent mass contribution values were 59.8 - 68.5% and did not meet the criteria. Only one sample was used for source apportionment estimation. The identified sources of VOCs were from VG, FB and BB. During the NE monsoon 7 samples were modeled. Five samples had the parameters of goodness of fit within the criteria. The identified sources of VOCs were from GV, VG and MW (Table 4.12).

At RB station during the SW monsoon, 2 samples were modeled. One sample had an R^2 of 0.97 and a chi-square of 1.14, but the percent mass contribution was 47.1% which did not meet the criteria. Only one sample was suitable for the estimation of VOCs source apportionment. The identified sources of VOCs were from FB, VP and BB. During the NE monsoon 6 samples were modeled. One sample had the percent mass contribution of 70% which did not meet the criteria. Five samples were used for source apportionment estimation. The identified sources of VOCs were from GV, DV and MW (Table 4.13).

Table 4.11 Source Contribution of VOCs at JK Station (Specific Wind Direction)

Southwest Wind Direction

Sources	Source contribution, ppbC			
	28 Jul 03	3 Aug 03	9 Aug 03	20 Sep 03
VG	1,800.7 ± 345.2	-	1,874.9 ± 191.7	-
FB	5,945.3 ± 921.8	8,263.8 ± 1,351.4	-	901.8 ± 121.8
VP	973.1 ± 327.2	28,590.9 ± 4,750.0	39,033.9 ± 6,269.2	-
LT	-	6,523.0 ± 1,946.0	19,708.2 ± 4,588.2	470.9 ± 151.3
BB	2,125.3 ± 539.1	-	-	-
BBQ	-	-	-	460.8 ± 69.3
Unexplained	499.40	16,747.1	27,732.1	816.7
R^2	0.97	0.98	0.96	0.98
Chi-square	1.43	0.74	1.01	0.71
Percent mass	95.6	72.1*	68.6*	69.2*
DF	6	3	7	7

Northeast Wind Direction

Sources	Source contribution, ppbC			
	7 Nov 03	13 Nov 03	1 Dec 03	13 Dec 03
GV	4,301.4 ± 487.2	1,865.6 ± 243.5	2,299.1 ± 380.4	914.0 ± 144.9
LT	848.4 ± 437.9	656.2 ± 245.3	812.4 ± 327.5	342.4 ± 122.1
BBQ	1,035.9 ± 166.5	898.4 ± 125.6	1,989.7 ± 257.6	293.0 ± 71.1
Unexplained	1,296.5	842.5	1,316.6	1,506.9
R^2	0.95	0.96	0.98	1.00
Chi-square	2.08	1.88	0.79	0.08
Percent mass	82.7	80.2	79.5	50.7*
DF	6	6	4	3

* Not accepted

Table 4.12 Source Contribution of VOCs at BS Station (Specific Wind Direction)

Southwest Wind Direction

Sources	Source contribution, ppbC		
	30 Jul 03	5 Aug 03	22 Sep 03
VG	2,348.7 ± 306.9	-	1,501.3 ± 189.4
FB	-	-	1,583.8 ± 201.5
VP	32,291.7 ± 5,195.3	26,515.6 ± 5,979.1	-
LT	15,192.2 ± 3,558.8	-	-
BB	-	4,758.3 ± 633.9	1081.5 ± 254.4
MW	-	18,861.0 ± 2,731.8	-
Unexplained	22,879.2	33,640.1	727.8
R^2	0.91	1.00	0.96
Chi-square	2.89	0.21	1.56
Percent mass	68.5*	59.8*	85.1
DF	4	4	8

Northeast Wind Direction

Sources	Source contribution, ppbC						
	9 Nov 03	15 Nov 03	21 Nov 03	27 Nov 03	3 Dec 03	9 Dec 03	15 Dec 03
GV	2,762.8 ± 473.2	2,410.2 ± 397.5	1,689.8 ± 211.4	1,576.4 ± 288.7	3,242.5 ± 500.0	1,283.6 ± 170.0	2,312.8 ± 349.3
VG	1,104.8 ± 441.2	370.7 ± 356.2	516.9 ± 175.2	1,541.9 ± 382.2	832.6 ± 319.1	1,063.8 ± 168.6	1,285.5 ± 277.7
MW	3,118.0 ± 580.2	1,888.1 ± 358.2	550.6 ± 107.1	666.3 ± 304.5	2,102.5 ± 408.0	408.8 ± 88.6	821.7 ± 191.4
Unexplained	501.0	-330.2	907.8	-433.9	-724.3	321.9	-813.1
R^2	0.98	0.99	0.99	0.99	0.98	0.97	0.97
Chi-square	0.84	0.54	0.55	1.08	1.02	1.51	1.59
Percent mass	93.3	107.6	75.2*	113.0	113.3	89.5	122.5*
DF	4	4	6	2	7	8	6

* Not accepted

Table 4.13 Source Contribution of VOCs at RB Station (Specific Wind Direction)

Southwest Wind Direction

Sources	Source contribution, ppbC	
	29 Jul 03	4 Aug 03
VG	2,114.4 ± 354.2	-
FB	1,255.7 ± 395.3	1,148.2 ± 186.0
VP	2,650.1 ± 428.7	833.3 ± 178.4
LT	6,289.9 ± 1,463.8	-
BB	-	2,029.8 ± 273.3
Unexplained	13,842.2	-125.3
R^2	0.97	0.97
Chi-square	1.14	1.52
Percent mass	47.1*	103.2
DF	4	7

Northeast Wind Direction

Sources	Source contribution, ppbC					
	8 Nov 03	14 Nov 03	26 Nov 03	2 Dec 03	8 Dec 03	14 Dec 03
GV	2,135.4 ± 425.1	1,414.8 ± 207.4	1,439.6 ± 198.6	1,550.9 ± 250.1	1,207.9 ± 167.5	2,236.0 ± 272.8
DV	837.9 ± 147.9	579.9 ± 99.8	448.1 ± 163.1	291.4 ± 227.2	464.6 ± 83.3	585.1 ± 151.3
MW	1,712.3 ± 506.7	1,289.4 ± 225.5	672.8 ± 118.9	615.6 ± 121.5	509.7 ± 102.0	644.1 ± 143.4
Unexplained	2,005.7	495.6	532.2	444.4	315.6	53.1
R^2	1.00	0.98	0.97	0.98	0.96	0.95
Chi-square	0.21	0.93	1.17	0.94	1.71	2.22
Percent mass	70.0*	86.9	82.8	84.7	87.4	98.5
DF	3	6	8	6	6	4

* Not accepted

4.5.2 All Wind Directions

By using only the dates with SW and NE wind directions, only a small number of samples were suitable for use. To avoid misinterpretation, source contribution of VOCs in Bangkok ambient air was examined regardless of wind direction. The data from all 68 samples were used for modeling. The source contribution results at each station for the entire study period are shown in Tables 4.14 - 4.17

Table 4.14 Source Contribution of VOCs at DD Station (All Wind Directions)

Sources	Source contribution, ppbC		
	27 Jul 03	8 Aug 03	25 Sep 03
GV	871.8 ± 121.7	0.0	344.0 ± 40.7
DV	0.0	0.0	0.0
VG	0.0	0.0	0.0
FB	1,123.6 ± 178.4	14.6 ± 3.6	0.0
VP	715.4 ± 156.2	0.0	0.0
LT	0.0	0.0	0.0
BB	0.0	35.8 ± 11.5	0.0
BBQ	0.0	10.8 ± 2.5	102.2 ± 23.5
MW	0.0	0.0	0.0
Unexplained	427.6	143.0	276.9
R^2	0.96	0.97	0.97
Chi-square	1.68	1.22	1.19
Percent mass	86.4	30.0*	61.7*
DF	8	6	5
WD	SW	SW	SW-NE
Sources	**Source contribution, ppbC**		
	7 Oct 03	**13 Oct 03**	**19 Oct 03**
GV	262.9 ± 37.6	383.3 ± 50.1	274.2 ± 30.6
DV	0.0	0.0	0.0
VG	0.0	0.0	0.0
FB	0.0	88.8 ± 41.3	0.0
VP	0.0	0.0	0.0
LT	0.0	0.0	0.0
BB	0.0	0.0	0.0
BBQ	130.9 ± 19.9	98.1 ± 19.0	42.0 ± 13.0
MW	109.14 ± 29.0	144.4 ± 37.5	0.0
Unexplained	337.3	79.7	-181.7
R^2	0.95	0.97	0.95
Chi-square	2.64	1.68	1.71
Percent mass	59.9*	90.0	235.1*
DF	6	8	5
WD	SW-NE	SW-NE	SW-NE

* Not accepted

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Table 4.14 (Con't)

Sources	Source contribution, ppbC				
	6 Nov 03	12 Nov 03	18 Nov 03	24 Nov 03	30 Nov 03
GV	176.9 ± 33.1	128.5 ± 24.5	350.7 ± 32.1	161.3 ± 32.8	67.5 ± 14.8
DV	30.3 ± 8.5	32.0 ± 8.2	0.0	49.4 ± 12.3	32.8 ± 7.4
VG	286.1 ± 47.3	200.0 ± 39.0	129.7 ± 29.8	232.9 ± 42.2	86.3 ± 17.3
FB	0.0	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	0.0	0.0
BBQ	0.0	0.0	0.0	0.0	0.0
MW	42.1 ± 13.2	29.7 ± 9.9	34.2 ± 9.9	48.0 ± 12.7	21.7 ± 5.5
Unexplained	46.0	44.9	44.6	6.8	16.2
R^2	0.99	0.98	0.97	0.98	0.98
Chi-square	0.76	1.45	1.05	1.28	1.46
Percent mass	92.1	89.7	92.0	98.6	92.8
DF	5	4	10	5	5
WD	NE	NE	NE-SW	NE	NE
Sources	Source contribution, ppbC				
	6 Dec 03	12 Dec 03	4 Feb 04	16 Feb 04	22 Feb 04
GV	97.8 ± 17.4	115.3 ± 22.6	172.7 ± 17.3	301.9 ± 39.3	129.7 ± 13.0
DV	25.8 ± 6.5	22.8 ± 6.2	0.0	0.0	0.0
VG	109.2 ± 21.6	195.3 ± 32.5	0.0	126.1 ± 26.1	0.0
FB	0.0	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	61.5 ± 28.0	0.0
BBQ	0.0	0.0	96.7 ± 9.7	0.0	35.4 ± 3.5
MW	17.9 ± 5.7	36.0	0.0	0.0	0.0
Unexplained	0.096	13.2	2.0	115.1	27.2
R^2	0.97	0.99	0.95	0.97	0.95
Chi-square	1.69	0.94	2.03	1.31	2.10
Percent mass	100.0	96.6	99.3	81.0	85.9
DF	5	5	5	10	5
WD	NE	NE	NE-SW	NE-SW	NE-SW

Table 4.15 Source Contribution of VOCs at JK station (All Wind Directions)

Sources	Source contribution, ppbC				
	28 Jul 03	3 Aug 03	9 Aug 03	20 Sep 03	26 Sep 03
GV	0.0	0.0	0.0	0.0	0.0
DV	0.0	0.0	0.0	0.0	0.0
VG	72.0 ± 13.8	0.0	75.0 ± 7.7	0.0	229.6 ± 25.3
FB	237.8 ± 36.9	330.6 ± 54.1	0.0	36.1 ± 4.9	103.9 ± 14.8
VP	38.9 ± 13.1	1,143.6 ± 190.0	1,561.4 ± 250.8	0.0	0.0
LT	0.0	260.9 ± 77.8	788.3 ± 183.5	18.8 ± 6.1	0.0
BB	85.0 ± 21.6	0.0	0.0	0.0	109.5 ± 24.6
BBQ	0.0	0.0	0.0	18.4 ± 2.8	0.0
MW	0.0	0.0	0.0	0.0	0.0
Unexplained	20.0	670.0	1,109.3	32.7	-0.8
R^2	0.97	0.98	0.96	0.98	0.95
Chi-square	1.43	0.74	1.01	0.71	1.99
Percent mass	95.6	72.1*	68.6*	69.2*	100.2
DF	6	3	7	7	9
WD	SW	SW	SW	SW	SW-NE

Sources	Source contribution, ppbC				
	2 Oct 03	8 Oct 03	14 Oct 03	20 Oct 03	
GV	0.0	0.0	0.0	50.8 ± 5.9	
DV	44.6 ± 10.4	0.0	110.4 ± 18.1	10.0 ± 2.6	
VG	238.0 ± 27.9	75.2 ± 11.5	89.8 ± 12.7	0.0	
FB	119.1 ± 15.1	0.0	0.0	0.0	
VP	0.0	49.0 ± 7.0	0.0	0.0	
LT	67.4 ± 24.8	0.0	36.8 ± 12.3	0.0	
BB	0.0	147.3 ± 23.9	0.0	0.0	
BBQ	0.0	0.0	0.0	0.0	
MW	0.0	0.0	0.0	0.0	
Unexplained	-5.4	13.5	3.9	38.3	
R^2	0.98	0.95	0.97	0.96	
Chi-square	1.02	2.03	1.39	1.34	
Percent mass	101.2	95.3	98.4	61.3*	
DF	9	6	4	5	
WD	SW-NE	SW-NE	SW-NE	SW-NE	

* Not accepted

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Table 4.15 (Con't)

Sources	Source contribution, ppbC			
	7 Nov 03	**13 Nov 03**	**19 Nov 03**	**1 Dec 03**
GV	172.1 ± 19.5	74.6 ± 9.7	222.5 ± 26.6	92.0 ± 15.2
DV	0.0	0.0	0.0	0.0
VG	0.0	0.0	89.5 ± 21.3	0.0
FB	0.0	0.0	0.0	0.0
VP	0.0	0.0	7.5 ± 2.4	0.0
LT	33.9 ± 17.5	26.2 ± 9.8	0.0	32.5 ± 13.1
BB	0.0	0.0	0.0	0.0
BBQ	41.1 ± 6.7	35.9 ± 5.0	0.0	79.6 ± 10.3
MW	0.0	0.0	13.3 ± 5.4	0.0
Unexplained	51.9	33.7	8.0	52.7
R^2	0.95	0.96	0.98	0.98
Chi-square	2.08	1.88	0.82	0.79
Percent mass	82.7	80.2	97.6	79.5
DF	6	6	7	4
WD	NE	NE	NE-SW	NE
Sources	**Source contribution, ppbC**			
	13 Dec 03	**5 Feb 04**	**17 Feb 04**	**23 Feb 04**
GV	36.6 ± 5.8	154.7 ± 26.2	109.9 ± 11.0	94.3 ± 15.5
DV	0.0	0.0	0.0	0.0
VG	0.0	0.0	0.0	0.0
FB	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0
LT	13.7 ± 4.9	55.3 ± 20.7	0.0	24.6 ± 11.0
BB	0.0	0.0	0.0	0.0
BBQ	11.7 ± 2.8	68.8 ± 14.8	0.0	31.9 ± 7.8
MW	0.0	0.0	26.9 ± 5.5	0.0
Unexplained	60.3	60.3	37.0	26.5
R^2	1.00	0.97	0.99	0.97
Chi-square	0.08	1.81	0.48	2.12
Percent mass	50.7*	82.2	78.7*	85.1
DF	3	3	5	2
WD	NE	NE-SW	NE-SW	NE-SW

* Not accepted

Table 4.16 Source Contribution of VOCs at BS station (All Wind Directions)

Sources	Source contribution, ppbC			
	30 Jul 03	**5 Aug 03**	**22 Sep 03**	**28 Sep 03**
GV	0.0	0.0	0.0	0.0
DV	0.0	0.0	0.0	0.0
VG	93.4 ± 12.3	1,060.6 ± 239.2	60.6 ± 8.9	0.0
FB	0.0	0.0	53.3 ± 5.7	67.0 ± 10.0
VP	1,291.7 ± 207.8	0.0	0.0	0.0
LT	607.7 ± 142.4	0.0	0.0	0.0
BB	0.0	190.3 ± 25.4	8.5 ± 3.9	106.9 ± 17.3
BBQ	0.0	0.0	0.0	0.0
MW	0.0	754.4 ± 109.3	0.0	0.0
Unexplained	915.2	1,345.6	29.1	-2.4
R^2	0.91	1.00	0.97	0.96
Chi-square	2.89	0.21	1.12	1.48
Percent mass	68.5*	59.8*	77.5*	101.4
DF	4	4	7	5
WD	SW	SW	SW	SW-NE
Sources	**Source contribution, ppbC**			
	4 Oct 03	**10 Oct 03**	**16 Oct 03**	**22 Oct 03**
GV	0.0	0.0	41.2 ± 6.0	32.7 ± 6.0
DV	0.0	0.0	10.3 ± 2.5	17.4 ± 2.9
VG	60.1 ± 7.6	23.8 ± 5.7	0.0	0.0
FB	63.4 ± 8.1	28.2 ± 5.9	0.0	0.0
VP	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0
BB	43.3 ± 10.2	53.1 ± 12.3	0.0	0.0
BBQ	0.0	0.0	0.0	0.0
MW	0.0	0.0	23.0 ± 3.8	20.2 ± 3.6
Unexplained	35.6	36.1	32.7	33.9
R^2	0.96	0.99	0.98	0.99
Chi-square	1.56	1.19	0.78	0.69
Percent mass	85.1	74.4*	69.5*	67.5*
DF	8	2	7	6
WD	SW-NE	SW-NE	SW-NE	SW-NE

* Not accepted

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Table 4.16 (Con't)

Sources	Source contribution, ppbC				
	9 Nov 03	**15 Nov 03**	**21 Nov 03**	**27 Nov 03**	**3 Dec 03**
GV	110.5 ± 18.9	96.4 ± 15.9	67.6 ± 8.5	63.1 ± 11.5	129.7 ± 20.0
DV	0.0	0.0	0.0	0.0	0.0
VG	44.2 ± 17.6	14.8 ± 14.2	20.7 ± 7.0	61.7 ± 15.3	33.3 ± 12.8
FB	0.0	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	0.0	0.0
BBQ	0.0	0.0	0.0	0.0	0.0
MW	124.7 ± 23.2	75.5 ± 14.3	22.0 ± 4.3	26.7 ± 12.2	84.1 ± 16.3
Unexplained	20.0	-13.2	36.3	-17.4	-29.0
R^2	0.98	0.99	0.99	0.99	0.98
Chi-square	0.84	0.54	0.55	1.08	1.02
Percent mass	93.3	107.6	75.2*	113.0	113.3
DF	4	4	6	2	7
WD	NE	NE	NE	NE	NE
Sources	**Source contribution, ppbC**				
	9 Dec 03	**15 Dec 03**	**7 Feb 04**	**19 Feb 04**	**25 Feb 04**
GV	51.3 ± 6.8	92.5 ± 14.0	140.5 ± 11.5	140.9 ± 12.4	63.9 ± 6.1
DV	0.0	0.0	12.3 ± 4.3	7.5 ± 3.7	6.9 ± 2.3
VG	42.6 ± 6.7	51.4 ± 11.1	0.0	0.0	0.0
FB	0.0	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	0.0	0.0
BBQ	0.0	0.0	0.0	0.0	0.0
MW	16.4 ± 3.5	32.9 ± 7.7	0.0	36.6 ± 7.3	20.7 ± 3.9
Unexplained	12.9	-32.5	10.9	15.2	8.5
R^2	0.97	0.97	0.97	0.95	0.95
Chi-square	1.51	1.59	1.02	1.81	1.81
Percent mass	89.5	122.5*	93.4	92.4	91.5
DF	8	6	9	9	10
WD	NE	NE	NE-SW	NE-SW	NE-SW

Table 4.17 Source Contribution of VOCs at RB station (All Wind Directions)

Sources	Source contribution, ppbC			
	29 Jul 03	4 Aug 03	27 Sep 03	3 Oct 03
GV	0.0	0.0	0.0	0.0
DV	0.0	0.0	18.4 ± 3.2	19.1 ± 3.2
VG	84.6 ± 14.2	0.0	0.0	0.0
FB	50.2 ± 15.8	45.9 ± 7.4	51.9 ± 7.7	45.9
VP	106.0 ± 17.1	33.3 ± 7.1	0.0	0.0
LT	251.6 ± 58.6	0.0	0.0	0.0
BB	0.0	81.2 ± 10.9	0.0	0.0
BBQ	0.0	0.0	0.0	0.0
MW	0.0	0.0	15.1 ± 5.5	15.8 ± 5.2
Unexplained	553.7	-5.0	25.1	32.2
R^2	0.97	0.97	0.94	0.95
Chi-square	1.14	1.52	2.78	2.36
Percent mass	47.1*	103.2	30.6*	35.9*
DF	4	7	5	5
WD	SW	SW	SW-NE	SW-NE
Sources	Source contribution, ppbC			
	9 Oct 03	15 Oct 03	21 Oct 03	
GV	0.0	49.5 ± 5.8	55.8 ± 6.9	
DV	0.0	8.6 ± 2.5	16.0 ± 4.0	
VG	138.1 ± 19.0	0.0	0.0	
FB	0.0	0.0	0.0	
VP	873.8 ± 195.3	0.0	0.0	
LT	325.1 ± 78.9	0.0	0.0	
BB	0.0	0.0	0.0	
BBQ	0.0	0.0	0.0	
MW	0.0	0.0	20.4 ± 4.2	
Unexplained	1,462.2	6.3	4.1	
R^2	0.98	0.95	0.96	
Chi-square	0.85	1.90	1.68	
Percent mass	47.8*	90.2	95.8	
DF	3	5	5	
WD	SW-NE	SW-NE	SW-NE	

* Not accepted

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Table 4.17 (Con't)

Sources	Source contribution, ppbC				
	8 Nov 03	**14 Nov 03**	**20 Nov 03**	**26 Nov 03**	**2 Dec 03**
GV	85.4 ± 17.0	56.6 ± 8.3	54.7 ± 5.5	57.6 ± 7.9	62.0 ± 10.0
DV	33.5 ± 5.9	23.2 ± 4.0	10.2 ± 1.0	17.9 ± 6.5	11.7 ± 9.1
VG	0.0	0.0	0.0	0.0	0.0
FB	0.0	0.0	0.0	0.0	0.0
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	0.0	0.0
BBQ	0.0	0.0	0.0	0.0	0.0
MW	68.5 ± 20.3	51.6 ± 9.0	19.5 ± 2.0	26.9 ± 4.8	24.6 ± 4.9
Unexplained	80.2	19.8	16.2	21.3	17.8
R^2	1.00	0.98	0.97	0.97	0.98
Chi-square	0.21	0.93	1.47	1.17	0.94
Percent mass	70.0*	86.9	83.9	82.8	84.7
DF	3	6	6	8	6
WD	NE	NE	NE-SW	NE	NE
Sources	**Source contribution, ppbC**				
	8 Dec 03	**14 Dec 03**	**6 Feb 04**	**18 Feb 04**	**24 Feb 04**
GV	48.3 ± 6.7	89.4 ± 10.9	65.0 ± 6.5	17.4 ± 5.8	0.0
DV	18.6 ± 3.3	23.4 ± 6.1	26.8 ± 2.7	14.2 ± 2.3	17.4 ± 1.7
VG	0.0	0.0	0.0	0.0	0.0
FB	0.0	0.0	0.0	0.0	45.6 ± 4.6
VP	0.0	0.0	0.0	0.0	0.0
LT	0.0	0.0	0.0	0.0	0.0
BB	0.0	0.0	0.0	0.0	0.0
BBQ	0.0	0.0	0.0	0.0	0.0
MW	20.4 ± 4.1	25.8 ± 5.7	20.4 ± 2.0	15.9 ± 5.4	10.7 ± 1.1
Unexplained	12.6	2.1	18.0	16.2	18.5
R^2	0.96	0.95	0.96	0.98	0.99
Chi-square	1.71	2.22	1.63	1.48	0.55
Percent mass	87.4	98.5	86.2	74.6*	79.9
DF	6	4	8	4	5
WD	NE	NE	NE-SW	NE-SW	NE-SW

* Not accepted