AIR QUALITY MONITORING AND ITS EMISSION SOURCES IN HANOI

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Abstract

The present study performed air monitoring along the major roads and at the major intersections roadside in Hanoi City. It was observed that the 24 hour average concentration of NO_2 and SO_2 differed for the weekday and weekend concentration at all selected sites. The 24 hour concentrations of NO_2 and SO_2 were ranged from 0.012-0.026 mg/m^3 and 0.17-0.85 mg/m^3, respectively. It is noted that the concentration of NO_2 and SO_2 was lower than concentrations reported in previous years of study. The results indicated that there was no hourly correlation between traffic levels and nitrogen dioxide, sulfur dioxide levels. Most of the 24 hour samples in all monitored sites showed that the concentration of CO were 2-3 folds higher than 24 hour Vietnamese standard. The result from this study and previous surveys indicated that, Hanoi city is probably being polluted by carbon monoxide. For all monitored sites with samples collected on weekday and weekends the 24 hourly average TSP were 2-5 times above daily Vietnamese standard. However, the limited number of samplings does not allow the determination of the yearly average value. The results of PM_{10} were also higher than WHO value of 0.1 mg/m^3. The 24 hour average of lead concentration was ranged from 0.001-0.006 mg/m^3 (both weekend and weekday samples). The results indicated that the lead content in all sampling areas does not exceeded Vietnamese standard. Although the higher traffic volume in Hanoi is increasing in compared to that of previous years, lower concentrations of lead were found during this study. Since Viet Nam phased out leaded gasoline in July 2001, it is likely that there has been a corresponding decrease of lead content in the air. Daily concentrations of ozone ranged from 0.024-0.057 mg/m^3 (in both weekday and weekend samples) in the all sampling sites indicate that, negligible ozone levels were measured. In the diurnal profiles, the highest ozone concentrations were found in the afternoon between 2 and 4pm. The results showed that the total VOCs concentration in all five sampling sites ranged from 0.075-0.187 mg/m^3. Among 8 target VOCs, the major ranking dominant components contributed to total VOCs accounting for C_6H_6 (benzene) ranged from 40%-60%, $CHCl_3$ 10%-30% (chloroform), $C_6H_3CH_3$ 17%-26% and other VOCs were very small or negligible values found at all sites. The benzene concentrations can be attributed to vehicle emissions. The daily benzene concentration (with averaged value of 0.051 mg/m^3 in all sampling sites) was lower than the guideline value Vietnamese standard (0.1 mg/m^3). It is illustrated that the total PAHs concentration in all five sampling sites ranged from 12.08-56.61 ng/m^3. In general, the PAHs concentration in the weekday was lower than that observed at the weekend. This finding is interesting as the weekend traffic was reduced compared to the weekday traffic. Thus, the elevated high PAHs concentration at weekend could be attributed to other emission sources rather than traffic activities. Among 12 target PAHs, the highest contribution to total PAHs content were found accounting for Benzo(g,h,i)perylene varied from 11.8%-21.8 % (average value of 18.2%) corresponding to 1.52-12.2 ng/m3 (average value of 5.0 ng/m3) in different sites. The surveyed results showed that the noise levels at the sampling sites varied from 71.9-80.7 dBA on average. The hourly average values also indicated that the noise levels at different times of the day were not affected by the variation of traffic and urban activities. Slight or no change value of noise levels were observed between weekday and weekend noise levels at all 5 sites. Similarly, the daily average values of noise were almost the same at all sites. The noise levels at all the sampling sites were found to be greater than Vietnamese standard in both day and night time.

Keywords: air pollution, PAHs, VOCs, nitrogen dioxide, sulfur dioxide

1. Introduction

Vietnam is not plagued with a brown cloud over its areas, at least not yet, and thus air pollution may not seem to be a serious issue at present. Nonetheless, with widespread use of old vehicles, coal stoves, uncontrolled incineration, rampant construction and poor quality roads, it is not difficult in Hanoi (and big cities in Vietnam) to find oneself breathing harmful air. The easiest form of pollution to identify is caused by persistent ambient particulate matter that is related to the level of development. The industrialization and modernization of Vietnam is increasing at such a rapid pace, that air pollution will indeed become a severe problem in the future. It is fortunate, however, that Vietnam has taken a significant first step toward making its air safer to breathe by completely phasing out the use of lead in gasoline on July 1, 2001. The industrialization and urbanization of Vietnam which will increase the number of factories, automobiles, motorcycles, and households in the cities, will eventually have negative environmental effects, including more air pollution.

Hanoi, the capital of Vietnam with total area of 927 square kilometers comprising of the 9 urban districts and 5 suburban districts (year of 2004). With 3 million people, Hanoi is being considered as a highest population density in Vietnam. By estimation, for the next 15 years, the population in Hanoi can be reached to 3.5 million (JICA, 2000). It is necessary to said that the half of Hanoi population is living in urban areas. In recent years, the booming urbanization and industrialization has been spontaneously happened in Hanoi. In parallel with high growth rate of gross regional product (higher than the national average) and improved socio-economic conditions, the degradation of environment has also been found, especially in air environment. The recent investigation indicated that, except for total suspended particulate (TSP) materials in the air, in general, no serious pollution has been recorded for the whole city, though occasional incidences of exceeding the standards have been found with NO_2 and SO_2 in some areas (industrial and highway areas, respectively). TSP value exceeds the allowance limit in the urbanized areas. In some concrete areas, heavy pollution by TSP has been found.

In this paper, an air quality monitoring was carried out in order to understand the current conditions of the study area. The survey was conducted along the major roads and at the major intersections where air quality is expected to deteriorate in the future.

2. Air quality monitoring

Scope of the survey

The target substances (pollutants) were selected in accordance with Vietnamese Environmental Standard. The following pollutants were observed: suspended particulate matters (PM_{10}, $PM_{2.5}$ smaller than 10 and 2.5 micrometers in diameter, respectively), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulate mater (TSP), volatile organic compounds (VOCs), poly aromatic hydrocarbons (PAHs), carbon monoxide (CO) and lead (Pb), ozone (O_3) for the time period of March 23, 2005 to April 10, 2005 to conduct a preliminary analysis of the relationship between vehicle count and air monitoring data. These pollutants were selected because they are associated with the vehicle emissions and for their potential health concern either directly or indirectly as precursors to other pollutants. The monitoring covers two (2) different traffic conditions, weekday and weekend respectively. Microclimate conditions were also recorded during the survey activities (hourly average).

Sampling method

Roadside sampling locations were located approximately 2m from the kerb side and were at approximately 1.5m high. Details of other sampling locations are in the relevant sections in this report. The air quality sampling had been carried out according to Vietnamese measurement standards. The measurements were conducted continuously for 24 hours, and hourly average values over a 24 hour period were recorded. The survey was conducted for two days (one weekday and one weekend) for each point. The samples were collected at the same location on the two days of sampling. The sampling duration and exposure time for relevant samplers were fixed with the exception of delays due to changing weather conditions which could affect the quality of the sample collected.

Sampling locations

The survey was designed to cover major roads in Hanoi City, which have large traffic volume and face to chronic traffic congestion. All five sampling sites were located near major and important roadways in urban and suburban area of Hanoi (Fig. 1). In general, all sites were selected due to the high percentage of vehicles traveling and some of them having a moderate number of trucks. The intersections contained no traffic lights, but in the morning and afternoon rush hour (7-8am and 5-6.30pm) it created a large amount of traffic queuing. Traffic congestion was also often observed these areas. During free flow vehicle speed averaged approximately 20-30 mph (in the rush hour time).

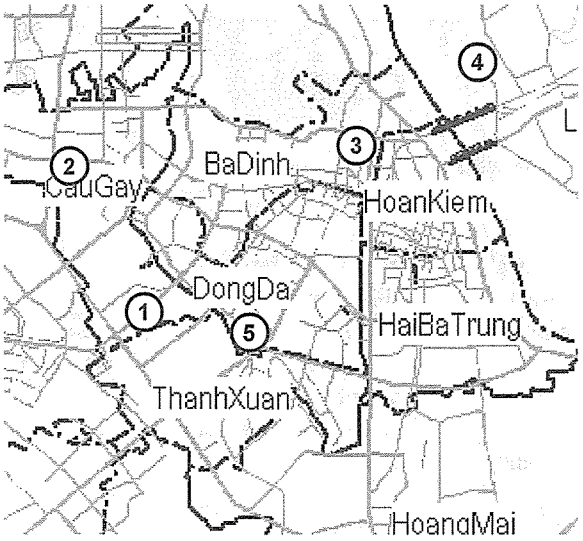

Figure 1. Sampling points in the Study Area

[(1) Cau Moi ; (2) Cau Giay ; (3) Chuong Duong ; (4) Cau Chui ; (5) Nga Tu Vong]

3. Result and discussion

Traffic data collection

The traffic flow was surveyed along five major streets in Hanoi. It was observed that motorcycles account for a much higher percentage of the total traffic flow than automobiles. However, the peak hour for each vehicle types differs, with motorcycles peaking at 6:30-9:00 a.m. and 4:30-7:30 p.m. and automobiles at 9:00-10:00 a.m. and 3:00-4:00 p.m at each location The highest density of traffic population were reached at 6:30-9:00 a.m. and 4:00-7:00 p.m. when people going to office and coming home, respectively (in Vietnam work hours are usually from 7.30 until 5.30pm). Differences were observed in the traffic volume between weekday and weekend by the lower volume of traffic in the weekend when people were not required to work. Generally, the total motorcycle flow in the 5 locations were not big different (except for Chuong Duong site, because of larger number of lanes in this site). The total number of motorcycles in a day (weekday and weekend) ranged from 250,000 to 350,000 at the sampling sites (except for Chuong Duong with number of 500,000). Furthermore, much higher volume of cars or trucks was observed at Chuong Duong and Cau Chui than other sites.

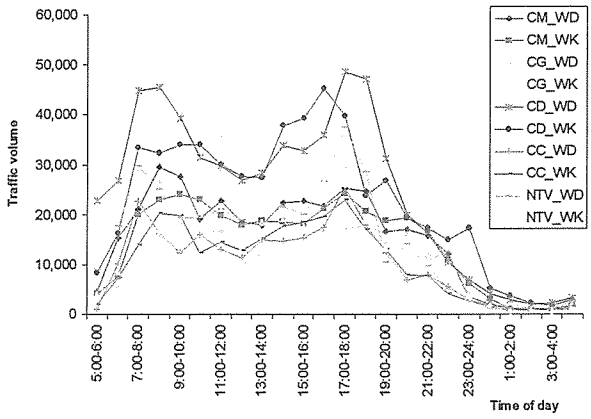

Figure 2. Daily traffic volume variation in a day

Meteorological conditions

During the sampling program in all five sites, the weather was suitable for sample collection, except for light rain in the short time (5-30 min.) during some of the sampling time. The meteorological condition changed slightly in all sampling day from 18.0-26.7 °C (temperature), and 67.8-89.7 % (relative humidity), 0.3-1.6 m/s (wind speed). However, in each sampling point, there was so much change of microclimate conditions in the weekday and weekend, except for wind direction. The big difference of wind direction was observed during the sampling day and sampling point. Moreover, the difference of observed meteorological and reported weather forecast was found.

Data explanation NO2 and SO2

It was observed that the 24 hour average concentration of NO_2 and SO_2 differed for the weekday and weekend concentration at all sites. The 24 hour concentrations of NO_2 and SO_2 were ranged from 0.012-0.026 mg/m^3 (average for weekday and weekend) and 0.17-0.85 mg/m^3 (average for weekday and weekend), respectively. Generally, the 24 hour average concentration of NO_2 and SO_2 (daily concentration) in all five sampling site has slightly changed for both weekday/weekend conditions and in all sites.

Table 1. 24 hour average concentration (mg/m^3) of NO_2 and SO_2 at sampling sites

Site and date	No. of samples	NO_2			SO_2		
		Max	Min	Avg.	Max	Min	Avg.
Cau Moi							
Weekday	23	0.029	0.015	0.023	0.49	0.14	0.32
Weekend	23	0.024	0.005	0.016	0.24	0.13	0.17
Cau Giay							
Weekday	24	0.019	0.005	0.013	0.21	0.02	0.11
Weekend	23	0.036	0.004	0.012	1.27	0.09	0.43
Chuong Duong							
Weekday	22	0.025	0.010	0.019	1.15	0.12	0.48
Weekend	23	0.039	0.013	0.026	0.03	0.08	0.19
Cau Chui							
Weekday	22	0.025	0.010	0.016	0.07	0.03	0.20
Weekend	23	0.018	0.007	0.013	1.05	0.03	0.35

Nga Tu Vong							
Weekday	22	0.031	0.010	0.020	1.85	0.11	0.72
Weekend	23	0.032	0.013	0.021	2.22	0.12	0.85
TCVN standards (1h-24h)		*0.4-0.1*			*0.5-0.3*		

It is observed that the concentration of NO_2 and SO_2 was slightly lower than concentrations reported in previous years of study. The results indicated that there was no hourly pattern between nitrogen dioxide, sulfur dioxide levels and traffic levels. It was observed that there was a neglible increase in the NO_2 concentration in the morning and afternoon rush hour time between 6:00-9:00 am and 4 and 7pm. These results indicate that traffic activities may be slightly contributed as a source for NO_2 emission in these 5 sites (there is no industrial activities in these sites, exception for Cau Moi site where small industrial activities occurred) or it may just be attributable to variations in the measurements. The results indicate that the daily concentration of SO_2 at Nga Tu Vong was higher than other locations; however the industrial activity in this location was reduced compared to other locations. In general, the daily NO_2 concentration is much lower 24 hour TCVN standard. The SO_2 concentration is higher than Vietnam standard.

Data explanation for CO

The CO concentration increased with the morning and afternoon rush hours and the lower levels were observed at other times. This means that, traffic activities positively contribute to the elevate concentration of carbon dioxide at the surveyed sites. The highest concentrations of CO were found at Cau Moi and Chuong Duong sites where the highest number of vehicles was recorded. Weekday peak rush hour concentrations were significantly higher than weekend concentrations for CO at Chuong Duong, Cau Moi and Cau Chui, however, higher traffic volume at the weekend time were found. It is, therefore, the higher concentration of CO in the weekend time can be explained by other emission sources. Furthermore, at the sampling sites where elevated trucks were observed, the CO content increased (CO contents are formed in the incomplete burning process of gasoline emitted by diesel burning engines). Most of the 24 hour samples in all monitored sites (except for Cau Chui at the weekday and Nga Tu Vong at the weekend) showed that the concentration of CO were 2-3 folds higher than 24 hour TCVN standard. Concentrations in Chuong Duong and Cau Moi were probably higher than other sites due to the higher traffic volume observed on these roads during the sampling program. Furthermore, elevated CO may be due to low speed (or traffic congestion) of traffic flow in different intersections leading to the incomplete burning process of gasoline.

Table 2. 24 hour average concentration (mg/m^3) of CO at sampling sites

Site and date	No. of samples	CO		
		Max	Min	Avg
Cau Moi				
Weekday	23	24.46	1.20	9.06
Weekend	23	19.42	2.83	11.84
Cau Giay				
Weekday	23	11.25	1.05	5.74
Weekend	23	10.25	2.84	5.39
Chuong Duong				
Weekday	22	20.41	1.93	9.76
Weekend	23	21.88	3.80	12.40
Cau Chui				
Weekday	22	9.25	0.91	2.50

Weekend	23	12.94	2.90	7.69
Nga Tu Vong				
Weekday	23	13.38	1.10	5.66
Weekend	23	8.37	0.55	4.34
TCVN standards (1h-24h)		*40-5*		

Although two 24 hour samplers at Cau Chui (weekday) and Nga Tu Vong (weekend) were found (between 50% and 87%) lower than 24 hour TCVN standard, it can be anticipated that the 24 hour standard for CO is likely to be exceeded in the future. The result from this study and previous surveys (DONRE, 2004) indicated that, Hanoi city is probably being polluted by carbon monooxide.

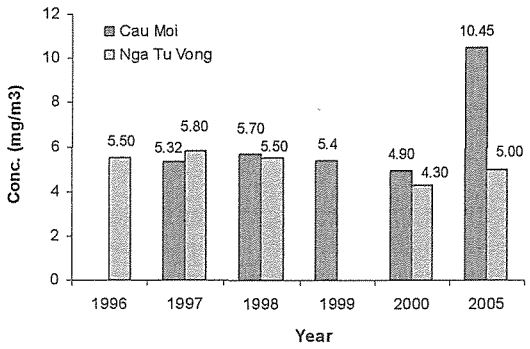

Figure 3. CO variation in recent years at Cau Moi and Nga Tu Vong

(The monitored values from 1997-2000 were 1 year average data)

Data explanation for PM10, PM2.5, TSP

The particulate matter monitoring of PM_{10}, $PM_{2.5}$ fractions and TSP was conducted at the five sites in Hanoi. The surveyed results pointed out an evident that the $PM_{2.5}$ is a part of PM_{10}; the mass of particles with diameter 10 mm is about twice as much as the mass of the particles with aerodynamic diameter up to 2.5 mm. For all monitored sites with samples collected on weekday and weekends the 24 hourly average TSP were 2-5 times above daily TCVN standard. However, the limited number of samplings does not allow the determination of the yearly average value. The results of PM_{10} were also higher than WHO value of 0.1 mg/m^3 (there is no official standard value for PM_{10} in Vietnam so far, it has been suggested the daily TCVN standard for PM_{10} should be in value of 0.15 mg/m^3). The highest content of TSP in the weekend at the Cau Moi can be attributed to the destroying of buildings due to roadworks in the area. Although the traffic volumes in the weekend were lower than those in weekday, the TSP, PM_{10}, $PM_{2.5}$ results were higher at some sampling sites. There is no evidence for clear pattern of TSP, PM_{10} and $PM_{2.5}$ reduction in the weekend. The higher contents of TSP, PM at the weekend can be explained by the contribution of other activities such as building construction or other emission sources. It is also noticeable that, the contents of TSP during the day time is higher than night time, this variation can be associated with main activities in the sampling areas as traffic and urban activities occurring during the daylight hours.

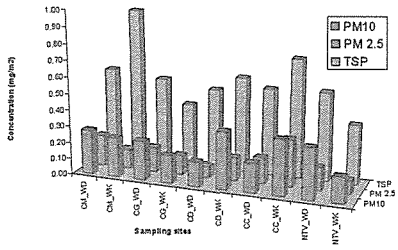

Figure 4. Daily content of PM_{10}, $PM_{2.5}$ and TSP at observed sites

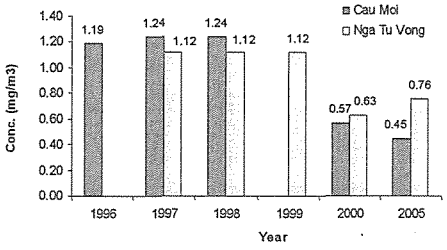

Figure 5. TSP variation in recent years at Cau Moi and Nga Tu Vong

The data from recent years showed that Hanoi area has been heavily polluted by TSP. Results indicate that the TSP level is reduced from previous studies conducted.

Data explanation for lead

In general, there was no measured difference of daily lead content in air between weekday and weekend samples during the sampling program. Additional, the 3 hour average lead concentration showed that the significant variation in day and night time was not found in all sampling locations. The 24 hour average of lead concentration was ranged from 0.001-0.006 mg/m^3 (both weekend and weekday samples). The results indicate that the lead content in all sampling areas does not exceed TCVN standard (except for Cau Moi site where a slightly higher value of 0.006 mg/m^3 was detected). Although the higher traffic volume in Hanoi is increasing in compared to that of previous years, lower concentrations of lead were found during this study. Since Vietnam phased out leaded gasoline in July 2001, it is likely that there has been a corresponding decrease of lead content in the air.

Data explanation for ozone

Ground level ozone is considered to be an important environmental threat affecting human health and causing damage to vegetation. Daily concentrations of ozone ranged from 0.024-0.057 mg/m^3 (in both weekday and weekend samples) in the all sampling sites indicate that, negligible ozone levels were measured. In the diurnal profiles, the highest ozone concentrations were found in the afternoon between 2 and 4pm. The maximum 1 hour value of 0.154 mg/m^3 was found at the weekend at the Chuong Duong sampling location. It can be due to unknown reasons or emission sources nearby and no significant reasons could be explained for these elevated ozone values. It is reported elsewhere that the ozone concentration at the weekend is higher than reported during the week and this could be due to one of five hypotheses:

- VOCs-sensitivity of ozone formation combined with a decrease in weekend NO_x emissions,
- Day of week differences in timing of NO_x emissions,
- Carryover of ozone and precursors on weekday and weekend night,
- Increased weekend emission.
- Less absorption of sunlight due to lower fine particle concentrations at weekend resulted in enhanced ozone formation might be a cause for the weekend effect.

Table 3. 24 hour average concentration (mg/m^3) of ozone at sampling sites

Site and date	No. of samples	Ozone		
		Max	Min	Avg
Cau Moi				
Weekday	24	0.064	0.004	0.024
Weekend	24	0.071	0.006	0.028
Cau Giay				

Weekday	24	0.060	0.004	0.025
Weekend	24	0.072	0.010	0.032
Chuong Duong				
Weekday	24	0.086	0.008	0.035
Weekend	24	0.154	0.012	0.057
Cau Chui				
Weekday	24	0.054	0.005	0.025
Weekend	24	0.086	0.024	0.047
Nga Tu Vong				
Weekday	24	0.056	0.008	0.029
Weekend	24	0.066	0.008	0.031
TCVN standards (1h-24h)		*0.2-0.06*		

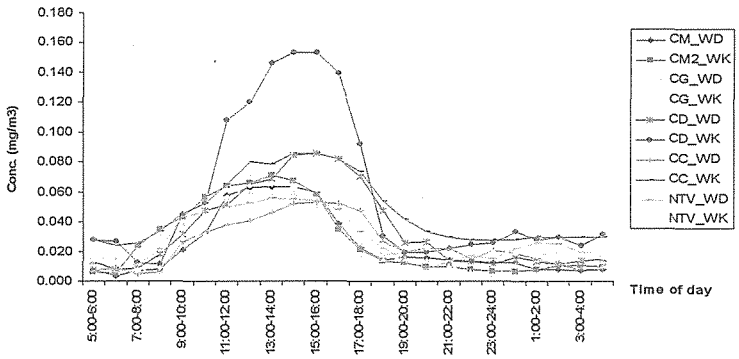

Figure 6. Daily content of ozone at observed sites

The average O_3 concentrations in the early morning (00-4 a.m) on weekdays and at weekend are similar (ranging from 0.008-0.032 mg/m^3) for five sites. It is assumed that the elevated weekend ozone levels are not a result of night carryover ozone. In this survey, there is no significant evidence to indicate the reason for the elevated weekend levels of ozone in the Chuong Duong and Cau Chui. In these sites, the daily PM contents in the weekend were higher than those in the weekday. However, the daily PM contents for the weekend samples for the 3 remaining sites were lower than those of the weekday samples, therefore no revere effect observed. For more understanding of the weekend effect for elevated ozone concentration, further studies are required and recommended.

Data explanation for VOCs

Volatile organic compounds (VOCs) in ambient air are associated with a range of activities, locations and specific sources such as industries, motor vehicles and area-based sources. VOCs such as benzene, toluene and xylene are associated with human health effects. Table 4 details the total VOCs concentration in all five sampling sites ranged from 0.075-0.187 mg/m^3). In general, the VOC content in the weekday was higher than those in the weekend (except for Chuong Duong site); it is probably due to the decrease of traffic volume in the weekend. The elevated higher VOCs concentration in the weekend at Chuong Duong could be because of other sudden emission sources.

Among 8 target VOCs, the major ranking dominant components contributed to total VOCs accounting for C_6H_6 (benzene) ranged from 40%-60%, $CHCl_3$ 10%-30% (chloroform), $C_6H_3CH_3$ 17%-26% and other VOCs were very small or negligible values found at all sites. The benzene concentrations can be attributed to vehicle emissions. The daily benzene concentration (with averaged value of 0.051 mg/m^3 in all sampling

sites) was lower than the guideline value TCVN standard (0.1 mg/m^3). The results also showed that, in diurnal profiles, the highest VOCs concentration were found in the rush hour in the morning and afternoon (6:00-9:00am and 4-7pm) when traffic was at its peak. The lowest VOCs concentrations were observed in the early hours of the morning (12am to 4am) when traffic activities were minimal. The surveyed results indicated that the total concentration of VOCs was below the guideline levels in the sampling locations selected in the Hanoi area. Unfortunately, no previous VOCs monitoring has been undertaken in Hanoi and therefore no comparisons can be made to other studies.

Table 5. 24 hour average concentration of VOCs and PAHs at sampling sites

Site and date	No. of samples	VOCs (mg/m^3)			PAHs (ng/m^3)		
		Max	Min	Avg.	Max	Min	Avg.
Cau Moi							
Weekday	6 (3)	0.215	0.162	0.187	18.71	9.88	15.20
Weekend	6 (3)	0.129	0.088	0.107	29.98	21.19	24.44
Cau Giay							
Weekday	6 (3)	0.155	0.092	0.117	13.66	11.10	12.08
Weekend	6 (3)	0.109	0.066	0.096	14.64	11.19	12.52
Chuong Duong							
Weekday	6 (3)	0.110	0.053	0.082	68.71	42.78	51.82
Weekend	6 (3)	0.164	0.102	0.124	76.89	34.24	56.61
Cau Chui							
Weekday	5 (3)	0.167	0.103	0.131	20.98	16.34	17.56
Weekend	6 (3)	0.128	0.079	0.107	56.10	18.65	41.68
Nga Tu Vong							
Weekday	6 (3)	0.165	0.092	0.132	30.72	20.93	26.85
Weekend	6 (3)	0.086	0.069	0.075	18.70	15.51	17.47
TCVN standards (1h-24h)							
Number of samples: 6 presented for VOCs and (3) presented for PAHs							

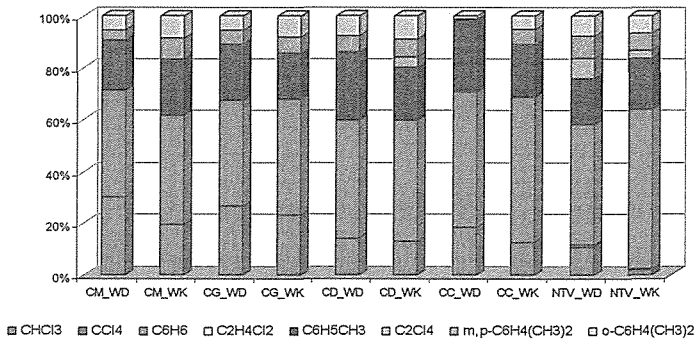

Figure 8. Percentage of each target VOC contributed to total VOCs

Data explanation for PAHs

PAHs are ubiquitous environmental pollutants and many of them are known or suspected as carcinogenic and mutagenic compounds. These organic compounds are produced by high-temperature reactions, such as incomplete combustion and pyrolysis of fossil fuels and other organic materials. They undergo thermal decomposition and react with a number of atmospheric chemicals producing derivatives, which can be

more toxic than the original compounds. Anthropogenic sources are generally referred to sources that produce energy such as domestic heating, engine exhaust (traffic), incinerators, and natural gas. Natural sources are usually volcanic eruptions and biomass burning. Another source of PAHs is from small particles of unburned components of fuel. Cigarette smoke is also a major source of PAHs for individual exposure. In the past, PAHs as a pollutant has not been considered. There were no guidelines for PAHs in the TCVN standard. This survey primary monitored the occurrence PAHs in the air in Hanoi area and individual PAH contributed to total PAHs.

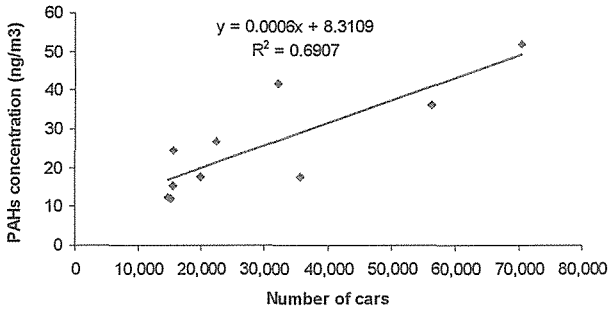

Figure 9. Relation between daily PAHs and daily averaged cars at sampling site

Table 5 illustrates that the total PAHs concentration in all five sampling sites ranged from 12.08-56.61 ng/m^3. In general, the PAHs concentration in the weekday was lower than that observed at the weekend (except for Nga Tu Vong site). This finding is interesting as the weekend traffic was reduced compared to the weekday traffic. Thus, the elevated high PAHs concentration at weekend could be attributed to other emission sources rather than traffic activities. The highest concentrations of PAHs were found at Chuong Duong where highest traffic volume (especially for cars and trucks) was observed. Interestingly, the hourly PAHs concentrations do not agree with the total daily traffic volumes, but the daily PAH concentrations showed the good relation between the daily total car and truck volumes in sampling sites and total motorbike level. It is, therefore, car and truck flow (not motorbikes) that could be a main emission source of PAHs in sampling sites.

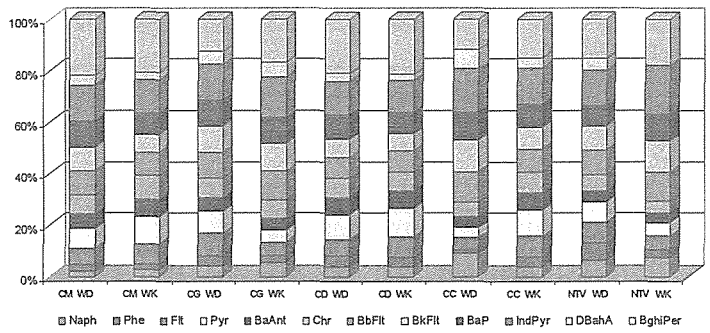

Figure 10. Proportion of different PAHs found in relation to total PAHs measured

The monitored results pointed out that no pollution of PAHs contents was observed in all 5 sampling sites and these concentrations were much lower than some other cities. The figure 11 indicated that the percentage of individual contribution to total PAHs were almost the same in all sampling sites. Among 12 target PAHs, the highest contribution to total PAHs content were found accounting for Benzo (g,h,i) perylene varied from 11.8%-21.8 % (average value of 18.2%) corresponding to 1.52-12.2 ng/m3 (average value of 5.0 ng/m3) in different sites.

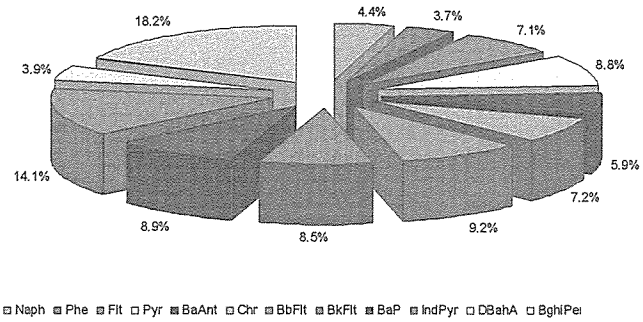

Figure 11. Averaged percentage of individual PAHs at 5 sampling sites

4. Conclusions

This investigation and previous studies indicated that the air quality in Hanoi has been significant improved. However, some compounds have not been monitored before such as VOCs and PAHs and some studies appear to give results which do not agree with industrial increases in Hanoi. There are a number of limitations in this study, the number of sampling sites selected, and their representativeness. The air quality of Hanoi downtown may be probably estimated by the quality of these major roads where anticipated high pollution sources exist due to typical urban activities. Except for total suspended particulate (TSP) materials, PM, SO2, carbon monoxide in the air, presently, no serious pollution has been recorded for the. For the PAHs and VOCs which are being considered as mutagen and carcinogenic compounds over the world, the much lower (except for PAHs) contents in compared with WHO standard were observed.

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