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## Air pollution caused by exhaust gas from 2 cycle engine in Vietnam

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### INTRODUCTION

HoChiMinh City is the biggest industrial and commercial center and the most polluted City in Vietnam. Statistics says that just 10 industrial zones and 2 export processing zones in the City daily discharge into the air 15 tones of PM, 150 tones of  $\text{SO}_2$ , 2 tones of  $\text{SO}_3$ , 10 tones of  $\text{NO}_x$  and 4.6 tones of CO. The present work is aim at analyzing data of measurements on  $\text{SO}_2$ ,  $\text{NO}_2$ , TSP,  $\text{PM}_{10}$ , lead, CO and ozone in ambient and roadside air from 1996 to 2001. VOC and metals, polyaromatic hydrocarbon(PAH) and nitro compounds in the particulates were also determined in 2000 and 2001 and the concentration of PAH in HoChiMinh city was higher than those in Hanoi or in Osaka.

### METHODS

From 1996 to 2000, air pollution monitoring was carried out with frequency of 10 days per month, 3 times per day at 7:30, 10:00 and 15:00, for one hour each time. From 2001 air pollutants are measured by continuous monitoring for 5 sites in the City. PAH were determined by using GC-MS(JEOL JMS 700D with 100% dimethyl-polysiloxane column ( SUPELCO, SPB-1, 15mx0.25mm i.d., 0.25  $\mu\text{m}$  film thickness).

### RESULTS AND DISCUSSION

Annual average concentration of  $\text{SO}_2$ , TSP, Pb from 1996 to 2000 is given in the Figures 1, 2 and 3. It can be seen that the concentration of  $\text{SO}_2$  in ambient air in urban site was lower than  $100\mu\text{g}/\text{m}^3$  and have not changed from 1997 to 2000, while TSP and lead concentration was very high, about 500 to  $2200\mu\text{g}/\text{m}^3$  for TSP and  $300\mu\text{g}/\text{m}^3$  for lead. It was showed also an upward tendency of TSP and lead. Concentrations of  $\text{SO}_2$ ,  $\text{NO}_x$ , oxidants, CO and  $\text{PM}_{10}$  in the 2001 are given on the Table 1.

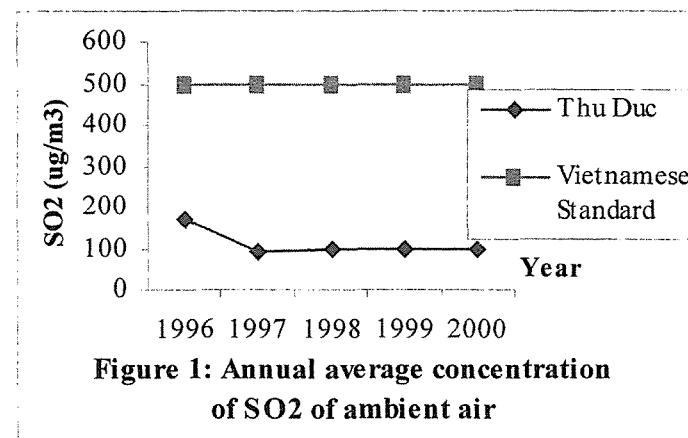


Figure 1: Annual average concentration of  $\text{SO}_2$  of ambient air

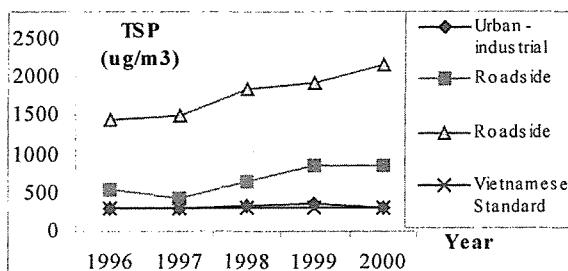


Figure 2: Annual average TSP in Ho Chi Minh City

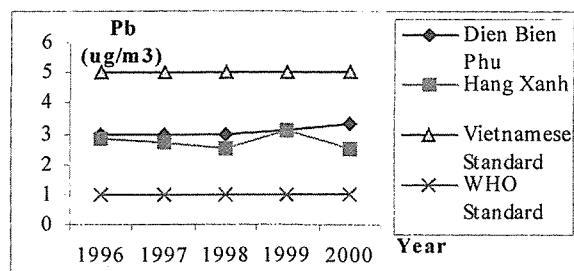


Figure 3: Annual average lead concentration of roadside air

Table 1: Monthly average concentration of some pollutants from December 2000 to April 2001

	SO <sub>2</sub> , $\mu\text{g}/\text{m}^3$	NO <sub>2</sub> , $\mu\text{g}/\text{m}^3$	NO, $\mu\text{g}/\text{m}^3$	O <sub>3</sub> , $\mu\text{g}/\text{m}^3$	CO, $\text{mg}/\text{m}^3$	PM <sub>10</sub> , $\mu\text{g}/\text{m}^3$
Residential	28.6 – 34.6	13.5 – 24.5	2.9 – 5.4	53.0 – 63.5	1.2 – 1.8	71.6 – 72.3
Traffic	50.5 – 54.5	33.3 – 65.7	49.0 – 58.3	19.3 – 21.0	5.5 – 6.9	158.2 – 175.0
Urban-industrial	41.4 – 44.9	24.9 – 31.8	12.3 – 14.5	*	*	*

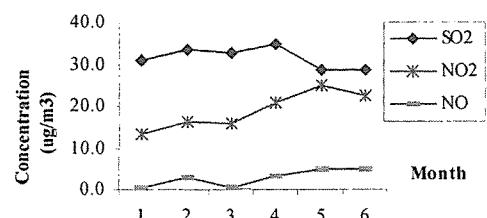


Figure 4: Monthly average concentration of SO<sub>2</sub>, NO<sub>2</sub> and NO from January to June 2001

Figure 4 shows that SO<sub>2</sub> concentration did not increase, and became slightly lower in rainy season (the rainy season lasts six months, from the end of May to November), while NO<sub>2</sub> and NO concentration has an upward tendency.

Figures 5, 6 and 7 show typical time dependence of NO<sub>2</sub>, NO and SO<sub>2</sub> concentration in day. There are two maximums of NO<sub>2</sub> concentration in a day at 7:30 to 9:30 and at 19:30 to 21:30 and a minimum at 13. In general, NO concentration is low from 10 AM until midnight, and it increases from midnight

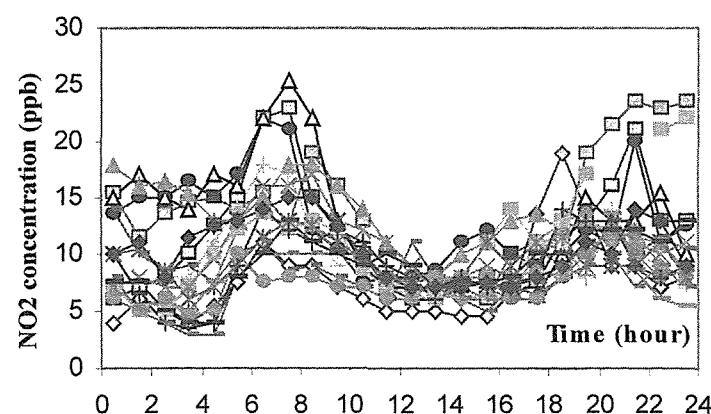
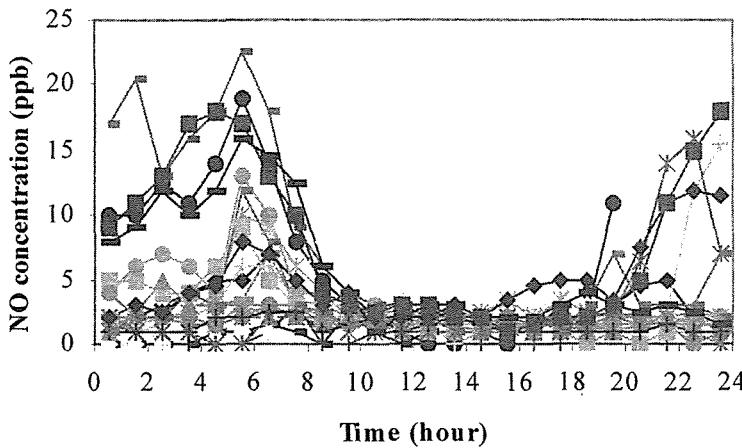
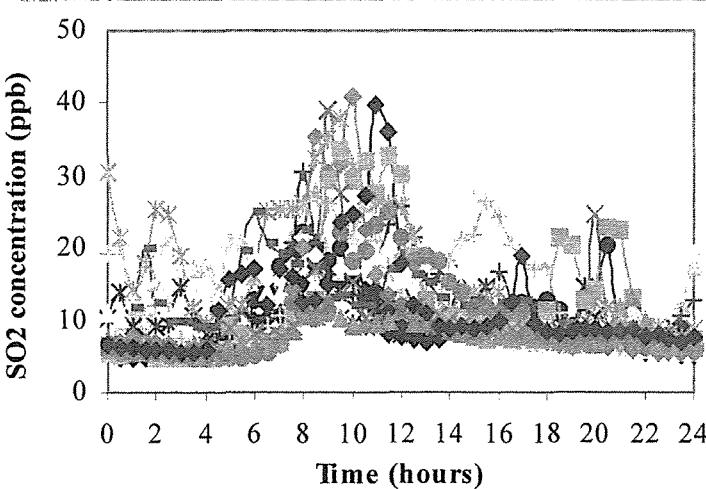


Figure 5: Concentration of NO<sub>2</sub> in day



**Figure 6: Concentration of NO in day**



**Figure 7: Concentration of SO<sub>2</sub> in day**

and reaches maximum at about 5 to 6 AM, then decreases. For SO<sub>2</sub> the maximum concentration is at the time from 9 to 10 AM, then decreases sharply from 10 AM to 1 PM and continues decrease until 4 AM. From 4 to 10 AM the SO<sub>2</sub> concentration increases very fast. However for some days an increase in NO and SO<sub>2</sub> concentration was observed from 7 PM.

The mentioned above can be explained by photochemical effect and traffic volume in the City. The rush hours in HoChiMinh City are from 7 to 8 AM and from 4:30 to 5:30 PM for two wheels vehicle. Traffic of heavy vehicles is prohibited in rush hours 6:00 to 8:00, 11:00 to 13:00 and 16:00 to 19:00 hours. High traffic volume of heavy vehicles after 7 PM in City leads to increasing of NO<sub>2</sub>, NO and SO<sub>2</sub> in the air.

As shown in Table 2, PAH in HoChiMinh city were very high compared with those in Osaka. One of the possible emission source seems to be the exhaust gas from 2 cycle engine.

**Table2 PAH in the particulates in Vietnam and in Osaka**

Sampling site	Ho Chi Mihn		Hanoi		Nha Trang	Osaka	
Year	2001		2001		2001	2001	
Filter No.	2	4	6	8	10	22	20
Date	7/5-6	7/7-8	7/9-10	7/10-11	7/12-13	6/26-27	7/19-20
SPM weight (mg)	0.39	0.55	0.61	0.78	0.40	0.23	0.17
Air volume (L)	7208.7*	7290.5	7425.0	7217.7	5020.0	7209.7	7215.1
phenanthrene	nd	nd	nd	4.3	nd	5.4	nd
anthracene	nd	nd	nd	nd	nd	nd	nd
dibenzothiophene	nd	nd	nd	nd	nd	nd	nd
fluoranthene	3.1	6.6	nd	nd	nd	7.0	6.0
pyrene	3.7	12	nd	nd	3.4	6.3	4.0
benzo[b]fluorene	nd	nd	nd	nd	nd	nd	nd
benz[a]anthracene	nd	5.6	nd	nd	3.1	nd	nd
triphenylene/chrysene a)	12	17	3.8	3.9	14	9.3	8.5
naphthacene	nd	4.3	nd	nd	nd	nd	nd
benzofluoranthenes b)	34	47	18	9.9	26	13	8.4
benzo[k]fluoranthene	18	28	9.7	6.1	16	10	8.1
benzo[e]pyrene	22	34	13	7.5	16	9.3	5.6
benzo[a]pyrene	7.2	16	7.4	5.3	11	6.5	4.2
perylene	nd	nd	nd	nd	nd	nd	nd
3-methylcholanthrene	nd	nd	nd	nd	nd	nd	nd
dibenzanthracenes c)	nd	nd	nd	nd	nd	nd	nd
benzo[ghi]perylene	37	80	23	15	21	8.1	4.8
indeno[1,2,3-cd]pyrene	25	43	16.0	9.4	17	6.6	3.3
coronene	27	51	15	10	12	nd	nd
dibenzo[a,h]pyrene	nd	nd	nd	nd	nd	nd	nd
$\Sigma$ PAH	189	344	105	72	140	81	53
Detection Limit ug/g	3.0	3.0	3.0	3.0	3.0	3.0	3.0

"nd", values are less than 2.0  $\mu\text{g/g}$ .

a) Triphenylene or chrysene were measured jointly.

b) Benzo[b]fluoranthene or benzo[k]fluoranthene were measured jointly.

c) Dibenz[a,h]anthracene or dibenz[a,c]anthracene were measured jointly.

As shown in Figure 8-11, the concentrations of saturated,unsaturated and aromatic hydrocarbons were very high in HoChiMinh city. The high concentrations of aromatic hydrocarbons such as benzene and toluene which usually contained in gasoline show that one of the main pollution source might be transportation in HoChiMinh city.

## CONCLUSION

- TSP, hydrocarbons and lead concentrations on the roadside air in center of HoChiMinh City are higher than WHO standards and have an upward tendency.
- Average concentrations of  $\text{SO}_2$ ,  $\text{NO}_2$ ,  $\text{NO}$ , oxidant,  $\text{CO}$  are not high in Vietnam.
- $\text{SO}_2$  concentration has not been changed since 1997, and is lower in rainy season.

- Nitrogen oxides concentration has an upward tendency.

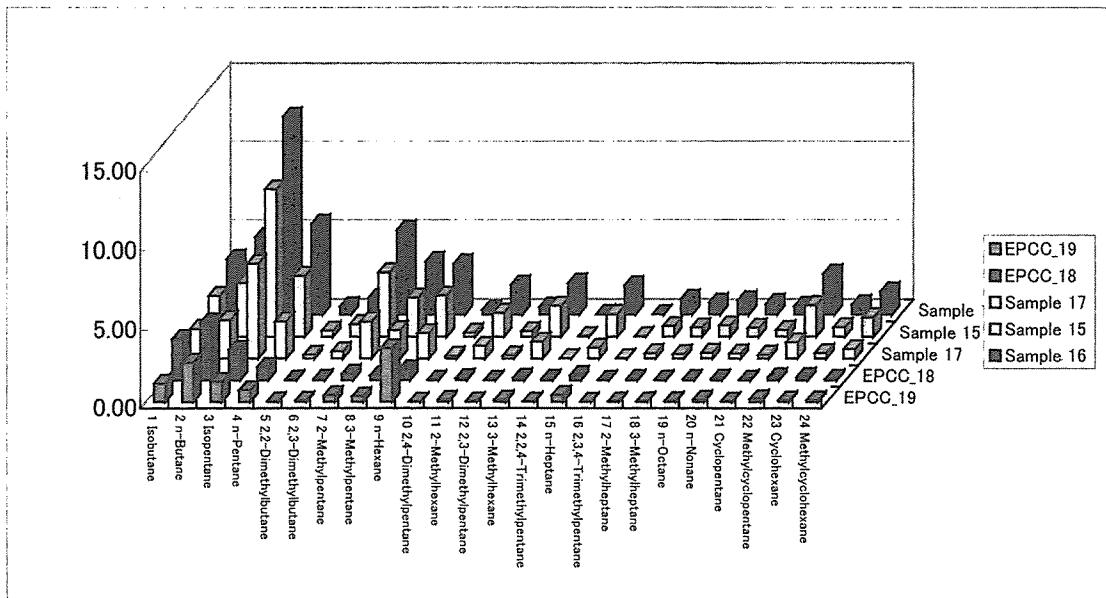


Figure 8. The concentrations of saturated hydrocarbons in Vietnam and in Osaka

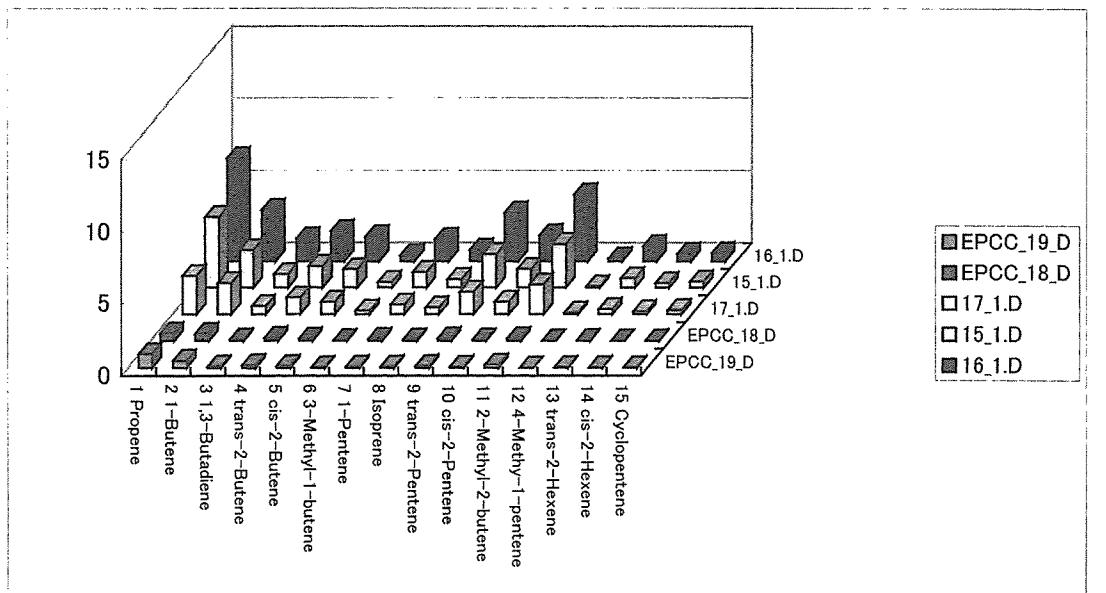


Figure 9. The concentrations of unsaturated hydrocarbons in Vietnam and in Osaka

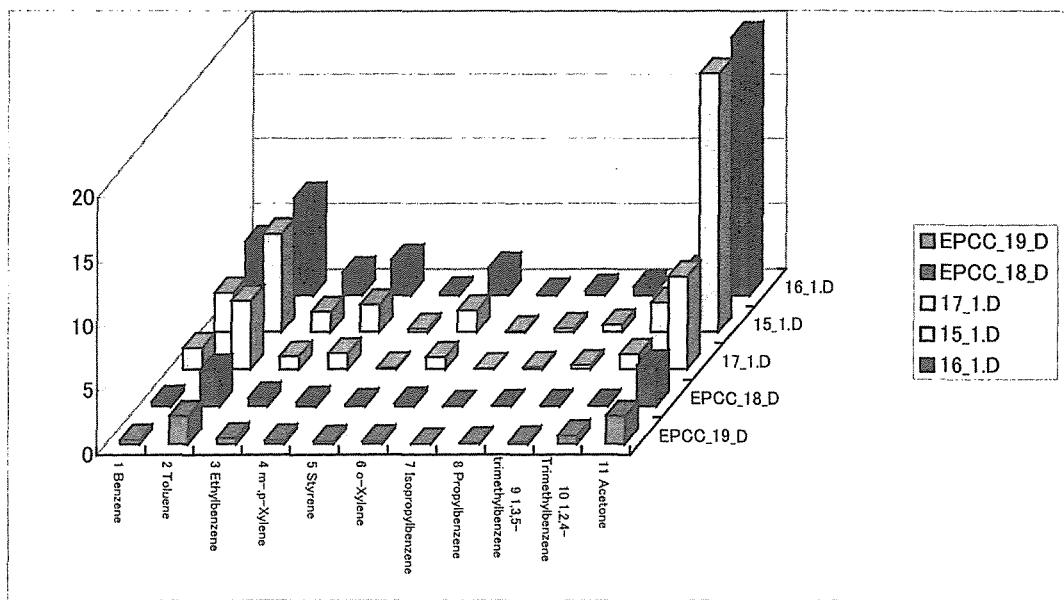


Figure 10. The concentrations of aromatic hydrocarbons in Vietnam and in Osaka

