Department of Science, Technology and Environment (DOSTE)
Ho Chi Minh City

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Passive sampling of SO_2 and NO_2 in ambient air in Ho Chi Minh City

November 2002

Bjarne Sivertsen

NILU
Norwegian Institute for Air Research

HCMC
Ho Chi Minh City
Environmental Improvement Project
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Summary

A screening study of air pollution using passive samplers in Ho Chi Minh City (HCMC), Vietnam was performed in order to evaluate the representativeness of selected continuous monitoring sites. The data would also give a simplified picture of the total concentration distribution over the city. The study was designed and performed during a period of 2 weeks in November 2002.

About 20 SO_2 and 20 NO_2 passive samplers were located in different parts of HCMC. Most of the passive samplers were installed at and around sites selected for continuous operation of air pollution monitors. These sites will be operated by DOSTE in the future.

The highest concentrations were observed in streets and near major roads.

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1. Introduction

As part of the NORAD funded part of the air quality monitoring component of the Ho Chi Minh City Environmental Improvement Project (HEIP) the Norwegian Institute for Air Research, NILU, conducted a study of the air pollution of SO_2 and NO_2 using passive samplers.

The Executing Agency for the **H**o Chi Minh City **E**nvironmental **I**mprovement Project **A**ir Quality Monitoring component (HEIA) is the Department of Science, Technology and Environment (DOSTE). Detailed descriptions of the total project can be found in Mission reports. (Sivertsen et.al. 2The passive samplers were installed in field to measure ground level concentrations as a result of emissions from traffic and industry.

2. The passive samplers

A sensitive diffusion sampler for sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) in ambient air has been used in several investigations to undertake a screening of the spatial concentration distribution.

The sampler was developed by the Swedish Environmental Research Institute (IVL) and has been used in several cases by NILU. The sampler includes an impregnated filter inside a small plastic tube. To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion.

The samplers are very easy to manufacture. For example, the samplers used by NILU are produced from commercially available 50 mm long polypropylene tubes. The tubes are cut to the desired length and then fitted with a solid cap containing the impregnated filter at one end, and an open cap containing the anticonvection mesh/membrane at the inlet end (as shown in Figure 1).

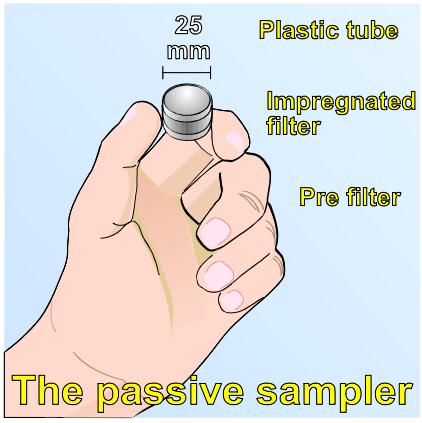

Figure 1: The passive sampler.

All components, except the impregnated filter can be reused. They have many other advantages as well for use in the field. For example they are small, light (~2 g), and require no electricity.

It should be emphasised that they provide time integrated concentrations with continuous time coverage, with the averaging time determined by the period they are exposed to ambient air (which can be daily, weekly, monthly, etc.). They are obviously not well suited for monitoring temporal variations over short time intervals, or for detection of individual peak values, or when real time measurements are needed.

2.1 The basic principle

The sampling technique is based on the property of molecular diffusion of gases, hence the term passive (also referred to as diffusive) sampling. The gas molecules diffuse into the sampler where they are quantitatively collected on an impregnated filter or an absorbent material. Thus they achieve a time-integrated (or average) concentration. No electricity, pumps or other supporting equipment are needed.

If the sampling efficiency is sufficiently high, then the sampling rate can be calculated from the cross sectional area perpendicular to the transport direction and the distance that the gas has to diffuse using Fick's first law of diffusion.

To work properly (and quantitatively) it is essential that the transport occurs solely by molecular diffusion and that no gas is lost to the walls of the sampler. Under these conditions then the sampling rate, and thus the concentration range of the sampler, is directly proportional to its cross sectional area and inversely proportional to its length.

Inorganic gases are absorbed by chemical reaction on a filter impregnated with a solution specific to each pollutant measured. The reaction product, which is washed out of the filter prior to analysis, is specific to the particular gas in question. When species do not react sufficiently fast with other chemicals (e.g.,

organics) they are instead trapped on an absorbent material. Such gases are then desorbed from the adsorbent during analysis.

2.2 Uptake rates and analyses

The uptake rate is only dependent upon the diffusion rate of the gas. The collection rate is 31 *l*/24h for SO_2 and 36 *l*/24h for NO_2. Also NH_3 can be collected at a rate of 59 *l*/24h.

For SO_2 the measuring ranges are approximately 0,1-80 ppb for a sampling period of one month. The corresponding range for NO_2 is 0,02-40 ppb. The passive samplers are assembled and made ready for use at NILU. After exposure the samplers are usually returned to NILU where concentrations of SO_2 are determined as sulphate by ion chromatography. NO_2 and NH_3 is determined by spectrophotometry.

The average concentration at the measurement site over the time period that the sampler is exposed to ambient conditions is determined by chemical analysis of the filter. Analysis consists of removing the impregnated filter and leaching the reaction product, typically using de-ionised water. The leachate is then analysed using an appropriate analytical technique. The highest concentration that can be measured depends on the amount of sorbent on the impregnated filter. This is typically estimated by the stoichiometric amount of the impregnate reduced by a safety factor (typically a factor of 2).

The lower detection limit of the samplers is determined by the use of blanks. As soon as a filter is impregnated it will begin to measure ambient levels. A filter kept in the laboratory will measure laboratory levels, while field blanks will measure the integrated exposure during the transport and storage periods.

The samplers are impregnated shortly before sent to the field, samplers labelled for batch number, a few filters checked immediately, and then filters identified for lab and field blanks. The laboratory blanks are stored in the lab and periodically tested. The field blanks are kept in their containers and accompany the samplers to the field and are returned after the filters are exposed. The field blanks are analysed along with the exposed samples. The concentrations determined from the exposed filters are then corrected using the blanks. The lower detection limit is commonly defined as 2 to 3 times the standard deviation of the blanks. The repeatability of the results is quantified and checked by use of duplicate samples.

3. Sampling sites in HCMC

Passive samplers were used to measure NO_2 and SO_2 concentrations at selected sites in HCMC. The sites were selected from two main criteria:

1. Measure at the same sites as other air quality monitoring are performed
2. Measure in different micro environments (streets, different heights, different distances from roads)

Most of the sites selected for passive sampling were the same as the positions of air quality measurements performed on a routine basis. These sites will be operated by DOSTE in the future.

The map in Appendix A give a picture of the spatial distribution of the sampling sites selected for Ho Chi Minh City.

The sampling sites as well as measuring periods are also presented in Appendix B.

4. Air quality limit values

To evaluate the air quality national and international authorities have presented air quality limit values and air quality guideline values. Limit values have been presented by Vietnamese authorities (TCVN 5937, 1995) and by the Norwegian Pollution Control Authority (SFT, 1992). The latter limit concentrations are similar to those given in the European Union Air Quality Daughter Directives. The World Health Organisation (WHO) has presented air quality guideline values.

The concentrations measured by the passive samplers in HCMC are representative for 12 day averages. As there are no limit values representing this averaging time we have compared the concentrations to 24 hour average limit values as given in Table 1.

Table 1: Air quality limit values for daily average concentrations of SO_2 and NO_2.

		24 hour average conc. (µg/m^3)		
Component	**Effect**	**TCVN**	**Europe (EU) Norway (SFT)**	**WHO**
SO_2	Health Vegetation	300	90 50	125
NO_2	Health	100	75	150

For Norway there are also seasonal average limit values given as 40 µg/m^3 for SO_2 and 50 µg/m^3 for NO_2.

5. Measured concentrations

5.1 Concentrations measured by monitors

A total of nine monitoring stations have been installed in the HCMC area, four supported by Danida and 5 supported by NORAD. Data from the four Danish sites were available during the passive sampling period. Some of the calibrations, however, had been questioned. SO_2 and NO_2 concentrations averaged over the passive sampling period from 14 to 26 November 2002 is presented in Table 2.

Table 2: Measured concentrations of SO2 and NO2 from monitors. The concentrations are averaged over the passive sampling period 14 to 26 November 2002.

Site	Conc. (µg/m^3)	
	SO_2	NO_2
Doste	66.7	68.0
HongBang	-	53.0
TansonHoa	77.1	15.2
Thuduc	-	11.2

5.2 Passive sampler concentrations

Passive sampling of SO_2 and NO_2 was undertaken at a total of 20 sites in Ho Chi Minh City. The samplers were brought to NILU for analysis. The results are presented in Table 3.

Table 3: Concentrations of SO_2 and NO_2 measured by passive samplers from 14 November to 26 November 2003.

Measurement site	SO_2 (µg/m^3)	NO_2 (µg/m^3)
Zoo, Quan 1	21	28
Zoo at fence	30	-
Tan San Hoa	32	36
Nguyen van Troi str	35	81
Tu Duc	39	30
Quan 2 PC build	72	18
Quan 2 at gate	23	24
ThongNat Hospital	-	-
Software city	26	25
Software city gate	-	31
Road 14	72	91
Binh Chanh educ.	25	58
Hong Bang	50	63
DOSTE fence	67	86
DOSTE shelter	48	72
DOSTE office	14	49
Liberty 1 hotel, 4.floor	51	79
Liberty1 hotel, entrance	40	54
Tran Hung Dao str. City centre	62	44
Nguyen Tat Thahn, Quan1	67	89

5.3 SO_2 concentrations

The SO_2 concentrations measured as an average over two weeks ranged from 21 µg/m^3 at the Zoo Park to 72 µg/m^3 at road 14, which has a high traffic density. The European limit values between 50 and 90 µg/m^3 were exceeded at 6 sites. The Vietnamese standards were not exceeded.

At the two sites where we had both samplers and monitors the sampler concentrations were somewhat higher than the concentrations estimated from monitor data. It is, however, difficult to draw any conclusions from only these two sites.

5.4 NO_2 concentrations

The NO_2 concentrations ranged from 18 µg/m^3 at District 2 to 91 µg/m^3 at road 14. Along the HCMC streets with high traffic density the NO_2 concentrations were typically between 80 and 90 µg/m^3. The European limit values between 40 and 75 µg/m^3 were exceeded at most of the roadside stations. The Vietnamese standards may have been exceeded at three of the narrowest streets.

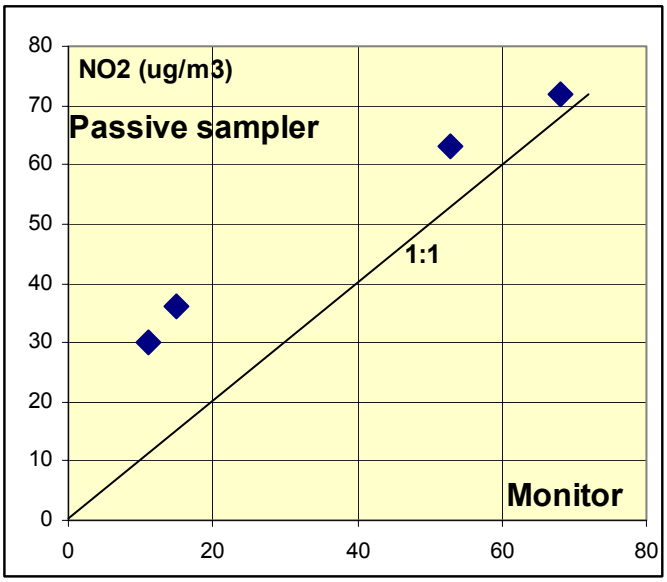

Figure 2: Twelve day average concentrations measured by passive samplers compared to the two-week averaged monitor concentrations of NO_2.

The passive sampler analyses showed consistently higher concentrations than the 12-day average concentrations estimated from the monitors. For the 4 sites where we had monitor data this is shown in Figure 2.

5.5 Effect of distance from the street

At one of the sites, at DOSTE we had placed samplers at different distances from the Dien Bien Phu Street. Both NO_2 concentrations and SO_2 concentrations decreased as a function of the distance from the street as shown in Figure 3.

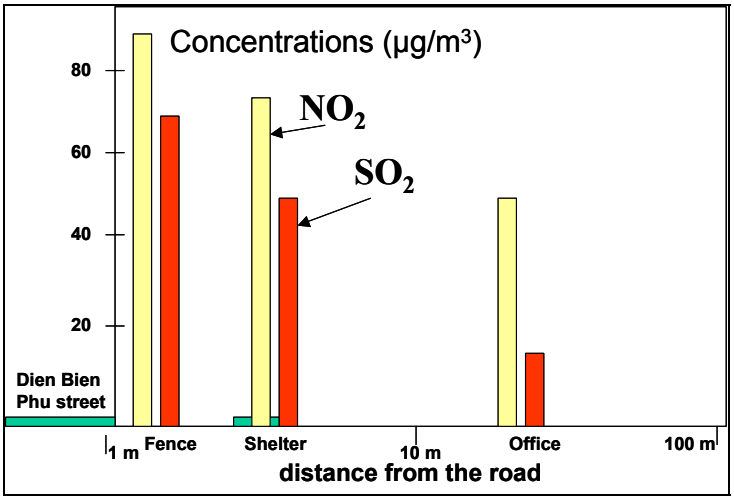

Figure 3: Twelve day average concentrations of SO_2 and NO_2 measured at different distances from the Dien Bien Phu Street at DOSTE.

The sharpest drop in concentrations was seen for SO_2, which dropped from 67 µg/m^3 at the fence to 14 µg/m^3 at the office about 30 m from the street. The NO_2 concentration dropped from 86 to 49 µg/m^3. The 40-50 µg/m^3 levels for NO_2 seem to be a typical long-term average concentration for the urban background in HCMC.

6. Discussions and conclusions

There are data from too few sites available to directly compare sampler data with monitor data. In the few comparable sites available it seemed that the monitors were under-estimating the levels compared to the results from passive sampling.

The main conclusion is, however, that the twelve day average concentrations of NO_2 and SO_2 measured at 20 sites in HCMC seem to be in agreement to the general information of air quality given by the monitoring network. Typical monthly average concentrations measured at the DOSTE site, based on the monthly reports produced by DOSTE, varies around 60-70 µg/m^3 for SO_2 and around 70-80 µg/m^3 for NO_2

The urban background concentration of NO_2 seem to be around 40 µg/m^3 for SO_2 about 20 to 30 µg/m^3 .

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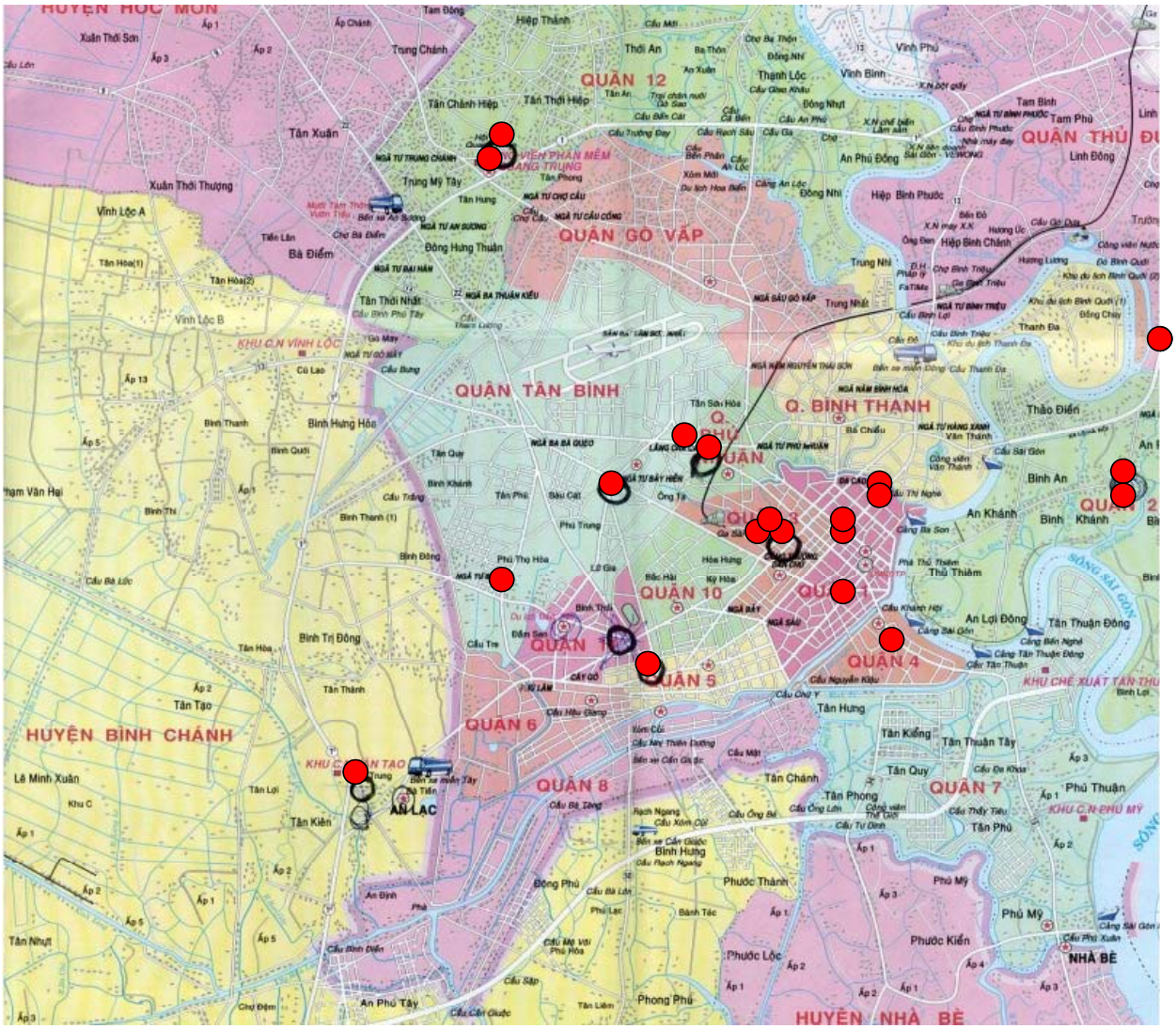
Appendix A

Location of sampling sites

The sampling sites for passive sampling in HCMC 14 to 23 November 2003.



Appendix B

Sampling sites

Passive air pollution sampling

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Field observations November 2002 **Observer:___Bjarne Sivertsen_____**

Sampling period				Site name	Coord.		Coord		Sampler identification		
From:		To:		(position)					SO_2	NO2	Comments
date	hr.	date	hr.		North		East		(red)	(blue)	
14Nov	0925	26 Nov	0820	Zoo, Quan 1					9	20	at shelter, taken down and transport in trafic 4 hours
14 Nov	0930	26 Nov	0825	zoo at fence					5	19	NO_2 lost
14 Nov	0945	26 Nov	1205	Tan San Hoa					7	16	at Danida shelter
14 Nov	0955	26 Nov	1210	Nguyen van Troi str					10	17	DOCSOF company gate
14 Nov	1030	26 Nov	0915	Tu Duc					6	18	Shelter
14 Nov	1120	26 Nov	0845	Quan 2 PC build					4	15	at roof shelter
14 Nov	1125	26 Nov	0845	Quan 2 at gate	10deg.	47.492	106 d	44.956	2	13	at fence 25 m from buildin
14 Nov	1200	26 Nov	1150	ThongNat Hospital					8	14	on NILU shelter – lost !!
14 Nov	1400	26 Nov	1015	Software city	10 deg	51.154	106	37.748	1	11	shelter Quan 12
14 Nov	1405	26 Nov	1015	Software city gate					3	12	at gate 90 m from shelter
14 Nov	1420	26 Nov	1050	Road 14					17	8	Daons Lag Ban Bich rd.
14 Nov	1500	26 Nov	1110	Binh Chanh educ.					13	10	at shelter, main road
14 Nov	1530	26 Nov	1125	Hong Bang					14	9	At Danida shelter

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Passive air pollution sampling

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Field observations

Observer:_____

Sampling period				Site name	UTM coord.		Location		Sampler identification		
From:		To:		(position)					SO_2	NO2	Comments
date	hr.	date	hr.		X	Y	east	west	(red)	(blue)	
14 Nov	1645	26 Nov	1400	DOSTE shelter					16	5	
14 Nov	1650	26 Nov	1400	DOSTE fence					19	6	
14 Nov	1650	26 Nov	1350	DOSTE office					18	7	
14 Nov	1900	25 Nov	1800	Liberty 1 4.floor					20	4	
14 Nov	1900	23 Nov	???	Liberty1 entrance					12	2	Taken into office, open till 25 Nov , then in box
15.nov	0945	26 Nov	1150	Tran Hung Dao str.					15	3	At sign
15.nov	1000	26 Nov	1225	Nguyen Tat Thahn					11	1	Quan 4

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ABSTRACT

As part of a screening study passive sampling of SO_2 and NO_2 was performed at 20 selected sites in Ho Chi Minh City. The main conclusion was that the two-week average concentrations of NO_2 and SO_2 measured at 20 sites in HCMC seem to be in agreement to the general information of air quality given by the monitoring network. Typical monthly average concentrations measured at the DOSTE site, based on the monthly reports produced by DOSTE, varies around 60-70 $\mu g/m^3$ for SO_2 and around 70-80 $\mu g/m^3$ for NO_2

NORWEGIAN TITLE

Passiv prøvetaking av SO_2 og NO_2 luftkonsentrasjoner i Ho Chi Minh City, Vietnam November 2002.

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ABSTRACT (in Norwegian)

** Classification*

A Unclassified (can be ordered from NILU)
B Restricted distribution
C Classified (not to be distributed)