社会開発調査部報告書

No. 32

Japan International Cooperation Agency (JICA)

Hanoi People's Committee

Socialist Republic of Vietnam

The Study on Environmental Improvement for Hanoi City in The Socialist Republic of Vietnam

Final Report

Supporting Report

July 2006

Nippon Koei Co., Ltd.

EX Corporation

Japan International Cooperation Agency (JICA)

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ESTIMATE OF PROJECT COST

Estimate of Base Cost : As of March 1999 Price Level
Currency Exchange Rate : USD1.0 = VND13,900 = Yen 122

THE STUDY
ON
ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

SUPPORTING REPORT

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A.1 Solid Waste Management

A.1.1 Waste Generation Quantity Survey

(1) Survey Schedule

The survey had been carried out for eight days from 24th to 31st August. As the data of first day, 24th August may contain waste generated during previous days, seven-days continuous data from 2nd day to 8th day were used for the estimation.

(2) Number of Sample Household Surveyed

100 sample households was selected.

(3) Categorization of households

100 households were divided into three categories according to types of houses

Categorization of households

Category		Number of sample households	District		Type of house or occupation
A		20	Dong Da	Urban	Governmental house (2 stories)
B	B1	20	Hoan Kiem		Private house
	B2	20	Tay Ho		
C	C1	20	Gia Lam	Sub-urban	Commuter or small business
	C2	10			Farmer
	C3	10			Farmer and traditional job
Total		100			

(4) Survey Method

100 households were selected as follows:

A. Government apartment: 20 households

B. Private houses: 40 households

C. Houses in sub-urban districts: 40 households

The surveyor delivered one plastic bag to each household every day for 8 consecutive days so that the households put their waste into the delivered plastic bags. The surveyor visited each household every morning, and collected waste-filled-plastic bags. In total 800 plastic bags were delivered. (1 plastic bag/household/day x 100 households x 8 days = 800 plastic bags) The data of the 1st day were disregarded, and data for the remaining 7 days (2nd to 8th days) were

used because the waste collected on the first day may contain waste generated in previous days.

Weight of all waste collected in plastic bags was measured. The surveyor also collected data on number of persons living in each of the surveyed households. Using the data on weight of waste and number of persons in the surveyed households, average unit weight of waste generated per person per day was calculated for

Then using the average unit weight data and Hanoi population data, weight of household waste generated in Hanoi were estimated.

(5) Summary of the Survey Result

Table above shows the summary of the survey result.

Summary of the Household Waste Generation Quantity Survey

(Unit generation rate: Gram/person/day)

Area code	Total Persons living (persons) (a)	7 days total weight (kg) (b)	Total plastic bags weight (kg) (c)	7 days net waste weight (kg) - (c) = (d)	Unit generation rate (g/person/day) (d)/(a)/7days x 1,000 = (e)*1
A1	93	373.03	5.67	367.36	583
B1	96	200.17	3.83	196.34	311
B2	117	318.91	3.92	315.00	398
B1, B2 Total/average	213	519.08	7.75	511.34	359
C1	102	168.60	2.34	166.26	233
C2	55	113.20	1.17	112.03	291
C3	47	222.40	1.04	221.36	697
C1, C2, C3 Total/average	204	504.20	4.55	499.65	355

*1) The unit generation rates were calculated by disregarding the days when household waste samples were not collected because of the absence of household persons.

(6) Estimation of Household Waste Generation Quantity

The data of population living in governmental houses, shown in next page, was supplied by the Department of Land and Housing Control. The latest data of population in each district in Hanoi was supplied from the Department of Statistics. Using these population statistics, the household waste generation quantity was estimated as shown the tables below.

Estimated Household Waste Generation Quantity

Area Code	Unit generation rate (gram/person/day) (a)	Population (persons) (b)	Generation weight (ton/day) (a) x (b) / 1,000,000 = (c)
A	(aA) 583	(bA) 473,637	(cA) 276.1
B1, B2	(aB) 359	(bB) 839,465	(cB) 301.4
7 Urban districts (A, B1, B2)	Calculate (cAB)/(bAB) = 440	(bAB)=(bA)+(bB)= 1,313,102	(cAB)=(cA)+(cB)= 77.5
5 sub-urban districts (C1, C2, C3)	(aC) 355	(bC) 1,167,482	(cC) 414.5
12 districts (Hanoi) (A, B1, B2, C1, C2, C3)	Calculate (cABC)/(bABC) =*400*	(bABC)=(bAB)+(bC)= *2,480,584*	(cABC)=(cAB)+(cC)= *992.0*

Households and Population living in the Government Apartments in Hanoi

	Number of households having contract for renting government houses a	Estimated number of households living in the government houses without contracts b	Total number of households living in the government houses c (a+b)	Number of population having contract for renting government houses A	Estimated number of population living in the government houses without contract B	Estimated Total population living in the government houses C (A+B)
Urban Districts						
1 Tay Ho	60	540	600	270	1,890	2,160
2 Ba Dinh	16,845	5,703	22,548	77,487	21,670	99,157
3 Hoan Kiem	14,794	4,016	18,810	68,052	14,860	82,912
4 Hai Ba Trung	19,603	6,963	26,566	84,293	28,548	112,841
5 Dong Da	26,800	7,829	34,629	123,280	29,750	153,030
6 Thanh xuan	2,422	1,043	3,465	12,110	5,215	17,325
7 Cau Giay+Tu Liem	3,063	604	3,667	14,174	2,174	16,348
Sub-Total	83,587	26,698	110,285	379,666	104,107	483,773
Sub urban districts						
8 Soc Son	0	0	0	0	0	0
9 Dong Anh	611	175	786	2,915	652	3,567
10 Gia Lam	1,711	174	1,885	8,165	713	8,878
11 Tu Liem (_7)	0	0	0	0	0	0
12 Thanh Tri	356	152	508	1,531	578	2,109
Sub-Total	2,678	501	3,179	12,611	1,943	14,554
Hanoi Grand Total	86,265	27,199	113,464	392,277	106,050	498,327

Source: Hanoi Department of Land Housing

A.1.2 Solid Waste Collection Quantity Survey

(1) Introduction

URENCO records waste amounts brought into the existing Tay Mo landfill site by using the truck scale. The truck scale data show that there are the following organizations which bring solid waste to Tay Mo landfill site:

a. URENCO
b. Urenco of Tu Liem
c. Urenco of Thanh Tri
d. Several enterprises

(2) Survey Periods

Occasionally, the truck scale has not been operational for some period. As of the end of November 1998, the records of the following three weeks are available to the JICA Study Team.

a. 22 September - 26 September 1998 (5 days from Monday to Friday)
b. 19 October - 25 October 1998 (7 days)
c. 26 October - 1 November 1998 (7 days)

(3) Survey Results

The JICA Study Team has analyzed the recorded data, and estimated average waste collection amounts, which are summarized in the table below:

Average Waste Collection Amounts Based on the Records of Truck Scale Kept at Tay Mo Landfill Site

Unit: ton/day

	22 September - 26 September 1998	19 October - 25 October 1998	26 October - 1 November 1998
A. Solid Waste A1. collected by URENCO	1,021.0	963.6	929.0
A2. collected by Other Organizations	85.3	55.8	33.6
A3. Total (A1 + A2)	1,106.3	1,019.4	962.6
B. Soil waste & Demolition waste collected by URENCO	222.3	258.4	327.8
C. (A3 + B)	1,328.6	1,277.8	1,290.4

Daily records of each survey week are shown in table A.1.1, A.1.2 and A.1.3. Other organizations shown in the tables include Urenco of Tu Liem, Urenco of Thanh Tri, and several enterprises.

As can be shown in those tables, URENCO collects about 80 % of solid waste (excluding soil waste and demolition waste) during the night time (6 PM - 2 PM), and the remaining 20% during the day time.

In view of the variation of waste collection amount, the JICA Study Team plans to obtain and analyze 2 more weeks of the truck scale data before estimating current average waste collection amounts.

Table A.1.1 Daily Waste Collection Amounts Recorded during 22 - 26 September 1998

(Unit: Ton)

DATE	Shift	Trans. Unit 1	Trans. Unit 2	Enterprise 5	Domestic Waste Total	Contract Waste	Soil	All Total
22 Sep.	Day	116.9	84.5	24.3	225.7	62.5	220.9	509.1
	Night	254.5	537.7	29.4	821.5	22.1	0.0	843.7
	Total	371.3	622.2	53.7	1,047.2	84.6	220.9	1,352.7
23 Sep.	Day	113.7	53.5	16.4	183.6	63.9	237.5	485.0
	Night	278.9	523.0	31.9	833.8	25.8	0.0	859.6
	Total	392.6	576.5	48.3	1,017.3	89.7	237.5	1,344.6
24 Sep.	Day	109.5	66.1	21.7	197.3	54.7	204.2	456.1
	Night	259.2	501.8	32.8	793.8	18.2	0.0	812.0
	Total	368.7	568.0	54.4	991.0	72.8	204.2	1,268.1
25 Sep.	Day	123.1	65.6	27.3	215.9	44.8	215.4	476.1
	Night	268.4	512.4	27.3	808.1	26.4	0.0	834.5
	Total	391.5	578.0	54.5	1,024.1	71.2	215.4	1,310.6
26 Sep.	Day	131.4	56.4	25.0	212.8	72.6	233.4	518.9
	Night	276.4	508.1	27.8	812.3	35.7	0.0	848.0
	Total	407.9	564.6	52.7	1,025.2	108.3	233.4	1,366.8
Average	Day	118.9	65.2	22.9	207.1	59.7	222.3	489.0
	Night	267.5	516.6	29.8	813.9	25.6	0.0	839.5
	Total	386.4	581.8	52.7	1,021.0	85.3	222.3	1,328.6

Note: Day time shift working hours are 09:00 - 16:00. Night shift working hours are 18:00 - 01:30.

Table A.1.2 Daily Waste Collection Amounts Recorded during 19 - 25 October 1998

	19-Oct Monday	20-Oct Tuesday	21-Oct Wednesday	22-Oct Thursday	23-Oct Friday	24-Oct Saturday	25-Oct Sunday	7 days Average(kg)	7days Average(ton)
A. General Waste									
1st Shift	267575	208060	229105	217715	181935	195600	201015	214429	214
2nd Shift	799265	756510	775120	753620	740420	737385	682210	749219	749
Sub total	1066840	964570	1004225	971335	922355	932985	883225	963648	964
B. Collection by Non-URENCO									
1st Shift	52870	36550	63220	27550	21200	15220	11320	32561	33
2nd Shift	28770	39200	35110	6390	10550	22410	20060	23213	23
Sub total	81640	75750	98330	33940	31750	37630	31380	55774	56
C. Soil/Demolition Waste									
1st Shift	236160	266680	229295	257580	250125	242245	326375	258351	258
2nd Shift	0	0	0	0	0	0	0	0	0
Sub total	236160	266680	229295	257580	250125	242245	326375	258351	258
D. Total (A+B+C)									
1st Shift	556605	511290	521620	502845	453260	453065	538710	505342	505
2nd Shift	828035	795710	810230	760010	750970	759795	702270	772431	772
Total	1384640	1307000	1331850	1262855	1204230	1212860	1240980	1277774	1278

Trips

	19-Oct Monday	20-Oct Tuesday	21-Oct Wednesday	22-Oct Thursday	23-Oct Friday	24-Oct Saturday	25-Oct Sunday	7 days Average
A. General Waste								
1st Shift	72	66	68	74	65	71	67	69
2nd Shift	193	194	194	200	194	191	187	193
Sub total	265	260	262	274	259	262	254	262
B. Non-URENCO								
1st Shift	7	8	7	10	8	9	3	7
2nd Shift	3	4	4	2	4	5	4	4
Sub total	10	12	11	12	12	14	7	11
C. Soil/Demolition Waste								
1st Shift	40	42	35	41	40	42	50	41
2nd Shift	0	0	0	0	0	0	0	0
Sub total	40	42	35	41	40	42	50	41
D. Total (A+B+C)								
1st Shift	119	116	110	125	113	122	120	118
2nd Shift	196	198	198	202	198	196	191	197
Total	315	314	308	327	311	318	311	315

Table A.1.3 Daily Waste Collection Amounts Recorded during 26 October - 1 November 1998

	26-Oct Monday	27-Oct Tuesday	28-Oct ednesda	29-Oct Thursday	30-Oct Friday	31-Oct Saturday	1-Nov Sunday	7 days Average (kg)	7days Average (ton)
A. General Waste									
1st Shift	206895	181930	191585	210865	199210	207765	208030	200897	201
2nd Shift	727800	763693	738115	524195	773520	778825	790495	728092	728
Sub total	934695	945623	929700	735060	972730	986590	998525	928989	929
B. Collection by Non-URENCO									
1st Shift	20220	19810	15590	19030	21230	22860	18170	19559	20
2nd Shift	11060	23040	11060	15380	15290	13060	9270	14023	14
Sub total	31280	42850	26650	34410	36520	35920	27440	33581	34
C. Soil/Demolition Waste									
1st Shift	323555	356675	463805	333555	247970	181550	151890	294143	294
2nd Shift	0	176045	59525	0	0	0	0	33653	34
Sub total	323555	532720	523330	333555	247970	181550	151890	327796	328
D. Total (A+B+C)									
1st Shift	550670	558415	670980	563450	468410	412175	378090	514599	515
2nd Shift	738860	962778	808700	539575	788810	791885	799765	775768	776
Total	1289530	1521193	1479680	1103025	1257220	1204060	1177855	1290366	1290

Trips

	26-Oct Monday	27-Oct Tuesday	28-Oct. ednesda	29-Oct. Thursday	30-Oct Friday	31-Oct Saturday	1-Nov Sunday	7 days Average
A. General Waste								
1st Shift	68	65	68	73	73	70	73	70
2nd Shift	194	196	193	191	190	192	195	193
Sub total	262	261	261	264	263	262	268	263
B. Non-URENCO								
1st Shift	7	12	8	5	7	5	5	7
2nd Shift	4	4	4	4	4	3	2	4
Sub total	11	16	12	9	11	8	7	11
C. Soil/Demolition Waste								
1st Shift	51	53	69	51	38	28	23	45
2nd Shift	0	27	9	0	0	0	0	5
Sub total	51	80	78	51	38	28	23	50
D. Total (A+B+C)								
1st Shift	126	130	145	129	118	103	101	122
2nd Shift	198	227	206	195	194	195	197	202
Total	324	357	351	324	312	298	298	323

(4) Relationship between Waste Generation and Collection Amounts

According to the household waste generation survey, total household waste generation amount in the 7 urban districts is estimated to be 577.5 ton/day. URENCO collects about 1,000 ton/day of waste excluding soil waste, demolition waste and night soil sludge. A director of an waste collection enterprise of URENCO expressed the following observation concerning waste collection amount by types:

a. household waste: 70 %
b. street waste: 15 %
c. commercial waste: 10 %
d. industrial waste: 5 %
e. total (a + b + c + d): 100%

The above observation seems to be realistic, and many cities of the developing countries show similar composition. Assuming the household waste shares 70 % of the waste collected by URENCO, 700 ton/day must be the household waste. This amount (700 ton/day) is much more than the estimated household generation amount of 577.5 ton/day. 700 ton/day is equivalent to the waste amount generated by 1.6 million population assuming the unit waste generation rate of 0.44 kg/capita/day, which is the rate found by the Household Waste Generation Survey of the JICA Study Team. In view of this situation, the following possibilities are considered:

Possible Explanation for Large Waste Collection Amount

Possible Explanation	Comments
1. Actual population in the 7 urban districts are 1.6 million instead of 1.3 million, which is the official statistic figure. The difference in the population are unregistered persons including immigrants from other provinces and students unregistered	This possibility seems to be worth considering seriously.
2. There are many people who commute for work from the 5 sub-urban districts of Hanoi to the 7 urban districts during day time.	This possibility seems to be worth considering seriously.
3. There are actually much non-household waste such as street waste, and commercial/industrial waste.	It is often observed that there are many households which discharge their waste to the sides of streets. However, this situation does not explain the big gap (422.5 ton/day) between the collected amount (1,000 ton/day) and estimated household waste generation amount (577.5 ton/day).
4. The result of the Household waste generation survey (0.44 kg/capita/day) is not correct.	a. According to another survey conducted by URENCO in 1992, the average household waste was 0.407 kg/capita/day. b. The JICA Study Team applied a normal method, where a plastic bag was delivered to each sample household every day during the survey period. The survey methodology is correct. c. There are some households which sell kitchen waste to some buyers, and did not put kitchen waste in the delivered plastic bags. However, such kitchen waste is not treated as waste. So, the existence of this situation is irrelevant to the question.
5. The truck scale installed in the existing landfill site in Tay Mo is not accurate.	URENCO have the truck scale regularly checked (calibrated), and receive the certificate of calibration. Therefore, this possibility may be ignored.

HPC is requested to cooperate with the JICA Study Team in finding the true situation, particularly actual population in the 7 urban districts and also day time population.

(5) Waste Amount Collected by Gia Lam Sub-Urban District

According to the information provided by Urenco of Gia Lam sub-urban district, this Urenco collects 119.5 m^3/day of solid waste on average. Assuming the bulk density of waste being 0.4, the collection amount is estimated to be 48 ton/day on average. The waste collected by this Urenco is currently disposed of at a dumping site located in the Gia Lam sub-urban district.

In future, there is a possibility that this Urenco may be absorbed by the big URENCO. Waste collected in Gia Lam may be transported to Duc Giang transfer station, and disposed of at Nam Son Landfill.

A.1.3 Solid Waste Quality Analysis

(1) Type of Solid Waste Analysis

The following types of waste quality analysis were conducted:

a. Physical composition analysis on wet base and estimation of bulk density (1st type analysis)
b. Physical composition analysis on dry base (2nd type analysis)
c. Chemical composition analysis of the 3 components, i.e., water content, ash content and combustible content (3rd type analysis)
d. Chemical composition analysis of the 6 elements, i.e., C, H, O, N, Cl, and sulfa (4th type analysis)

(2) Types of Samples

6 samples were prepared and analyzed for the 1st type analysis (physical composition analysis on wet base). Then, the same waste samples was used for analysis of 2nd, 3rd and 4th types. Of the 6 samples, 3 samples were household waste samples collected through the household waste generation survey, and the remaining 3 samples were general domestic waste collected by URENCO trucks.

Sources of Waste Samples

Sample No.	Sample Source	Remarks
Sample M1	20 bags from area A	Dong Da District (Governmental house)
Sample M2	20 bags from area B	Hoan Kiem & Tay Ho (Private house)
Sample M3	20 bags from area C	Gia Lam District
Sample M4	Truck No. 51-04	Open Truck
Sample M5	Truck No. 70-67	Open Truck
Sample M6	Truck No. 95-34	Small Compactor

(3) Survey Schedule

Samples M1, M2 and M3 were taken and analyzed for the physical composition analysis on wet base on 28th August and analyzed for other physical and chemical during following days. Sample M4, M5 and M6 from the collection vehicles at Tay Mo were taken on 8th September.

(4) Survey Method

Sample Preparation

As shown above, there were two different sources where waste samples were collected. One is household and the other is waste collected by waste collection trucks of URENCO. 3 samples were collected from each type of waste. In case of household waste, household waste collected for household waste generation survey was used as sample for composition analysis. Household waste contained in 20 plastic bags was used to prepare one sample. In case of waste collected by waste collection truck, one waste sample of 50 kg was prepared by using conical-quartering method.

Physical Composition Analysis on Wet Base

Sample waste was manually sorted according to types (9 different types as shown in the table below). Weight of waste of each type was measured, and waste composition was estimated in terms of percentage.

Physical Composition Analysis on Dry Base

After the wet base analysis was completed, the sorted sample waste were put in electric dryer for about 4 days, and then it weight was measured according to type of waste, and then waste composition on dry base was estimated in terms of percentage.

Chemical Composition Analysis of the 3 Components (Water, Ash, and Combustible)

This analysis was conducted for each of the following five types of waste, i.e., kitchen waste, paper, plastic/rubber, timber/rag, and bone/shell. The sample waste, which was dried already for the above dry base physical composition analysis, was used for this analysis. The sample waste was burned to ash. Based on this burning data and the data of the physical composition analysis, the composition of 3 elements was measured in terms of percentage.

Chemical Composition Analysis of the 6 elements (C, H, O, N, Cl; and Sulfa)

This analysis was conducted for each of the following five types of waste, i.e., kitchen waste, paper, plastic/rubber, timber/rag, bone/shell. The sample waste, which was dried already for the above dry base physical composition analysis, was used for this analysis. The sample waste was pulverized, and homogenized, and then burned at high temperature. Gases generated from the burning process were collected and analyzed using laboratory equipment, and the composition of the 6 elements was estimated in terms of percentage.

(5) Summary of the Survey Result

Table below shows the physical composition ratio of each sample on wet base. The components of sample M1; M2; M3 contain high percentage of cinders and, coal residues generated from cooking activities. The components of sample M5 and M6 contain high percentage of organic matters. All organic matters such as leaves and market waste are put into the category of kitchen waste.

Physical Composition of Sample Waste on Wet Bas

(Unit: %)

Types of Waste	M1	M2	M3	Ave.	M4	M5	M6	Ave.
Bulk Density in Car [kg/m^3]	-	-	-	-	487.6	425.2	505.3	468.8
Bulk Density [kg/m^3]	380.0	368.0	378.0	375.3	384.4	408.9	362.2	385.2
Kitchen waste	39.50	30.60	37.70	36.45	34.90	42.40	67.50	47.51
Paper	3.20	4.10	2.40	3.25	11.50	5.40	4.90	7.28
Plastics, rubbers	6.70	9.60	4.10	6.90	9.80	6.50	6.10	7.47
Bricks, stones	14.60	7.30	5.20	9.36	4.60	7.00	1.20	4.41
Timber, rags	1.30	1.20	2.10	1.58	1.70	2.70	1.20	1.92
Bones, shells	1.10	1.50	2.10	1.58	1.20	1.20	0.60	0.96
Metal, tin cans	1.10	0.60	0.60	0.79	0.70	0.60	0	0.38
Glass	1.90	4.8	0.30	2.07	1.70	0.60	0	0.77
Sand and Dust	30.60	40.30	45.50	38.03	34.10	33.60	18.50	29.31

Other result of solid waste quality analysis such as physical composition analysis on dry base and chemical analysis is summarized in Solid Waste Quality Analysis Report by CEETIA.

A.1.4 Time and Motion Study

(1) Aim

Ordinarily a time and motion study are done by an operational body on solid waste management aiming at more efficient collection and haulage, in some cases it is done by the third party such as university, research organization, and so on for the own purposes respectively.

The aim of a time and motion study (herein after referred as TMS) carried out by JICA Study Team together with URENCO is to clarify the actual conditions, then to find out major directions for more advantageous way of collection and haulage.

(2) Method

Observatory and time and weight measuring method is applied throughout the collection works by truck. While to obtain every cost on the operation was inevitable. Eventually the efficiency by type of truck was calculated as below.

a. Time efficiency: consumed time per waste collected & hauled (ton)
b. Cost efficiency: consumed cost per waste collected & hauled (ton)

(3) Execution

Prefer to the execution of TMS, some preparatory meeting were held among the execution team which consisted of JICA Study Team, URENCO, and assistants. Objective vehicles were arranged by URENCO.

(4) Result

TMS has been carried out for totally 7 days and the result of survey is shown in section E.3 of Data Book.

A.2 Water Quality Study

A.2.1 Water Quality Survey

Water Quality Survey was conducted in September and October, 1997 as a part of the Study by the sub-contractor, "Institute of Chemistry, Vietnam National Center for Natural Science and Technology". The survey was carried out in six area by 2 types of analysis as shown below.

Number of Sampling in Water Quality Survey

Survey Area	Sampling Points (refer to Annex 1)	Analysis	
		Category I	Category II
Urban	To Rich, River, Lu River, Set River, Kim River, drainage ditches and small lakes in Urban Area	10	20
Sub-urban	Small rivers, drainage ditches and lakes in Sub-urban Area	5	15
Rivers	Cau River, Calo River, Red River, Dung River, Nhue River	10	0
Wastewater Treatment Plants	Influent and effluent of five wastewater treatment plants.	10	0
Industrial wastewater	15 samples of effluent of selected industrial factories	15	0
Ground water	Selected 15 points of groundwater wells.	5	10

There are two types of analysis categories for two purposes. Category I includes 24 kinds of water quality items analysis for the purpose to understand detail conditions of water bodies, and Category II includes 6 kinds of water quality analysis for the purpose to understand general level of water pollution mainly caused by organic and nutrient matter. The analysis items of water quality are as shown below.

Water Quality Analysis Items

Category	Water Quality Analysis Items
Category I:	pH, Turbidity, Electric conductivity, DO, BOD, COD, SS, Total Nitrogen, Ammonia Nitrogen, Total Phosphorus, Iron, Manganese, Arsenic, Cadmium, Chrome, Hexavalent Chromium, Copper, Cyanide, Lead, Total Mercury, Fluoride, Chloride, Fecal Coliform, Total Coliform
Category II:	DO, BOD, COD, SS, Total Nitrogen, Total Phosphorus,

* Refer to Table A.2.1 and A 2.2

Methods of water quality analysis are shown in Table A.2.3. All of the water samples were preserved at 4 °C until analysis works were made.

A.2.2 Water Quality Analyses

Evaluation of water quality at this stage is carried out by Compassion with the Water Quality Standard in Vietnam, as shown in Table A.2.4.

(1) Assessment

1) Surface Water

(a) Organic Matter

A check list for DO, BOD and COD values at each point is shown in Table A.2.5. Comparing with the Surface Water Quality Standard B Level, all the points in the urban area are outside the Standard for COD values and almost all of the points are outside the Standard for BOD values. Some points in the Rural Area are outside the Standard for BOD and COD values. Compared with the Surface Water Quality Standard A Level, almost all sampling points area outside the Standard on BOD, COD and DO.

(b) Other Material

Only Ammonia, Iron, Manganese and Fluoride on several points as shown below, exceed the Surface Water Quality Standard B Level.

Water Quality Items	Sampling Points which exceed Standard
Ammonia	1UW1, 1UW3, 1UW5, 1UW8, 1UW9, 1UW10 1SW3
Iron	1SW1, 1SW2, 1SW3, 1SW4, 1SW5 1RW3, 1RW4, 1RW5, 1RW7, 1RW9, 1RW10
Manganese	1UW10
Fluoride	1UW2, 1UW3, 1UW4, 1UW5, 1UW9, 1UW10

2) Groundwater

The results of this survey show Iron and Manganese items of all sampling points are within the Standard. Cyanide (1GW5), Lead (1GW2), Fluoride (1GW1, 1GW2, 1GW4, 1GW5) exceed the standard.

High ammonia values are recorded on many sampling points. The Vietnamese Standard does not cover Ammonia. 1GW2, 1GW3 and 1GW4

are over 1.00 of Ammonia. 1GW2, 2GW5, 2GW6, 2GW7, 2GW8 and 2GW9 are over 2.0 of Total Nitrogen

(2) Distribution of water quality data

Results of the water quality survey on BOD and DO of water bodies in Urban Area, Rural Area and Major Big Rivers are shown in Figure A.2.1, A.2.2 and A.2.3 respectively. The water quality items of BOD and DO which are indicator of organic pollution.

Details of survey are described in Data Book.

Table A.2.1 ANALYTICAL PARAMETER AND NUMBER

(Category 1:Present condition of Environmental Pollution)

(Unit: No. of analyses)

	Parameter	Urban Water Areas	Suburban Water Areas	Rivers	Treatment Plants (In/out flow)	Industrial wastewater	Under-ground water
	Name of Group	1-UW	1-SW	1-RW	1-TW	1-IW	1-GW
	Number of samples	10	5	10	10	15	5
	Number of analyses						
1	ph	10	5	10	10	15	5
2	Turbidity	10	5	10	10	15	5
3	Eldctrical Conductivity	10	5	10	10	15	5
4	DO	10	5	10	10	15	5
5	BOD	10	5	10	10	15	5
6	COD	10	5	10	10	15	5
7	SS	10	5	10	10	15	5
8	Total Nitrogen	10	5	10	10	15	5
9	Ammonia Nitrogen	10	5	10	10	15	5
10	Total Phosphorus	10	5	10	10	15	5
11	Iron	10	5	10	10	15	5
12	Manganese	10	5	10	10	15	5
13	Arsenic	10	5	10	10	15	5
14	Cadmium	10	5	10	10	15	
15	Chrome	10	5	10	10	15	
16	Hexavalent Chromium	10	5	10	10	15	
17	Copper	10	5	10	10	15	
18	Cyanide	10	5	10	10	15	
19	Lead	10	5	10	10	15	
20	Total Mercury	10	5	10	10	15	
21	Fluoride	10	5	10		15	5
22	Chloride	10	5	10		15	5
23	Fecal Coliform Count	10	5	10	10	15	5
24	Total Coliform Count	10	5	10	10	15	
	Total	240	120	240	220	360	80

Table A.2.2 ANALYTICAL PARAMETER AND NUMBER

(Category II:Indicator of Environmental Pollution)

(Unit: No. of analyses)

	Parameter	Urban Water Areas	Suburban Water Areas	Rivers	Treatment Plants (In/out flow)	Industrial wastewater	Under-ground water
	Name of Group	II-UW	II-SW				II-GW
	Number of samples	20	15				10
	Number of analyses						
1	ph						
2	Turbidity						
3	Eldctrical Conductivity						
4	DO	20	15				10
5	BOD	20	15				10
6	COD	20	15				10
7	SS	20	15				10
8	Total Nitrogen	20	15				10
9	Ammonia Nitrogen						
10	Total Phosphorus	20	15				10
11	Iron						
12	Manganese						
13	Arsenic						
14	Cadmium						
15	Chrome						
16	Hexavalent Chromium						
17	Copper						
18	Cyanide						
19	Lead						
20	Total Mercury						
21	Fluoride						
22	Chloride						
23	Fecal Coliform Count						
24	Total Coliform Count						
	Total	120	90				60

Table A.2.3 Water Quality Analytical Method

No	Parameter	Unit	Anal. method	Determ. limits
1	pH	-	sensor pH meter	0.05
2	Turbidity	NTU	sensor meter	0.5
3	Elec. conductivity	µS/cm	sensor cond. meter	1
4	DO	mg/l	sensor	0.01
5	BOD_5	mg/l	sensor	0.01
6	COD	mg/l	Titration TCVN 4565-1988	0.01
7	SS	mg/l		0.01
8	Total Nitrogen	mg/l	TCVN 5987-1995 ISO 5663-1984	0.005
9	Ammonia nitrogen	mg/l	TCVN 5988-1995 ISO 5664-1984	0.005
10	NH_3-N	mg/l	Spectrophotometer	0.015
11	PO_4^{3-}-P	mg/l	AAS - visible spectr.	0.005
12	Iron	mg/l	AAS- visible spectr.	0.010
13	Manganese	mg/l	AAS-visible spectr. TCVN 4578-1988	0.005
14	Arsenic	mg/l	AAS / Polarographic TCVN 4571-88	0.001
15	Cadmium	mg/l	AAS / Polarographic TCVN 4574-88	0.001
16	Chrome	mg/l		0.001
17	Hexavalent chromium	mg/l		0.001
18	Copper	mg/l	AAS / Polarographic TCVN 4572-88	0.001
19	Lead	mg/l	AAS / Polarographic TCVN 1978-88	0.001
20	Cyanide	mg/l	TCVN 2660-78	0.001
21	Total mercury	mg/l	AAS / Polarographic TCVN 5989-1995 ISO 5666-1:1983	0.001
22	Fluoride	mg/l	TCVN 4568-88	0.001
23	Chloride	mg/l	TCVN 2656-78	0.001
24	Fecal coliform count	MNP/ 100ml	Membrane filter	3
25	Total coliform count	MNP/ 100ml	Membrane filter	3

Table A.2.4 Summary of Vietnamese Water Quality Standard

No.	Items	Surface Water		Groundwater	Industrial Effluent		
		A	B		A	B	C
1	pH	6 - 8.5	5.5 - 9.0	6.5 - 8.5	6 - 9	5.5 - 9	5 - 9
2	Turbidity						
3	Electrical Conductivity						
4	DO	6	2				
5	BOD	4	25		20	50	100
6	COD	10	35		50	100	400
7	SS	20	80		50	100	200
8	Total Nitrogen				30	60	60
9	Ammonia Nitrogen	0.05	1		0.1	1	10
10	Total Phosphorus				4	6	8
11	Iron	1	2	1 -5	1	5	10
12	Manganese	0.1	0.8	0.1 - 0.5	0.2	1	5
13	Arsenic	0.05	0.1	0.05	0.05	0.1	0.5
14	Cadmium	0.01	0.02	0.01	0.01	0.02	0.5
15	Chrome						
16	Hexavalent Chromium	0.05	0.05	0.05	0.05	0.1	0.5
17	Copper	0.1	1	1	0.2	1	5
18	Cyanide			0.01	0.05	0.1	0.2
19	Lead	0.05	0.1	0.05	0.1	0.5	1
20	Total Mercury	0.001	0.002	0.001	0.005	0.005	0.01
21	Fluoride	1	1.5	1	1	2	5
22	Chloride			200 - 600			
23	Fecal Coliform Count	5000	10000	not detectable			
24	Total Coliform Count			3			

Note: 1) Surface Water A: applied to the surface water using for source of domestic water supply

B: applied to the surface water using for the purposes other than domestic supply

Note: 2) Industrial Effluent A: discharge into the water bodies using for domestic water supply

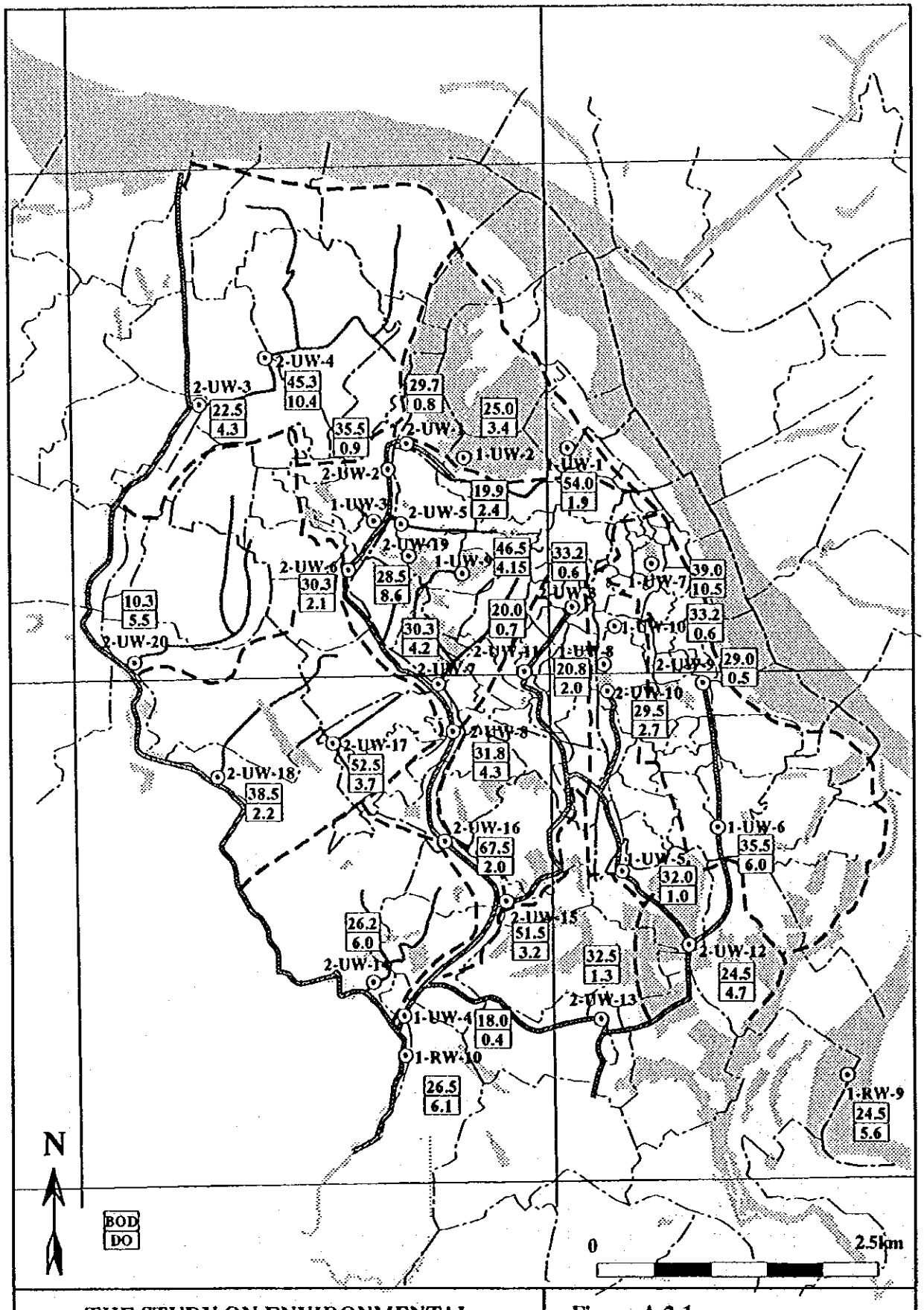
B: discharge only into the water bodies using for navigation, irrigation purposes or for bathing, aquatic breeding and cultivation

C: discharge to other

Table A.2.5 Check List for DO, BOD and COD, comparing with Vietnamese Standard

	DO	BOD	COD		DO	BOD	COD
1UW1	x	x	x	1SW1			
1UW2		x	x	1SW2			
1UW3	x	x	x	1SW3			x
1UW4	x		x	1SW4			x
1UW5	x	x	x	1SW5		x	x
1UW6		x	x				
1UW7		x	x	2SW1			
1UW8	x		x	2SW2			x
1UW9		x	x	2SW3	x	x	x
1UW10	x	x	x	2SW4		x	x
				2SW5			
2UW1	x	x	x	2SW6			
2UW2	x	x	x	2SW7		x	x
2UW3			x	2SW8			x
2UW4		x	x	2SW9			x
2UW5			x	2SW10			x
2UW6		x	x	2SW11			
2UW7		x	x	2SW12			
2UW8		x	x	2SW13			
2UW9	x	x	x	2SW14			
2UW10		x	x	2SW15			
2UW11	x		x				
2UW12			x	1RW1			
2UW13	x	x	x	1RW2			
2UW14		x	x	1RW3			
2UW15		x	x	1RW4			x
2UW16		x	x	1RW5			
2UW17		x	x	1RW6			
2UW18		x	x	1RW7			
2UW19		x	x	1RW8			x
2UW20			x	1RW9		x	x
				1RW10		x	x

x: Less than 2 mg/L of DO. More than 25 mg/L of BOD. More than 35 mg/L of COD

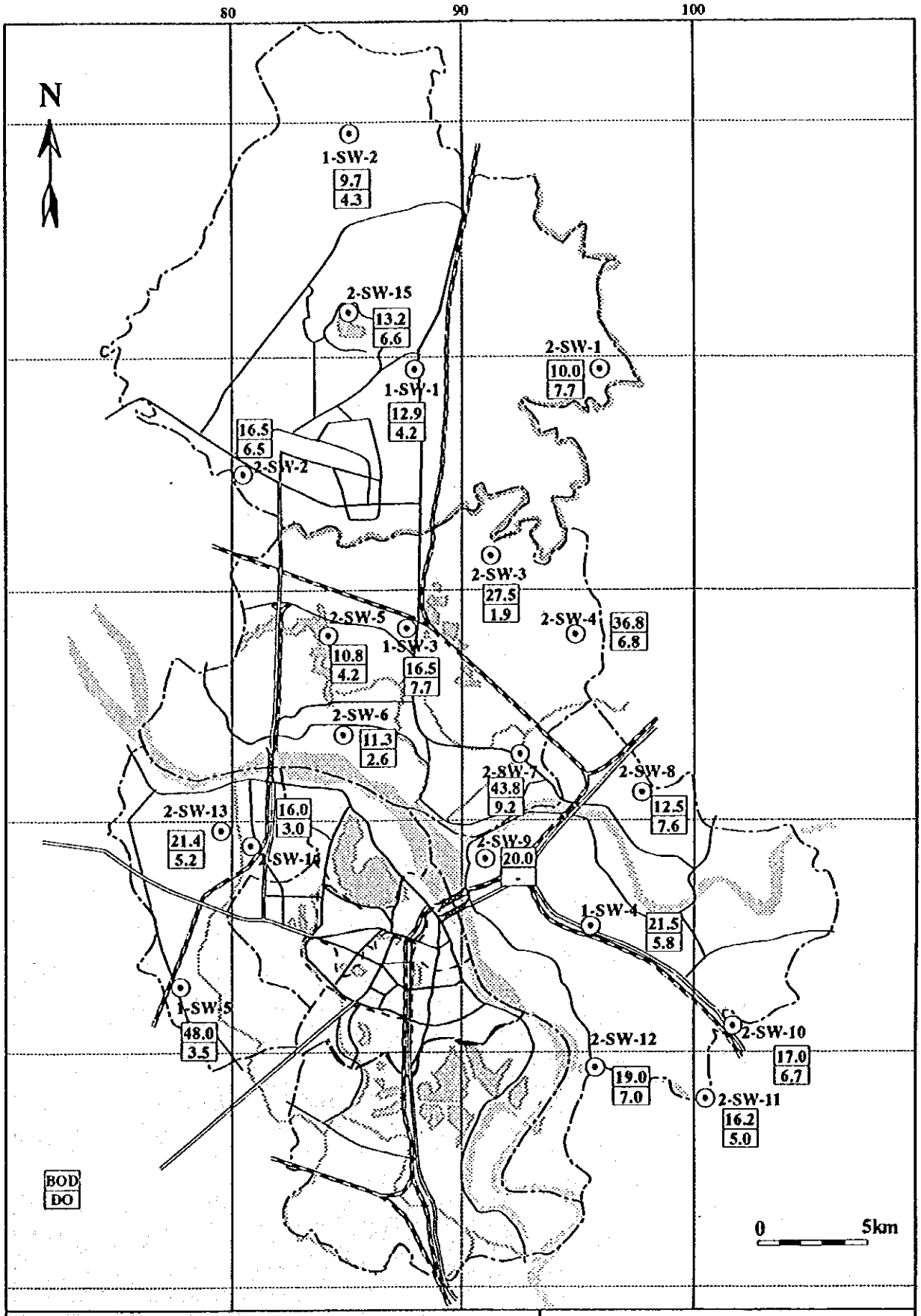


THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY

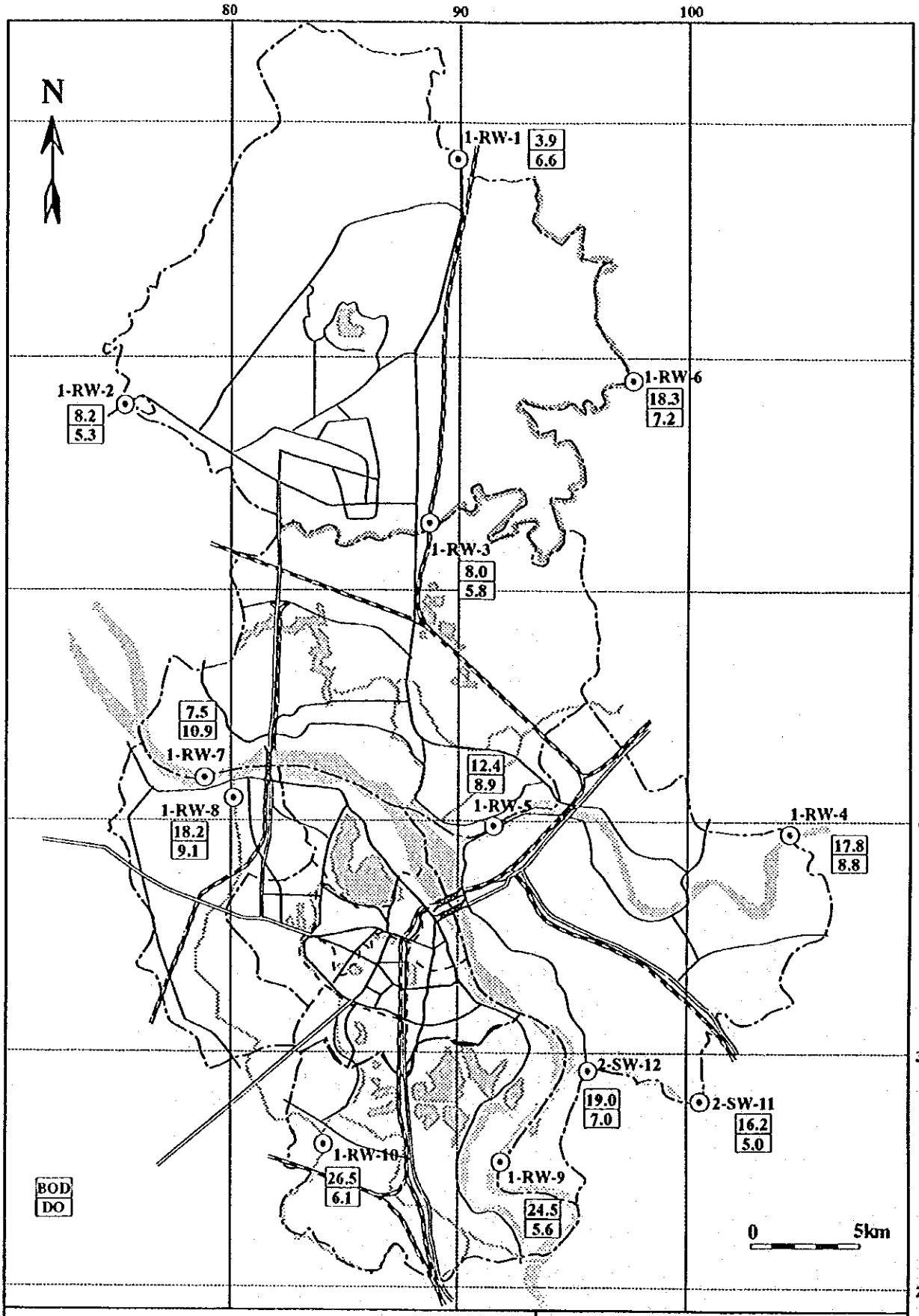
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure A.2.1

BOD and DO Values in Urban Area



THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY	Figure A.2.2 BOD and DO Values in Sub-urban Area
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure A.2.3 BOD and DO Values in Major Big River

A.3 Air Quality Study

A.3.1 Air Quality survey and analysis

As part of the JICA Study on Environmental Improvement for Hanoi City, an air quality survey was conducted from October 10 to 17, 1998.

Sulfur dioxide (SO2) and nitrogen dioxide (NO2) were sampled at five stations in Hanoi. Meteorological conditions were also recorded during the survey. All stations were located near roadways. Two of the stations were located in the urban area and three stations were located in the suburban areas. The survey aims at measuring traffic and industrial related air pollution.

Sampling and analysis was carried out by the personnel from the Laboratory of Analytical Chemistry , Chromatography and Spectrophotography from the Institute of Chemistry of the National Center of Natural Sciences and Technology in Hanoi. Members from the JICA study team supervised the sampling activities.

(1) Sampling and analysis method

Sampling for air quality was performed using Ogawa passive diffusion samplers. These samplers are very simple of use since there is no pump nor flow controlling devices. The sampler is loaded with a pollutant specific chemically treated filter paper that reacts with the target pollutant as air diffuses in the sampler. The exposed filter papers are they analyzed by spectrophotometry for NO_2 or by ion chromatography for SO_2. The average pollutant concentration over the exposure period can be then be determined. Correction factors for variation of pollutant diffusion rates with air temperature and humidity are provided with the samplers.

(2) Description of sampling points and sampling schedule

The five sampling areas are located at major roadways in urban and suburban Hanoi. The sampling locations are shown on Figure A.3.1. Table below gives a more detailed description of the sampling areas. In the urban areas, the samplers were located on the separation at the center of road. For the suburban areas, the samplers were located on the roadside.

Station location for the air quality survey

Station	Name	Purpose of sampling	Location
1	Thuong Dinh	Traffic and industrial pollution	On Duong Nguyen Trai (Route No.6 in Thuong Dinh industrial area) in Thanh Xuan district, near National University
2	Bach Mai	Traffic pollution	On Duong Giai Phong (Route No.1), a few hundred meters north from the intersection with Pho Dai La, at the frontier between Dong Da and Hai Ba Trung districts
3	Sai Dong	Traffic and industrial pollution	On Route No.5 to Hai Phong, near the Sai Dong industrial zone in Gia Lam district
4	Dong Anh	Low traffic and Industrial pollution	Roadside of Route No.3, nearby a commercial housing area in Dong Anh district
5	Soc Son	Low traffic and background pollution	Roadside of Route No.3, nearby a the post office in a residential area in Soc Son district

For NO_2, the recommended exposure time is from 24 hours to several weeks. For SO_2, the recommended sampling duration is 168 hours (7 days) to several weeks, unless SO_2 concentrations are expected to be very high. From previous air quality surveys near major roadways in Hanoi, the expected NO_2 and SO_2 concentrations were not expected to be very high. For this reason and to insure that the analysis results would be over the detection limits of the analytic methods, a 7 days exposure time was used for SO_2 and various exposure times (ranging from 1 to 7 days) were used for NO_2.

For NO_2, all of the samplers were located exactly at the same location for each of the 5 sampling locations. Only the sampling duration or exposure time of the samplers varied. For SO_2, all samples have the same duration or exposure time, but the samplers were distributed in the sampling area.

Meteorological parameters (wind speed and direction, temperature, humidity) were recorded six times per 24 hour period at each of the air quality sampling sites.

(3) Results and analysis

Table below presents the Vietnamese TCVN standards and the World Health Organization (WHO) guidelines for SO_2 and NO_2. The air quality survey results are presented in Table for NO_2 and SO_2.

WHO air quality guidelines are a little more stringent than the Vietnamese TCVN standards and they provide a long term guideline concentration for SO_2. Comparison of monitoring results with the standards is difficult because most of the samples represent a longer period than the standards.

WHO Air Quality Guidelines and Vietnamese Air Quality Standards

Pollutant	Averaging time	WHO Guideline (1)	Vietnamese standard (2)
Sulfur dioxide	1 hour	0.35 mg/m³	0.5 mg/m³
	24 hours	0.125 mg/m³	0.3 mg/m³
	1 year	0.05 mg/m³	--
Nitrogen dioxide	1 hour	0.3 mg/m³	0.4 mg/m³
	24 hours	0.1 mg/m³	0.1 mg/m³

(1) Recommended Air Quality Guidelines for the Western Pacific Region, WHO, December 1995.
(2) TCVN 5937 – 1995

For NO_2, the highest concentrations were found at the Bach Mai and Thuong Dinh urban stations. The two 24 hour samples at both urban sites were between 64% and 86% of the 24 hour TCVN standard. From this result, it can be expected that the 24 hour standard for NO_2 could be exceeded a few times during a whole year at the centerline of major urban roadways.

At the three suburban stations, the NO_2 concentrations were 2 to 3 times lower than at the urban stations. This type of result was expected since NO_x emissions and high ground level concentrations are most of the time associated with motor vehicles in the center of urban areas. During the survey, NO_2 concentrations were higher in Soc Son than in Sai Dong and Dong Anh.

For SO_2, the highest concentrations were recorded at the Sai Dong station, followed by the two urban stations. Concentrations in Dong Anh and Soc Son were lower than at the other stations. Concentrations at Sai Dong station, at the center of Route No.5 to Hai Phong, are probably higher because of the much larger traffic of diesel trucks and buses on that road. All of the 7 day average concentrations at all five monitoring sites were much lower than the 1 hour and 24 hour TCVN standards, but were very close to the annual WHO guideline.

Air Sampling Results for NO_2 (mg/m^3) in October 1998

Sample	Date	Exposure (days)	Thuong Dinh	Bach Mai	Sai Dong	Dong Anh	Soc Son
1	Oct. 10	1	0.064	0.086	0.038	0.029	0.041
2a	Oct. 10-11	2	0.054	0.064	0.026	0.021	0.032
2b	Oct. 10-11	2	0.053	0.063	0.026	0.022	0.033
3	Oct. 10-13	4	0.049	0.054	0.026	0.018	0.028
4	Oct. 13	1	0.073	0.078	0.039	0.027	0.036
5	Oct. 13-14	2	0.060	0.061	0.031	0.021	0.033
6a	Oct. 13-16	4	0.047	0.050	0.023	0.020	0.026
6b	Oct.13-16	4	0.046	0.049	0.022	0.019	0.026
7	Oct. 10-16	7	0.042	0.044	0.019	0.019	0.025

Samples 2a, 2b and 6a, 6b are duplicates
Vietnam air quality standard for NO_2 : 0.4 mg/m^3 for 1 hour, 0.1 mg/m^3 for 24 hours

Air Sampling Results for SO_2 (mg/m^3) in October 1998

Sample	Date	Exposure (days)	Thuong Dinh	Bach Mai	Sai Dong	Dong Anh	Soc Son
1	Oct. 10-16	7	0.047	0.058	0.059	0.027	0.030
2	Oct. 10-16	7	0.049	0.048	0.062	0.018	0.026
3	Oct. 10-16	7	0.053	0.053	0.054	0.024	0.021
4	Oct. 10-16	7	0.045	0.074	0.054	0.051	0.038
5	Oct. 10-16	7	0.049	0.053	0.065	0.064	0.019
6	Oct. 10-16	7	0.067	0.083	0.087	0.043	0.047
7	Oct. 10-16	7	0.049	0.055	0.095	0.040	0.032
Minimum			0.045	0.048	0.054	0.018	0.019
Maximum			0.067	0.083	0.095	0.064	0.047
Average			0.052	0.061	0.068	0.038	0.031

Vietnam air quality standard for SO_2 : 0.5 mg/m^3 for 1 hour, 0.3 mg/m^3 for 24 hours

(4) Results of the Air Quality Survey

In the urban area, there is a quite high probability that NO_2 concentrations along the busiest roadsides exceed the 24 hour standard a few times during a year. In the sub-urban areas, NO_2 concentrations are 2-3 times lower than in the urban area.

SO_2 concentrations were the highest on Route No.5 to Hai Phong near Sai Dong industrial area, followed by the two urban sampling sites. In Dong Anh and Soc Son, SO_2 concentrations were much lower.

Most of the results from the survey are representative of a local area composed of the road itself and a narrow band (10 - 20 meters) along the roadsides. Results are not representative of the whole district or commune were the samples were taken. Results are not representative either of area located downwind of industrial zone with large sources of SO_2 and NO_x.

A.3.2 Other surveys, data collection and analyses

(1) Air Quality standards

Air Quality standards are defined in the following TCVNs:

- TCVN 5937-1995: "Air quality - Ambient air quality standards "
- TCVN 5938-1995:"Air quality - Maximum allowable concentration of hazardous substances in ambient air"

These standards are applied to the evaluation of ambient air quality and to the monitoring of air pollution status. They are not applicable to the workplace atmosphere. Other TCVN standards define the air sampling and analysis methods for most of the pollutants for which a standard was defined. These methods usually follow the International Standard Organization (ISO) recommended methods.

The Vietnamese air quality standard (TCVN 5937-1995) for "classic" air pollutant are presented in the table below. The standards are usually for 1 hour and 24 hours periods. Their is no standard for long term periods. Table also present the World Health Organisation (WHO) recommended air quality guidelines for the western pacific region. In general, the Vietnamese air quality standard, as for a lot of countries around the world, are higher (less stringent) than the WHO guidelines.

Comparison of WHO Air Quality Guidelines and Vietnamese Air Quality Standards

Pollutant	Averaging time	WHO Guideline (1)	Vietnamese standard (2)
Sulfur dioxide	1 hour	0.35 mg/m³	0.5 mg/m³
	24 hours	0.125 mg/m³	0.3 mg/m³
	1 year	0.05 mg/m³	--
Nitrogen dioxide	1 hour	0.3 mg/m³	0.4 mg/m³
	24 hours	0.1 mg/m³	0.1 mg/m³
Carbon monoxide	1 hour	30 mg/m³	40 mg/m³
	8 hours	10 mg/m³	10 mg/m³
	24 hours	--	5 mg/m³
Total Suspended Particulate (TSP) matter	1 hour	--	0.3 mg/m³
	24 hours	0.15 mg/m³	0.2 mg/m³
	1 year	0.09 mg/m³	--
PM10 (3)	24 hours	0.1 mg/m³	--
	1 year	0.06 mg/m³	--
Ozone	1 hour	0.12 mg/m³	0.2 mg/m³
	8 hours	0.06 mg/m³	--
	24 hours	--	0.06 mg/m³
Lead	24 hou	--	0.005 mg/m³
	3 months	0.001 mg/m³	--

(1) Recommended Air Quality Guidelines for the Western Pacific Region, WHO, December 1995.
(2) TCVN 5937 - 1995
(3) Particulate matter less than 10 micrometer in diameter

(2) Air emission standards

General industrial air emission are regulated by the two following standards:

- TCVN 5939-1995:"Air quality - Industrial emission standards - Inorganic substances and dusts"
- TCVN 5940-1995:"Air quality - Industrial emission standards - Organic substances"

A MAC (maximum allowable concentration) for inorganic substances and dusts is defined for existing sources and for new sources. Emissions standards for particular sources (petroleum refining, cement, motor vehicles) are specified in separate standards.

(3) Air emission standards and emission testing for motor vehicles

Environmental regulations and standards for motor vehicles are listed in standard 22-TCN-224-95 by the Ministry of Transportation.

Table hereunder presents the air emission standards new motor vehicles

For new motorcycles, the actual emission standard is as following:

- for hydrocarbons (HC) : less than 5 g/km per vehicle;
- for carbon monoxide (CO) : less than 12 g/km per vehicle.

Air Emission Standard for New Vehicles (4 wheelers and more)

Vehicle reference weight (RW) (kg)	Gasoline vehicle (g/km/vehicle)			Diesel vehicle (g/km/vehicle)	
	CO	HC	Nox	CO	HC + NOx
RW < 750	65	6.0	8.5		
750 < RW < 850	71	6.3	8.5	58	19
850 < RW < 1020	76	6.5	8.5		
1020 < RW < 1250	87	7.1	10.2	67	20.5
1250 < RW < 1470	99	7.6	11.9	76	22
1470 < RW < 1700	110	8.1	12.3	84	23.5
1700 < RW < 1930	121	8.6	12.8	93	25
1930 < RW < 2150	132	9.1	13.2	101	26.5
RW > 2150	143	9.6	13.6	110	28

Notes: RW = Empty vehicle weight + 100 kg

For old vehicles, the following standards apply:

- for gasoline vehicle: CO in exhaust gases must be lower than 6%;
- for diesel vehicle: black smoke must be lower than 50%.

The Ministry of Science, Technology and Environment is presently developing a new standard for motor vehicle in collaboration with Ministry of Transportation and the Ministry of Health.

Also, motor vehicles are regularly tested in seven (7) emission testing centers in Hanoi (3 operated by TUPWS and 4 by the ministry of transport) following the schedule listed in the table below

Regulatory Testing Schedule for Motor Vehicles

Type of Vehicle	First test for new vehicle- (month)	For used vehicle (month)
Trucks with weight capacity 5000 kg		
- Foreign made (including foreign joint venture made and assembly in Vietnam)	24	12
- Manufacture and assemble in Vietnam	12	6
Trucks with weight capacity higher than 5000 kg		
- Foreign made (including foreign joint venture made and assembly in Vietnam)	24	12
- Manufacture and assemble in Vietnam	18	12
Cars (for less than 10 persons)		
Foreign made (including foreign joint venture made and assembly in Vietnam)		
- For the transportation service.	24	12
- Not for transportation service.	30	18
Buses (for more than 10 persons)		
Foreign made (including foreign joint venture made and assembly in Vietnam)		
- For the transportation service.	18	6
- Not for transportation service.	24	12
Manufacture and assemble in Vietnam.		
- For the transportation service.	12	6
- Not for transportation service.	18	12
Three wheel motor vehicles:		
Foreign made (including foreign joint venture made and assembly in Vietnam)		
- For the transportation service.	24	6
- Not for transportation service.	30	12
Manufacture and assemble in Vietnam.		
- For the transportation service.	18	6
- Not for transportation service.	12	12
For the vehicles have been used for more than 7 years		6

(4) Air quality monitoring activities in Hanoi City

Most of the air quality monitoring activities are performed by Institutes and Universities under contract by the DOSTE or NEA. There is no long term continuous air quality monitoring program in Hanoi City. Usually, monitoring

consist a few days survey repeated 2 or 4 times during a year. Lack of equipment, personnel and budget are the main reasons why there is no continuous or regular air monitoring program in Hanoi City.

The NEA air monitoring activities in Hanoi are part of the National Monitoring Program started in 1995. Air samples are taken every three months at 3 or 4 stations in Hanoi. One of the station is located outside the urban area to determine background air quality. The principal goal of the program is to establish general air quality in the urban area. Air quality near specific industries in not part of the objectives of the NEA monitoring program.

Also, some air quality surveys are conducted for purposes of Environmental Impact Assessment reporting for existing or new industrial establishments. These surveys are usually conducted on a few days period and consist of a few samples taken around the facilities or proposed sites.

The existing air quality surveys data permits to identify "chronic" or permanent air quality problems, but does not permit to identify episodic and larger scale air quality problems usually related to special or unusual meteorological conditions. Also, long term average concentrations of pollutants cannot be estimated from the data collected because of the too few air quality samples in the same area.

(5) Air quality measurements by DOSTE in each district

Measurements of air quality in 5 urban and 3 suburban districts are presented in the table. Gaseous pollutant concentration were all much lower than the standards. TSP concentrations were several times above standard, ranging from 2.5 to 4 times the hourly standard.

Air quality results by districts of Hanoi (January 1997)

District	CO (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	TSP (mg/m^3)
Hoan Kiem	0.881	0.026	0.042	0.52
Hai Ba Trung	0.970	0.021	0.061	0.67
Dong Da	0.982	0.033	0.051	0.80
Ba Dinh	1.032	0.024	0.072	0.55
Tay Ho	1.042	0.035	0.072	0.78
Thanh Tri	3.815	0.040	0.083	0.72
Tu Liem	1.837	0.032	0.065	0.59
Gia Lam	1.670	0.043	0.092	0.80
TCVN standard	40	0.4	0.5	0.3

Note: results are averages of samples taken during daytime at 2 or 3 sites.

Source: Institute of chemistry, (in Vietnamese), January 1997.

(4) Air quality in existing industrial zones

1) Results for six existing industrial zones

Air quality surveys in industrial zones have been conducted many times in the past 8 years. In 1996 and 1997, the Institute of Chemistry from the National Center of Natural Sciences and Technology has conducted several surveys in 6 industrials areas for the EMD of Hanoi DOSTE. Results from the 1997 surveys are presented in the next table. Total suspended particulates (TSP) concentrations are usually several times higher than the hourly and daily standards. SO_2 is the major gaseous contaminant in the industrial zones since coal and heavy oil are still the major sources of energy for the main industries. NO_2 and CO are usually much lower than their respective standards, but average daily CO concentration can get very close and sometimes a little higher than the standard (5 mg/m^3).

Air Quality monitoring results in 6 industrial zones in 1997

Station and date	Number of samples	CO (mg/m³)			NO_2 (mg/m³)			SO_2 (mg/m³)			TSP (mg/m³)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Thuong Dinh													
01/01/97	10	1.1	3.8	2.6	0.015	0.070	0.062	0.062	0.096	0.075	0.280	0.600	0.475
15-18/10/97	14	1.3	4.2	3.0	0.022	0.123	0.086	0.050	0.127	0.089	0.280	0.700	0.492
17-20/11/97	14	0.9	4.5	2.9	0.024	0.115	0.075	0.052	0.153	0.093	0.240	0.720	0.484
8-12/12/97	14	1.2	4.3	2.8	0.019	0.101	0.070	0.050	0.173	0.098	0.270	0.780	0.500
15-17/12/97	14	1.0	4.2	3.1	0.020	0.105	0.075	0.047	0.166	0.111	0.380	0.770	0.590
All	66	0.9	4.5	2.9	0.015	0.123	0.074	0.047	0.173	0.094	0.240	0.780	0.510
Mai Dong													
11/01/97	10	1.7	7.2	6.4	0.025	0.079	0.065	0.050	0.086	0.076	0.510	1.100	0.760
15-18/10/97	14	2.2	7.4	6.4	0.022	0.072	0.062	0.032	0.125	0.085	0.520	1.620	0.827
17-20/11/97	14	2.3	7.8	6.2	0.025	0.076	0.063	0.032	0.152	0.101	0.320	0.810	0.620
8-12/12/97	14	2.1	7.5	6.5	0.030	0.093	0.071	0.040	0.127	0.090	0.500	1.020	0.790
16-17/12/97	14	2.0	7.7	6.5	0.027	0.081	0.066	0.031	0.127	0.100	0.520	1.020	0.828
All	66	1.7	7.8	6.4	0.022	0.093	0.065	0.031	0.152	0.091	0.320	1.620	0.765
Van Dien													
29-30/01/97	10	1.7	4.5	3.5	0.019	0.051	0.030	0.043	0.112	0.085	0.300	0.800	0.675
15-17/10/97	14	2.2	5.1	3.9	0.024	0.054	0.039	0.035	0.172	0.104	0.350	0.850	0.723
17-20/11/97	14	1.9	5.3	4.0	0.027	0.067	0.045	0.032	0.160	0.107	0.280	0.810	0.684
8-11/12/97	14	2.2	5.3	4.1	0.022	0.072	0.044	0.037	0.112	0.112	0.320	0.880	0.690
16-17/12/97	14	2.3	5.7	4.4	0.022	0.077	0.049	0.035	0.116	0.116	0.320	0.870	0.680
All	66	1.7	5.7	4.0	0.019	0.077	0.042	0.032	0.160	0.106	0.280	0.880	0.691
Cau Dien													
6-7/01/97	10	1.3	2.5	1.9	0.015	0.082	0.060	0.051	0.102	0.082	0.300	0.610	0.497
15-18/10/97	14	1.4	2.5	2.0	0.017	0.082	0.069	0.025	0.153	0.090	0.300	0.750	0.570
17-20/11/97	14	0.9	2.9	2.2	0.021	0.078	0.069	0.025	0.132	0.104	0.200	0.720	0.567
8-11/12/97	14	1.4	3.6	2.4	0.022	0.101	0.075	0.032	0.127	0.094	0.300	0.860	0.600
15-17/12/97	14	1.0	2.9	2.4	0.019	0.092	0.067	0.031	0.111	0.083	0.250	0.760	0.460
All	66	0.9	3.6	2.2	0.015	0.101	0.068	0.025	0.153	0.091	0.200	0.860	0.541
Phap Van													
25/01/97	10	1.5	5.7	3.3	0.013	0.043	0.038	0.054	0.137	0.090	0.300	0.700	0.575
15-17/10/97	14	1.3	4.8	4.3	0.015	0.052	0.043	0.063	0.152	0.107	0.200	0.870	0.637
17-20/11/97	14	1.1	5.1	4.4	0.025	0.055	0.046	0.029	0.127	0.097	0.320	0.730	0.545
11-12/12/97	14	1.5	4.9	4.2	0.025	0.067	0.047	0.053	0.133	0.103	0.270	0.790	0.614
15-17/12/97	14	1.4	5.7	4.6	0.025	0.067	0.049	0.037	0.117	0.103	0.270	0.720	0.526
All	66	1.1	5.7	4.2	0.013	0.067	0.045	0.029	0.152	0.101	0.200	0.870	0.580
Chem													
6-7/01/97	10	0.9	1.9	1.4	0.010	0.033	0.025	0.032	0.095	0.079	0.300	0.600	0.487
15-17/10/97	14	1.1	3.4	2.1	0.015	0.032	0.025	0.024	0.127	0.083	0.250	0.700	0.475
17-19/11/97	14	0.9	6.3	3.0	0.020	0.062	0.043	0.025	0.127	0.079	0.270	0.780	0.604
11-12/12/97	14	1.0	4.6	2.8	0.018	0.052	0.035	0.030	0.127	0.089	0.270	0.800	0.570
15-17/12/97	14	1.3	5.1	2.7	0.019	0.054	0.038	0.030	0.127	0.092	0.270	0.830	0.566
All	66	0.9	6.3	2.5	0.010	0.062	0.034	0.024	0.127	0.085	0.250	0.830	0.544
TCVN Standards (1 hour - 24 hours)		40 - 5			0.4 - 0.1			0.5 - 0.3			0.3 - 0.2		

Notes: Samples are taken over a 5 to 60 minutes period in the morning and the afternoon at 5 to 7 sites surrounding the industrial areas. Minimum values are usually obtained upwind of the industrial sources.
Minimum and maximum values should be compared with the 1 hour standard.
Average values represent the average of all samples taken in a given area during a survey. They could be compared with caution (since they do not represent a 24 hour period at the same station) with the 24 hours standards.

Source: Analysis Results of Air Samples in 6 Industrial Areas of Hanoi, January 1997 and October-November-December 1997 (in Vietnamese), Institute of Chemistry, National Center of Natural Sciences and Technology.

2) Dong Anh

For the EIA for the Dong Anh Electrical Equipment manufacturing plant, a quick air quality survey (SO_2, NO_2) was conducted in the vicinities of the plant. Results were much lower than the standards.

A another air quality survey was conducted in Dong Anh industrial zone for the EIA of the Dong Anh mechanical Steel Structure plant. Air quality samples on the plant site were above standards for TSP, SO_2 and NO_2. In the

residential area located 200 meters from the site, all air quality parameters were much lower than the standards.

3) Duc Giang

A short air quality survey was conducted on the 27th of August 1998 near the Duc Giang industrial area in Gia Lam district. Results for gases (CO, NO_2, SO_2) at the three sampling sites were all below the hourly standard. The CO and NO_2 concentrations were very low and the SO_2 concentration reached 50% of the standard. For TSP, the results ranged from 90% to 140% of the hourly standard.

4) Air dispersion modeling results for major industrial zones

Some air dispersion modeling for industrial sources in the main existing industrial zones was performed by the Center for Environmental Engineering of Town and Industrial Area (CEETIA) of Hanoi University of Civil Engineering. Calculated winter or summer TSP concentrations vary from 4 to 7 times the long term average recommended concentration by WHO (0.09 mg/m^3) in Thuong Dinh, Mai Dong, Van Dien and Sai Dong industrial areas. The highest concentrations are calculated near the industrial sources and usually inside the industrial zones limits. Concentrations decrease rapidly with the distance from the sources. For SO_2, the Thuong Dinh and Mai Dong industrial areas were also identified has problematic areas by the air dispersion modeling studies. Usually, air quality problems identified by the air dispersion modeling studies are localized to the industrial zone and the immediate surrounding areas.

(1) Air quality in new industrial zones

1) Thang Long (north) industrial zone

A air quality survey was conducted for 24 hour periods from January 9-12, 1997. TSP, SO_2, NO_2 and CO were measured every 2 hours during daytime and every 2-3 hours during nighttime at 6 sampling sites. The main sources of air pollution in the area are domestic sources and traffic, mainly the Noi Bai Airport Highway. Results were all much below the standards, except for CO and TSP. Here also the 24 hour average CO concentration was very close or a little higher than the standard, especially near the roadways. For TSP, most of the stations add some hourly values higher than the standard and half the stations add 24 hour average TSP concentrations over the standard.

2) Noi Bai industrial zone

At least two short air quality surveys (A few hours and 1 day duration) were conducted in the new Noi Bai industrial as part as the EIA process for new projects (NCI Vietnam and Advanced Building Systems) in the area. Results indicate very low concentrations of CO, NO_2, and SO_2. TSP concentrations were lower than the standard but were still quite high (up to 80% of the hourly standard).

(8) Air quality in suburban areas

Air quality survey was conducted by CEETIA in Duoi Ca - Phap Van area on August 18-29, 1996 and in Nam Du Thuong area on August 5-11, 1998. Both areas are located in Thanh Tri suburban district. Results for gases (CO, NO_2, SO_2) were all much lower than the standards. For TSP, the 24 hours averages in Nam Du Thuong were all below standard. In the Duoi Ca area, a few hourly samples exceeded the standard and the daily average was above the standard.

(9) Air quality near major roadways

1) Survey by the Institute for Transportation Techniques and Science

Monitoring results from 1995 by the Institute for Transportation Techniques and Science for 3 majors traffic intersections in urban Hanoi are presented in the next table and compared with the applicable standard. Even with only three samples at each intersection, it is possible to conclude that CO and NO_2 are below standards, that SO_2 concentrations could on some occasion exceed the standard and that TSP is several time over the standard most of the time during heavy traffic hours.

Air quality monitoring results at major road intersections (27/03/95)

Nga tu So				
Time	CO (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	TSP (mg/m^3)
7:30 - 8:30	0.77	0.02	0.15	1.2
8:30 - 9:30	0.75	0.02	0.40	1.5
16:30 – 17:30	0.77	0.04	0.10	0.43
Nga tu Vong				
Time	CO (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	TSP (mg/m^3)
7:30 - 8:30	2.0	0.01	0.08	1.3
8:30 - 9:30	0.80	0.20	0.38	1.2
16:30 – 17:30	0.73	0.01	0.10	2.5
Chan Cau Chuong duong - Tran Quang Khai				
Time	CO (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	TSP (mg/m^3)
7:30 - 8:30	1.5	0.01	0.15	0.23
8:30 - 9:30	1.3	0.02	0.5	0.56
16:30 – 17:30	0.75	0.02	0.2	0.20
TCVN standard	40	0.4	0.5	0.3

Ref [25]

2) Surveys for the Master Plan of Urban Transport for Hanoi City

During the preparation of the Master Plan of Urban Transport for Hanoi City (JICA, 1997), a air quality survey was conducted for a whole week of January 1996 on Cau Nam Street in Hoan Kiem District. A second station was located in Phu Thong commune (Tu Liem district) to determine background level concentrations of TSP, CO, NO_2 and SO_2. Results are presented in the table below. On the road side, TSP concentrations were about 2-3 times the standard. At the background station, hourly and daily TSP concentrations were about at one half of the allowable concentrations, i.e. concentrations on the road side were about 6 times higher than the background concentrations. Gaseous pollutants measurements were all much lower than there respective standard, except for the daily CO and NO_2 concentrations who reached 70% of the daily standards at the road side station.

One of the main findings of this survey is that the hourly concentrations of gases do not correlate at all with traffic volume variations. Also, no daily pattern was observed in the toxic gases concentrations. This indicates that traffic is not such a dominant source for toxic gases concentrations. For TSP however, there is a strong hourly variation during the day with very high concentrations (2-3 times the hourly standard) from 6:00 to 22:00 and with concentrations similar to the background station at night. This pattern can be correlated with the main activities in the area: traffic and other urban activities. However, domestic combustion and vehicle emission can not explain why their is a daily pattern for TSP and not for gases. This suggest

that a other source of TSP is the main cause of the TSP daily pattern. Road dust resuspension from traffic could explain the daily pattern since streets in Hanoi usually have a high surface dust load (20 - 40 g/m^2, sometimes 100 - 240 g/m^2 (Standard: 10 mg/m^2)). Also, TSP emissions from roaddust resuspension is usually about 10 times more important than exhaust TSP emissions from motor vehicles.

Results from Road Air Quality Survey in Hoan Kiem District in 1996 by JICA

January 5 - 12, 1996

Daily averages

Day	Pollutant concentration (mg/m^3)							
	CO		NO_2		SO_2		TSP	
	Road side	Background	Road side	Background	Road side	Background	Road side	Background
1	1.99	0.93	0.013	0.002	0.105	0.027	0.443	0.090
2	1.49	0.89	0.034	0.017	0.100	0.015	0.447	0.090
3	3.59	1.16	0.039	0.025	0.096	0.056	0.526	0.095
4	2.67	1.01	0.058	0.062	0.089	0.062	0.580	0.058
5	1.44	0.68	0.062	0.015	0.062	0.026	0.538	0.058
6	1.52	0.74	0.023	0.015	0.017	0.010	0.592	0.093
7	1.11	0.84	0.005	0.001	0.059	0.024	0.496	0.098
TCVN Standard	5		0.1		0.3		0.2	

Hourly maximums

Day	Pollutant concentration (mg/m^3)							
	CO		NO_2		SO_2		TSP	
	Road side	Background	Road side	Background	Road side	Background	Road side	Background
1	2.96	1.74	0.036	0.023	0.174	0.042	0.995	0.115
2	3.96	1.49	0.049	0.029	0.165	0.030	0.852	0.136
3	5.25	1.93	0.087	0.038	0.153	0.072	0.993	0.150
4	3.55	1.16	0.078	0.032	0.108	0.096	0.934	0.113
5	2.87	0.90	0.095	0.048	0.108	0.039	0.852	0.176
6	3.53	1.69	0.055	0.024	0.042	0.026	0.915	0.156
7	1.92	1.02	0.015	0.009	0.126	0.048	0.976	0.160
TCVN Standard	40		0.4		0.5		0.3	

Notes: Road side station is located on Cau Nam Street, Hoan Kiem district.
Background station is located in Phu Thong commune, Tu Liem district.

Source: JICA, Master Plan of Urban Transport for Hanoi City, January 1997.

During the same JICA study, a second air quality survey, with a total of 8 monitoring sites was conducted in Tu Liem district. Five of the monitoring sites were sampled on the same day and the 3 other sites were sampled on 3 different days. Hourly concentrations of CO were much lower than the standards, but 24 hours average CO concentration were very close and sometimes a little higher than the standard. SO_2 and NO_2 hourly and daily

concentrations were also lower than the standards. Again, TSP concentrations ranged from values close to the standards to values equal to 2-3 the standards, especially for road side monitoring sites.

Results from road air quality survey in Tu Liem district by JICA i

August 5 - 9, 1996

Daily averages

Day	Monitoring Location	Pollutant concentration (mg/m^3)				
		CO	NO_2	SO_2	TSP	Lead
5	A1	2.89	0.026	0.001	0.183	
5	A2	4.27	0.037	0.009	0.196	
5	A3	2.53	0.014	0.003	0.257	
5	A4	4.53	0.033	0.009	0.193	
5	A5	4.57	0.032	0.047	0.249	
7	A6	3.67	0.010	0.092	0.516	0.0043
8	A7	5.13	0.006	0.029	0.494	0.0057
9	A8	5.20	0.004	0.027	0.386	0.0046
TCVN Standard		5	0.1	0.3	0.2	0.005

Hourly maximums

Day	Monitoring Location	Pollutant concentration (mg/m^3)				
		CO	NO_2	SO_2	TSP	Lead
5	A1	3.42	0.038	0.007	0.230	
5	A2	6.81	0.066	0.034	0.231	
5	A3	3.12	0.041	0.013	0.321	
5	A4	7.14	0.048	0.022	0.234	
5	A5	5.59	0.064	0.015	0.364	
7	A6	4.36	0.013	0.122	0.601	0.0050
8	A7	5.67	0.010	0.041	0.581	0.0085
9	A8	5.61	0.007	0.034	0.418	0.0052
TCVN Standard		40	0.4	0.5	0.3	-

Site locations:

A1	Phu Thuong Commune (background station)
A2	Xuan La Commune
A3	Nghia Do Commune
A4	Co Nhue Commune
A5	on road side in Dong Ngac Commune (Gach Hamlet)
A6	on road side of South Thang Long - Noi Bai Highway, Co Nhue Commune
A7	on road side of South Thang Long - Noi Bai Highway, Dong Ngac Commune
A8	on road side under railway viaduct, Dong Ngac Commune

Source: JICA, Master Plan of Urban Transport for Hanoi City, January 1997.

(10) Background urban air quality

From 1993 to 1995, several surveys of background urban air quality were conducted. A summary of the results is presented hereunder. Monitoring sites are located in Lenin Park, Bach Tao Park (south of West Lake) and at the Thu Le zoo (west Ba Dinh district). In general, background urban CO and SO_2 concentrations are very low compared to the TCVN standards or WHO guidelines. NO_2 as reached on one occasion a value of about 60% of the hourly standard. TSP is very frequently over the hourly standard during daytime (all the samples were taken during daytime). The average of all TSP samples at one location is 3 to 4 times above WHO annual guideline.

Air Quality monitoring results at baseline stations in urban Hanoi from August 1994 to March 1995

Baseline Station	Number of samples	Average and maximum values (mg/m^3) CO	SO_2	NO_2	TSP
Thu Le Zoo	30	1.73 / 8.3	0.003 / 0.029	0.044 / 0.176	0.32 / 0.48
Lenine Park	22	0.97 / 5.0	0.009 / 0.057	0.021 / 0.190	0.25 / 0.34
Bach Thao Park	30	1.31 / 8.0	0.001 / 0.015	0.051 / 0.239	0.36 / 0.48
1 hour TCVN Standard		40	0.5	0.4	0.3
Long term WHO Guideline		--	0.05	--	0.09

First value is the average of all samples. To compare with WHO long term guideline.
Second value is the maximum value from all the samples. To compare with 1 hour TCVN standard.
Source [27]

(11) General climatic conditions

General climate conditions for Hanoi are summarized in the next table. The average annual temperature is 23.5°C. The minimum monthly temperature is 16.4 °C in January and the maximum monthly temperature is 28.9°C in July. Rainfall is unevenly distributed during the year. The rainy season last from May to October with an average rainfall of 1300 mm and accounts for about 78% of the annual precipitation amount (1676 mm).

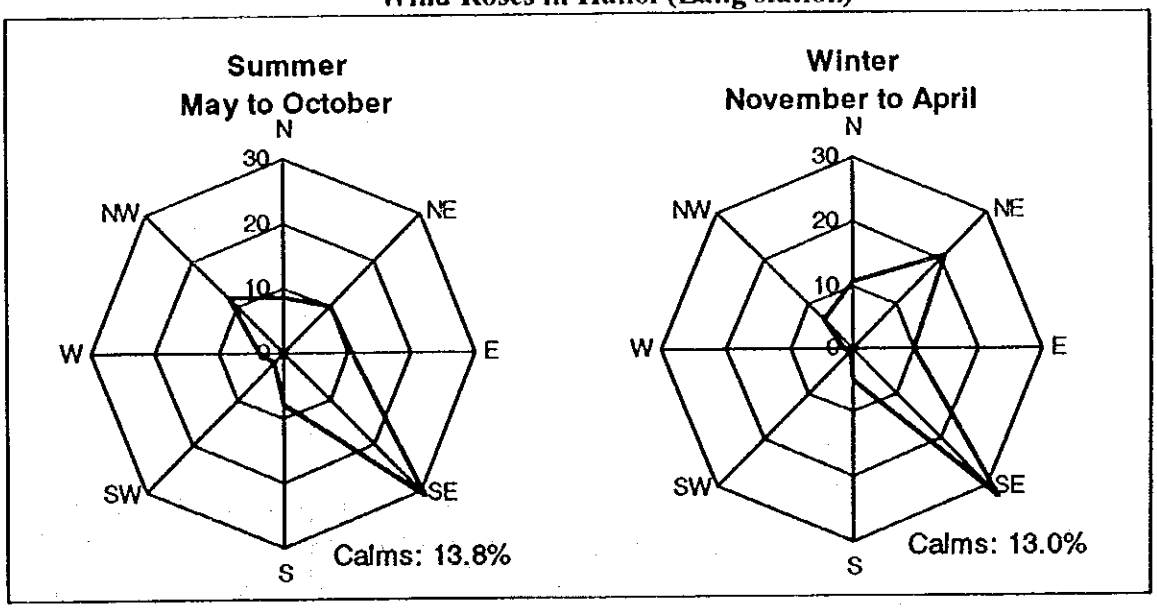
Figure in next page presents the wind roses for the summer and winter season in Hanoi. Predominant wind are from the south-east with a very high frequency (over 30%). During winter, north-east winds are also very important with a over 20% frequency. Calm conditions are present about 13% of the time.

Average Climatic Conditions in Hanoi

Month	Average Temperature (°C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)	Prevailing wind direction	Sunshine (hours)	Number of rainy days
January	16.4	83	18.6	71.4	NE - SE	67.3	8.4
February	17.0	85	26.2	59.7	SE - NE	44.7	11.3
March	20.2	87	43.8	56.9	SE	46.2	15.0
April	23.7	87	90.1	65.2	SE	80.2	13.3
May	27.3	84	188.5	98.6	SE	165.8	14.2
June	28.8	83	239.9	97.8	SE	155.6	14.7
July	28.9	84	288.2	100	SE	182.6	15.7
August	28.2	86	318.0	84.1	SE	162.8	16.7
September	27.2	85	265.3	84.4	NW	160.5	13.7
October	24.6	82	130.7	95.6	SE - NW	165.0	9.0
November	21.4	81	43.4	89.8	NE - SE	125.1	6.5
December	18.2	81	23.4	85.0	NE -SE	108.8	6.0
Year	23.4	84	1676.2	989	SE	1464.6	144.5

Summary of data from Lang station (1890-1990)

Wind Roses in Hanoi (Lang station)



(12) Fuel specification

Specifications for various fuels used by motor vehicles are specified in the following TCVN Standards:

- TCVN 5690 : 1998, Leaded gasoline - Specification;
- TCVN 5689 : 1997, Petroleum products - Diesel fuel oils - Specification.

For leaded gasoline (MOGAS 83, 92 or 97), the maximum allowable lead content is 0.15 g/l. This is in the lower range of lead content for leaded gasoline around

the world (World Bank, 1997). According to Petrolimex, the major importation and distribution company of petroleum products in North Vietnam (about 80-85% of the market), the actual lead content of gasoline is lower than 0.15 g/l. The TCVN standard for gasoline does not specify limits for aromatics such as benzene in the gasoline formulation.

For diesel fuel, there are two types of standardized fuel: DO 0.5%S and DO 1.0%S. The DO 0.5%S has a maximum allowable sulfur content of 0.5% (mass) and is mainly used by diesel engine vehicles. DO 1.0%S has a sulfur content between 0.5% and 1% and is mainly used by industries.

Other fuel used by industry are coal and heavy fuel oil. In general the coal used by industry is a low sulfur anthracite coal from Quang Linh. The average sulfur content of that coal varies between 0.4% and 0.7% and ash content is about 7%. Heavy fuel oil as a average sulfur content of 2.8%. and an ash content of 0.8%.

(13) Fuel consumption

Data from Petrolimex sales in 1997. which represents about 80% of total sales in North Vietnam are presented in the table below. These figures are for the urban districts and Gia Lam district.

Annual fuel consumption for urban districts and Gia Lam district in 1997

Type of fuel	Annual consumption
Gasoline (Mogas 83, 92)	150 000 m^3
Diesel oil	100 000 m^3
Fuel oil	

(14) Industrial atmospheric emissions

Most of industrial atmospheric emission in Hanoi are related to combustion of various fuels. Other emission are related to industrial processes such as the phosphate fertilizer company (SO_2, HF) in Van Dien industrial zone and such as the various tile and brick factories for TSP emissions.

Next table presents estimates of pollutant loads by type of industry in 1995. The tile and brick factories account for more than 90% of TSP emissions for industries. For NOx and CO, this inventory of atmospheric emissions is incomplete.

Estimated industrial atmospheric emissions for 1995 (t/y)

Industrie	Dust	SO2	NOx	CO
Car	1.4	0.09		
Bike	60	3.8		
Aluminum	33	2.1		
Car overhaul	0.4	0.1		
Fertilizer	1.3			
Paint	55	0.1		
Soap	91	12.9		
Toothpaste	16	1		
Cement products	57	6.6	12	
Brick	10752	672		
Tile	71415	1406	56	547
China	1104	216		
Glass	75	14	5	0.2
Paper	859	32		27.4
Can food	75	4.7		
Fish sauce	49	3.1		
Sweets and biscuits	692	43		
Beer	1600	100		
Cigarette	702	44		
Textile	1098	69		
Tower	104	6.5		
Total	88840	2637	73	575

Source: Cited in "Report on the Current Condition of Air Environment in Hanoi City" (in Vietnamese), Center for Environmental Technology Consultancy, July 1998.

Industrial coal and fuel oil consumption by district for the 111 largest fuel consuming factories are presented in the table below. The 22 344 t/y consumption for fuel oil fits very well with the 20 000 t/y sales of Petrolimex in 1997 for urban and Gia Lam districts. Second table in next page shows that in the urban area, the chemical, textile and food processing industries account for the majority of air emissions related to fuel combustion.

Industrial fuel consumption by district

District	Number of factories	Coal (t/y)	Oil (t/y)
Hoan Kiem	7	1 524	250
Ba Dinh	10	12 785	1 150
Hai Ba Trung	23	47 884	5 932
Dong Da	23	51 990	4 312
Total urban	**68**	**114 183**	**10 609**
Soc Son	3	3 100	-
Tu Liem	6	500	-
Gia Lam	7	13 076	10 237
Dong Anh	11	25 882	100
Thanh Tri	16	33 313	1 362
Total suburban	**43**	**75 871**	**11 735**
Total	**111**	**190 054**	**22 344**

Source: DOSTE, 1998 [ref 33]

Industrial fuel consumption by type of industry in urban districts

Type of industry	Number of factories	Coal (t/y)	Oil (t/y)
Chemical	18	46 300	3 260
Textile, paper	12	35 800	5 912
Electronics	4	978	-
Machinery	13	6 712	597
Stationary	6	2 495	95
Food processing, including alcohol and cigarettes	15	21 898	770

Source: DOSTE, 1998 [ref 33]

Next table presents the estimated industrial atmospheric emissions related to coal and fuel oil combustion for the 111 largest fuel consuming factories. The highest emissions factors from US-EPA and WHO-World Bank for uncontrolled sources were selected to estimate annual emissions. For SO_2, the emission factors are reliable since a mass balance on sulfur is used in calculating the emission factors. For other pollutants, the emission factors are likely too low and less reliable, since a large proportion of combustion devices in Hanoi are old and combustion controls are non existent.

Estimation of industrial atmospheric emissions related to fuel combustion

Fuel	SO_2		NO_x (as NO_2)		CO		TSP	
	kg/t	t/yr	kg/t	t/yr	kg/t	t/yr	kg/t	t/yr
Coal (0.5% S) 190 054 t/y	10	1 900	9	1 710	2.5	475	42	7 982
Fuel oil (2% S) 22 344 t/y	40	894	8.2	183	0.64	14	5.76	129
Total		2 794		1 893		489		8 111

SO_2 : emission factors based on a total conversion of fuel sulfur to sulfur dioxide.

NOx : US-EPA emission factors for uncontrolled coal and fuel oil industrial combustion.

CO : based on World Bank - WHO default emission factors in DSS-IPC (Decision Support System for Integrated Pollution Control)

TSP : based on World Bank - WHO default emission factors in DSS-IPC (Decision Support System for Integrated Pollution Control) and an average ash content of 7% for coal. Also, the emission factor for fuel oil combustion was multiplied by a factor of 2 to account for the low maintenance of combustion devices.

(15) Domestic atmospheric emissions

Domestic or household emissions are almost exclusively composed of combustion gases from fuels used for cooking. Table below presents the proportion of households using various fuel type for cooking in the urban districts and the suburban areas. Coal is used by more than 70% of households in the suburban areas and is used by 40-50% of household in the urban districts. The use of gas or electricity for cooking is still very low, with the exception of Hoan Kiem district (24%).

Hanoi as 5 coal processing plants producing between 5000 and 10 000 tons of coal briquettes annually. This production accounts for about 30% of domestic consumption. The remaining coal comes from small coal processing facilities using manual techniques which produce a much lower quality or more polluting coal. Based on these figures, it is estimated that the household annual coal consumption is about 125 000 tons per year. In 1994, there were 57 establishments selling about 130 tons per month of compressed gas for household for a total domestic gas consumption of 1 560 tons per year. Based on emission factors from World Bank - WHO, the estimated loads from domestic coal combustion for other are presented in the table next page.

Frequency of households fuel used for cooking

Area / District	Coal	Kerosene	Wood	Gas or electricity
Hoan Kiem	41.0	29.5	5.5	24.0
Ba Dinh	48.2	30.7	11.1	10.0
Hai Ba Trung	41.9	38.4	11.1	8.6
Dong Da	57.4	19.7	15.0	7.8
Total Urban	47.9	29.1	11.2	11.7
Total Suburban	71.5	10.5	13.5	4.5

Source: "Population and Urban Living Environment in Hanoi City", National Institute for Urban and Rural Planning, Ministry of Construction, VIE/93/P02 Project, 1996.

Estimation atmospheric emissions related to household coal combustion

Fuel	SO_2		NO_x (as NO_2)		CO		TSP	
	kg/t	t/yr	kg/t	t/yr	kg/t	t/yr	kg/t	t/yr
Coal (0.5% S) 125 000 t/y	10	1 250	1.5	188	45	5 625	7.5	938

Based on World Bank - WHO emission factors for residential coal combustion in DSS-IPC (Decision Support System for Integrated Pollution Control)

(16) Transportation atmospheric emissions

The total annual consumption of gasoline can be roughly estimated from the 150 000 m^3 of leaded gasoline (0.15 g Pb/l maximum) sold in 1997 by Petrolimex in Hanoi (urban and Gia Lam district). Considering the fact that Petrolimex sales represent about 80% of total sales in North Vietnam and adding an extra 25% for fuel consumption in other suburban districts; the total annual consumption of gasoline is estimated at 234 400 m^3 (approximately 173 500 t/yr).

Using the same assumptions, the diesel fuel sales by Petrolimex in 1997 give an estimated total consumption of 156 250 m^3/y (approximately 132 800 t/y) for diesel. Based on the 0.5% sulfur content specification for diesel fuel, the sulfur dioxide emissions from diesel engines are estimated at 1 328 t/y.

Based on the 234 400 m^3 estimate for leaded gasoline consumption in Hanoi and a maximum lead content of 0.15 g/l, the total amount of lead emitted in the atmosphere by gasoline motor vehicles can be estimated at 35 tons per year.

Other emissions from transport include CO, NO_x, and TSP. SO_2 and TSP exhaust emission are mainly from diesel motor vehicles. The larger part of TSP emissions from road transport is from road dust resuspension. In order to evaluate emission from mobile sources, the total amount of traveled kilometers by transport mode must be establish as well as the average pollutant emissions (g/km) for each transport mode. This information is not available at the present time, but rough estimates can still be made based on fuel consumption of gasoline and diesel and

on average emission factors available for other countries. Next table presents the estimated emissions for mobile sources. Table also presents the assumptions for fuel consumption distribution by traffic mode and the emission factors used in the calculation of atmospheric emissions.

Diesel vehicles are the main sources of SO_2, TSP and NO_x from road transport activities. Gasoline vehicle, especially motorcycles, are the main emitters of CO.

Estimated atmospheric emissions related to transport

(exhaust emissions)

	Fuel (t/y) (%)	SO_2 g/kg fuel	SO_2 t/y	NOx g/kg fuel	NOx t/y	CO g/kg fuel	CO t/y	TSP g/kg fuel	TSP t/y
Diesel vehicles	132 800								
light (11 l/100 km)	20%	10	266	16.23	431	37.3	991	11.26	299
heavy (30.8 l/100km)	80%	10	1 062	79.6	8 457	38.2	4058	15.1	1 604
Total diesel			1 328		8 888		5049		1 903
Gasoline vehicles	173 500								
car (12.1 /100 km)	5%	0.45	4	45.5	395	542	4 702	3.32	29
moto (5.1 l/100 km)	95%	0.45	74	7.79	1 284	526	86 698	3.63	598
Total gasoline			78		1 679		91 400		627
Total			1 406		10 566		96 449		2 530

Emission factors (g/kg fuel):

- CO and NOx : worst case from European CORINAIR program and DSS-IPC emission factors for uncontrolled car emissions, 4 stroke motorcycle (>50 cc), light and heavy diesel vehicles.
- SO_2 : based on a 0.5% sulfur in diesel fuel.
- TSP : worst case from US-EPA emission factors for 1975 (uncontrolled vehicle emission and use of leaded gasoline) and DSS-IPC emission factors.

Average fuel consumption (l/100km) per vehicle class is also based on the European Corinair program data.
Distribution of fuel consumption (% of total consumption) per vehicle class is arbitrary.

Based on the assumptions for fuel consumption distribution and fuel consumption by vehicle category presented in next page, the total traveled distance by motor vehicles is estimated at 5 155 million kilometers per year. Based on a 30 g/m^2 average surface silt load on paved road and 140 days of rain per year, the US-EPA model for road dust resuspension gives an average emission factor of 8.7 g/km. Total road dust resuspension is estimated at 44 850 t/y.

(17) Summary of atmospheric emissions

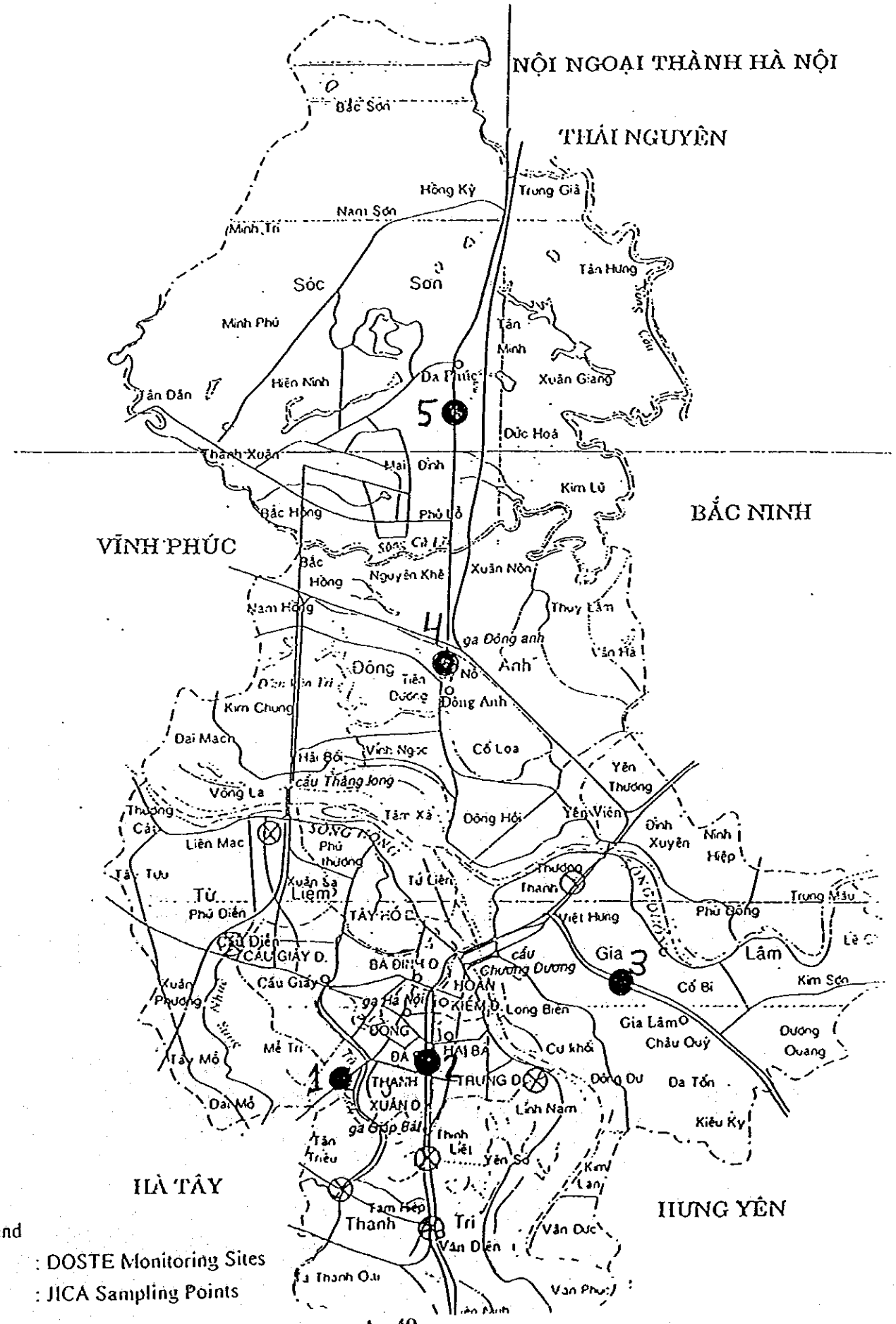
The summary of estimated atmospheric emissions by sector of activity is presented in the table next page. Sulfur dioxide and total suspended particulates emissions are mostly related to industries. Transportation is the major contributor to nitrogen oxides and carbon monoxide emissions. Road dust resuspension on paved road is also a major contributor to TSP emissions.

Estimated air pollutant emissions (t/y) by sector of activity in Hanoi

Sector of Activity	SO_2	NOx	CO	TSP
Industry (fuel combustion only)	2 794	1 894	489	8 111
Industry (process)				82 000*
Transport	1 406	10 566	96 449	2 530
Road dust resuspension	--	--	--	44 850
Domestic (coal combustion only)	1 250	188	5 625	938
Total	**5 450**	**12 248**	**102 563**	**138 429**

* from the estimated TSP emissions for 1995 for tile and brick manufacturing cited in "Report on the Current Condition of Air Environment in Hanoi City" (in Vietnamese), Center for Environmental Technology Consultancy, July 1998.

Figure A.3.1 Location of sampling points for the Air Quality survey



Legend

⊗ : DOSTE Monitoring Sites

● : JICA Sampling Points