社会開発調査部報告書

No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

POLLUTION CONTROL DEPARTMENT
THE GOVERNMENT OF THE KINGDOM OF THAILAND

FINAL REPORT
VOL.2
MAIN REPORT

FEBRUARY 2003

THE ACID DEPOSITION CONTROL STRATEGY IN THE KINGDOM OF THAILAND

SUURI-KEIKAKU CO.,LTD.
PACIFIC CONSULTANTS INTERNATIONAL

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POLLUTION CONTROL DEPARTMENT
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The exchange rates applied in this Study are:

US$ 1.00	=	Japanese Yen 120.00
Baht 1.00	=	Japanese Yen 2.85

(as of February 2003)

PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct "the Study on the Acid Deposition Control Strategy in the kingdom of Thailand" and entrusted the Study to the Japan International Cooperation Agency.

JICA selected and dispatched to the Kingdom of Thailand a study team headed by Mr. Hideshi Kase, Suuri-Keikaku Co., Ltd., and composed of members of Suuri-Keikaku Co., Ltd. and Pacific Consultants International, five times between January 2002 to February 2003.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand and conducted field surveys at the study area. After the team returned to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the mitigation of acid deposition in Thailand as well as the countries participating in the Acid Deposition Monitoring Network in East Asia and to the enhancement of friendly relationship between our two countries.

Finally I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the study.

February 2003

Takao Kawakami
President
Japan International Cooperation Agency

February 2003

Mr. Takao Kawakami

President

Japan International Cooperation Agency

Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to formally submit herewith the final report of "the Study on the Acid Deposition Control Strategy in the Kingdom of Thailand".

This report compiles the results of the Study which was undertaken in the Kingdom of Thailand from January 2002 through February 2003 by the Study Team, organized jointly by Suuri-Keikaku Co., Ltd. and Pacific Consultants International.

We owed a lot to many people for the accomplishment of the Study. First, we would like to express our sincere gratitude and appreciation to all those extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Pollution Control Department, the counterpart agency.

We also acknowledge all the officials concerned of your agency, the JICA Advisory Committee, Ministry of Foreign Affairs, Embassy of Japan, and Ministry of Environment.

We wish the report would be able to contribute to appropriate policies and measures for the mitigation of the acid deposition in Thailand as well as the countries participating in the Acid Deposition Monitoring Network in East Asia.

Sincerely Yours,

賀勢秀史

Mr. Hideshi Kase

Team Leader

JICA Study Team

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Abbreviation

AAT	Airport Authority Thailand
Airport Study	The Study on Airport Development Master Plan in the Kingdom of Thailand, January 2000
AP	Acidification Potential
AQNMD	Air Quality and Noise Management Division
BHP	Brake Horse Power
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BMTA	Bangkok Metropolitan Transit Authority
CDC/NCEP	Climate Diagnosis Center / National Centers for Environmental Prediction
CDM	Clean Development Mechanism
COPERT3	Computer Program to Calculate Emissions from Road Transport
CVS	Constant Volume Sampler
DCR	Department of Commercial Registrations
DEDP	Department of Energy Development and Promotion
DIW	Department of Industrial Works
DMR	Department of Mineral Resources
DOH	Department of Highways
DWT	Dead Weight Tonnage
ECE	Economic Commission for Europe
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
EPPO	Energy Policy and Planning Office
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EUDC	Extra Urban Driving Cycle
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GRP	Gross Regional Product
GRT	Gross Registered Tonnage
GWh	GigaWatt-Hour (109 Watt-Hour)
Harbor Study	The Master Plan Study for the Coastal Channels and Ports Development in the Kingdom of Thailand, March 2002
HDDV	Heavy Duty Diesel Vehicle
HSD	High Speed Diesel
I/M	Inspection and Maintenance
IFCT	Industrial Finance Corporation of Thailand
IPCC	International Panel on Climate Change
IPP	Independent Power Producer
JBIC	Japan Bank for International Cooperation
kg	10^3 grams
kL	10^3 litre
kton	10^3 ton
LDDT	Light Duty Diesel Truck
LDDV	Light Duty Diesel Vehicle

LDGV	Light Duty Gasoline Vehicle
LEV	Low Emission Vehicle
LPG	Liquefied Petroleum Gas
LSD	Low Speed Diesel
LTD	Department of Land Transport
LTO	Landing and Take Off
LTP-2	Consulting Services for the Study on the Strengthening of DOH's Management and Updating of the Long-Term Strategic Investment Plan, December 2001
M m3	million m3
MC	Motorcycle
MJ	Million Joules
MMscf	Million Standard Cubic Feet
MOF	Ministry of Finance
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology and Environment
MOTC	Ministry of Transport and Communications
MRT	Mass Rapid Transit
NBIA	New Bangkok International Co., Ltd
NEPO	National Energy Policy Office
NESDB	National Economic and Social Development Board
NG	Natural Gas
NGV	Natural Gas Vehicle
NP	Neutralization Potential
NSO	National Statistical Office
O & M	Operation and Maintenance
OCMLT	Office of The Commission for the Management of Land Traffic
OEPP	Office of Environmental Policy and Planning
OVR	Overage Vehicle Retirement
PCD	Pollution Control Department
PCU	Passenger Car Unit
PTT	PTT Public Company Limited
PTT	Petroleum Authority of Thailand
RTP	Royal Thai Police
SBIA	Second Bangkok International Airport
scf	Standard Cubic Feet
SMHI	Swedish Meteorological and Hydrological Institute
SPP	Small Power Producer
SRT	State Railway of Thailand
TDRI	Thailand Development Research Institute
TDRI	Thai Development Research Institute
TDSRT	Investment of Capacity Constraints and Determination of the Need for Track Doubling of SRT Network (2002)
TISI	Thai Industrial Standards Institute
TJ	1012 Joules
TMD	Thailand Meteorological Department
toe	Ton of Oil Equivalent

ULG	Unleaded Gasoline
URMAP	Urban Rail Transportation Mater Plan (BMA and Surrounding Areas), November 2001
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VR	Vehicle Retirement
WB	World Bank
WHO	World Health Organization

List of Study Member

JICA Study Team

Mr. Hideshi Kase	Supervisor/Planning of Countermeasure
Mr. Masahiko Fujimoto	Vice-Supervisor/Preparation of Mobile Source Inventory
Mr. Makoto Miyakawa	Preparation of Stationary Source Inventory
Mr. Kenichi Kuramoto	Evaluation of Monitoring Results
Mr. Akeo Fukayama	Simulation by ATMOS2 and Training
Mr. Toru Tabata	Simulation by Airviro and Training
Mr. Kenji Asakawa	Planning of Countermeasure
Dr. Akira Ogihara	Project Evaluation
Mr. Bungo Kinokuni	Coordination and Web Development

Thai Counterpart Team

Dr. Supat Wangwongwatana	Supervisor, Deputy Director General of Pollution Control Department
Ms. Mingquan Wichayarangsaridh	Director of Air Quality and Noise Management Bureau (AQNMB)
Mr. Punsak Theramongkol	Vice-Supervisor, AQNMB
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Description of the Study

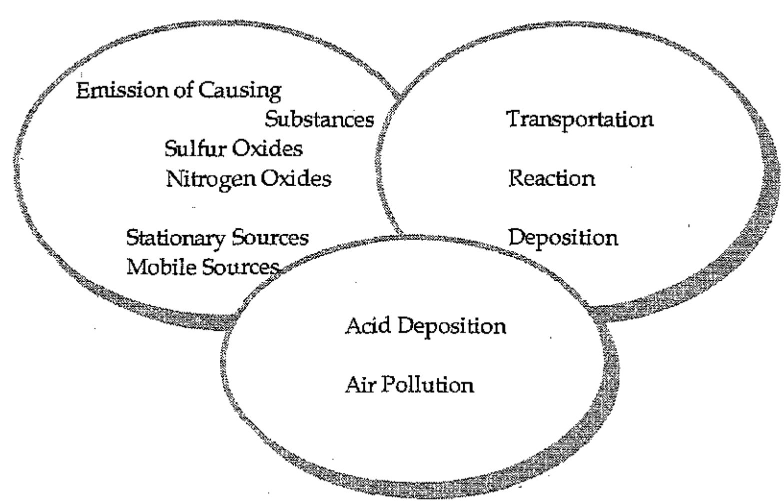
Description of the Study

1. Outline

Acid deposition is trans-boundary pollution in East Asia. Due to long-range transport, it is necessary to tackle the pollution by respective nation and by whole countries of East Asia. In addition, it is necessary that mitigation activities should be arranged not on isolated basis but on systematic approach basis. For this end, the systematic approach for preparation of acid deposition control strategy was applied to Thailand. The approach can be applied to other East Asian countries. In the course of the preparation, necessary technology transfer was carried out in Thailand. And international seminar was held for the dissemination of the outcome of the Study.

Emission of sulfur oxides and nitrogen oxides causes acid deposition, and leads to ambient air pollution. Currently, acid deposition and ambient air pollution are both subjects of public concern in Thailand. The major causing substances of acid deposition and ambient air pollution are sulfur oxides and nitrogen oxides. The Study investigated into acid deposition together with ambient air pollution, caused by the same substances.

The collection and evaluation of monitoring results was one of starting points. The preparation of inventories, i.e. the list of discharging amounts and the location of causing substances, was an indispensable field of the Study. Socio-economic condition was an important factor of the inventory. Based on monitoring results and the inventory, the simulation analysis of sulfur deposition of whole Thailand and SO_2 and NOx concentrations in the BMR were another point of the study. According to the evaluation of monitoring and simulation results, atmospheric SO_2 and NO_2 concentrations in the BMR were current problems to tackle. Because the reduction of causing substances is a method of mitigation, countermeasures for the reduction of sulfur oxides and nitrogen oxides in the BMR were investigated.



Acid Deposition and Air Pollution

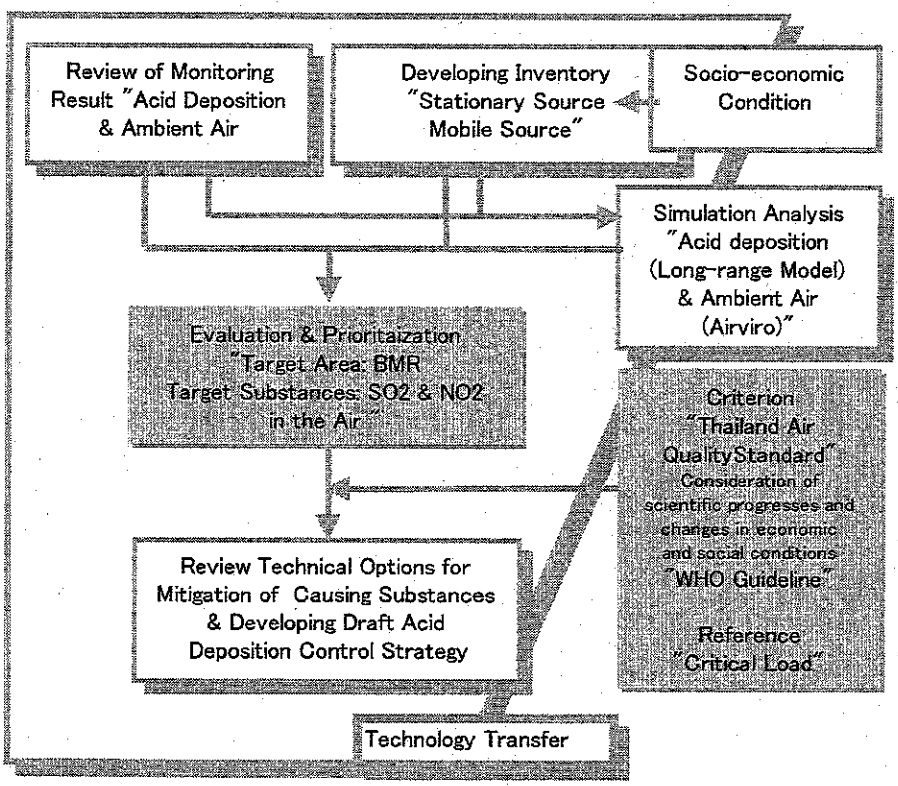
A draft control strategy, including countermeasures for pollutant reduction and enhancement of management, was prepared.

Technology transfer, especially for the preparation of inventories, the simulation by international model and investigation for policy, was implemented in the course of the Study.

2. Objectives

In order to prepare the strategy for mitigation of acid deposition including ambient air pollution, the Study selected the following objectives;

1. to develop/elaborate the emission inventories of substances that cause acid deposition in the whole country;
2. to apply a long-range transport model, based on the latest emission inventories developed in 1. above;
3. to review possible technical options to mitigate substances that cause acid deposition, based on the results of the simulation by the long-range transport model, and develop an acid deposition control strategy for consideration by the Royal Thai Government;
4. to train the technical staff of the relevant government agencies / institutions on the above subjects; and
5. to review the monitoring result of acid deposition and ambient air in the country.



Objectives of the Study

3. Methodology

3.1 Components and Method

Components and methods of the Study are;

1. Investigation of current acid deposition and ambient air concentration of SO_2 and NO_2
   - Collection of existing materials
   - Evaluation of collected data
2. Study for socio-economic conditions
   - Investigation into national and provincial conditions, collection and evaluation of future conditions
   - Analysis of energy growth elasticity to economic growth
3. Preparation of an emission inventory worthy of analysis of the current situation and projection for the future
   - Preparing an inventory of stationary and mobile sources for causing substances, i.e. sulfur oxides for the country, moreover nitrogen oxides for the BMR
   - Revision of the mobile source emission equation of nitrogen oxides
4. Simulation analysis of current and future status, based on current concentration and the prepared inventory
   - Validity check by monitoring results
   - Sulfur simulations for the country
   - Sulfur dioxide and nitrogen oxides simulation for the BMR
5. Evaluation of conditions and prioritization of the problems to be tackled
6. Preparation of countermeasures and a management strategy
   - Technical, political, social and financial feasibility study and preparation of countermeasures
   - consideration for the enhancement of management
7. Technology transfer for the counterparts

3.2 Background

The Study investigates and collects scientific, social, and economic materials. If there is a lack of domestic materials, international data are collected and they support the investigation. For the Study, research of environmental issues is out of scope.

One of important approaches for this field depends on the critical load. The approach has shown successful results in Europe. However, on consideration of the argument over the critical load value and its adequacy in East Asia, the Study regards the critical load approach as reference.

4. Outputs

The systematic approach for preparation of acid deposition control strategy was applied to Thailand. The approach can be applied to other East Asian countries. After evaluation of the condition, the Study revealed that the current issues for mitigation was atmospheric pollution in the BMR. The outputs of the Study were as follows.

For draft acid deposition control strategy;

- Countermeasure for SO_2 is concentrated to the shift from high sulfur fuel to natural gas in the industrial sector in the BMR.

- Countermeasures for NO_2 are the introduction of substantial compliance with the emission standard, low emission vehicle promotion, and over age vehicle retirement in the BMR.

- Enhancement of environmental management for acid deposition and atmospheric pollution.

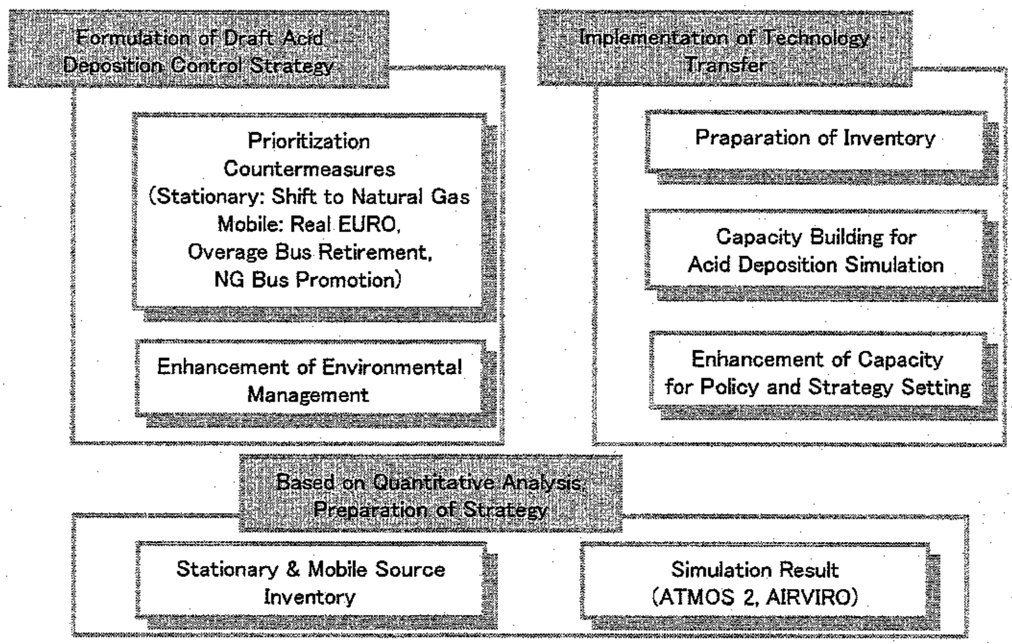
Moreover, one of important factors of the Study was technology transfer.

- Technology transfer activities for inventory, simulation and policy setting were built in to the Study. And it was undertaken on various parts of the Study.

- Through the activity of transfer, series of technology, i.e. from monitoring to simulation and preparation of countermeasures were transferred.

- The technology transfer to East Asian countries was carried out by the international seminar.

During the Study, the inventory for stationary and mobile sources was prepared. And based on the inventory, the simulation analysis was implemented. The inventory and the outcome of the simulation were utilized for the preparation of strategy, and they were regarded as the quantitative basis for countermeasures against acid deposition and air pollution in Thailand.



【 Concept of Outputs 】

Charpter 1

Acid Deposition and Air Quality Data Analysis

1. Acid Deposition and Air Quality Data Analysis

1.1. Result of Wet Deposition Monitoring

Concerning acid deposition monitoring, following activities are being carried out now in Thailand:

- EANET monitoring program;
- Joint Monitoring Program between PCD and Universities, and
- Joint Examination between ERTC and SERI.

Details of monitoring activities are described in Supporting Report, Chapter 1.

PCD carries out data validation following the EANET manual (Supporting Report, Chapter 1). As the data validation doesn't focus on data screening but just indicator for recheck, PCD does not reject monitoring data exceeding allowable range for preparing reports. The Study Team utilizes all data for model simulation, however analysis of acid deposition in this chapter is carried out tentatively by data within allowable range of R1 and R2 validation.

Data calculation was carried out considering the following factors;

- Rainy Season: May to October,
- Dry Season: November to April, and
- Deposition amount of each parameter was calculated by the following equation.

$$EP = MP \times \frac{TR}{AR}$$

EP: Estimated value of respective measuring parameter
MP: Total deposited amount of respective measuring parameter
TR: Measured total rain amount
AR: Total rain amount of accepted sampling period

For the evaluation of wet deposition amount in this chapter, the Study Team used this estimated value.

1.1.1 Brief Description of Wet deposition

The monthly and yearly averages of analyzed concentration of acid deposition parameters in the year 2000 are shown in Table 1.1.1.1, the monthly and yearly deposition amount of each parameters in the year 2000 are shown in Table 1.1.1.2.

Table 1.1.1.1 Brief Description of Concentration of Acid Deposition

	SO_4^{2-} (umol/L)	nss-SO_4^{2-} (umol/L)	NO_3^- (umol/L)	Cl^- (umol/L)	NH_4^+ (umol/L)	Na^+ (umol/L)	K^+ (umol/L)	Ca_2^+ (umol/L)	nss-Ca_2^+ (umol/L)	Mg_2^+ (umol/L)	H^+ (umol/L)	pH	EC (mS/m)
Bangkok (OEPP-Urban Site)													
Yearly Base													
Min	4.9	4.4	0.4	4.1	2.1	1.7	<1	<0.3	<0.3	<0.2	0.1	3.91	0.430
Max	96.0	95.1	212.9	25.6	191.5	24.4	14.2	65.0	64.6	8.2	123.0	6.99	6.83
Average	33.6	33.1	37.7	12.2	52.2	9.0	4.1	15.2	15.0	2.7	23.0	5.08	2.37
Monthly Base Average													
Feb													
Mar	38.3	37.9	40.6	18.4	52.6	6.9	<1	12.5	12.4	2.5	37.2	4.43	3.23
Apr	79.6	78.6	143.3	18.1	168.3	17.6	6.2	37.0	36.6	6.9	32.6	4.51	4.96
May	57.7	57.2	48.2	12.5	104.1	7.1	1.1	19.3	19.1	3.4	32.1	4.57	3.39
Jun	14.0	13.3	20.1	13.0	32.4	11.5	3.5	10.7	10.5	2.6	2.9	5.99	1.24
Jul	21.2	20.6	17.0	10.5	43.3	9.4	3.6	9.3	9.0	2.0	2.3	5.72	1.27
Aug	10.7	10.4	1.7	7.2	17.1	5.0	<1	2.7	2.7	0.0	5.7	5.62	0.760
Sep	48.4	47.8	51.6	14.7	39.5	9.3	8.3	24.7	24.5	3.6	49.0	4.40	3.66
Oct	27.7	27.4	26.7	8.5	31.9	5.1	4.2	10.2	10.1	1.6	32.3	4.59	2.16
Samutprkan (TMD-Urban Site)													
Yearly Base													
Min	9.7	9.1	<0.3	2.0	5.7	1.1	<1	<1	<0.3	<0.2	0.4	4.18	0.630
Max	157.9	155.9	103.6	47.5	229.8	45.5	20.8	94.5	93.5	14.2	66.1	6.42	5.83
Average	36.0	35.2	17.0	15.5	42.9	13.4	4.4	14.5	14.3	3.3	14.6	5.19	1.86
Monthly Base Average													
Feb													
Mar													
Apr	29.3	28.1	19.2	18.2	30.7	18.5	5.1	6.1	5.7	1.5	20.5	4.79	1.94
May	45.9	44.7	38.9	18.9	45.0	19.0	7.7	29.5	29.1	4.8	17.7	4.84	2.50
Jun	29.5	28.6	14.9	14.4	38.9	13.4	3.0	8.2	7.9	2.7	9.8	5.07	1.77
Jul	48.7	47.5	14.3	20.8	62.1	19.8	3.4	20.1	19.7	4.5	8.0	5.56	2.12
Aug	37.7	37.2	5.3	12.8	48.1	9.0	4.9	8.1	7.9	2.7	12.7	5.33	1.65
Sep	29.4	28.7	12.5	16.4	35.8	12.8	4.4	14.9	14.6	3.2	8.3	5.40	1.47
Oct	25.9	25.5	26.2	7.8	26.2	5.6	3.6	11.4	11.2	2.5	33.4	4.69	1.93
Patumuthani (ERTC-Rural Site)													
Yearly Base													
Min	8.4	8.0	5.7	2.0	16.1	1.7	0.4	2.0	2.0	<0.2	0.1	4.43	0.630
Max	70.7	69.8	77.3	35.7	101.4	82.9	11.4	58.6	58.3	8.2	37.2	6.95	4.14
Average	23.4	22.3	20.4	14.7	41.3	18.0	2.5	16.2	15.8	2.6	4.5	6.03	1.53
Monthly Base Average													
Feb													
Mar	70.7	69.8	77.3	23.4	101.4	15.2	10.0	58.6	58.3	8.2	7.2	5.14	4.14
Apr	9.0	8.8	11.9	2.0	18.9	1.7	0.5	2.0	2.0	0.0	8.7	5.06	0.850
May	20.1	19.2	17.7	16.1	47.6	15.0	3.7	12.2	11.9	2.4	0.5	6.41	1.37
Jun	24.8	22.8	20.0	16.9	34.6	32.2	1.7	11.6	10.9	2.8	1.4	5.98	1.42
Jul	18.5	17.3	11.2	17.2	34.1	19.4	1.9	22.4	22.0	3.0	0.2	6.72	1.19
Aug	28.1	27.8	31.8	9.2	57.9	5.2	2.2	18.6	18.5	2.5	1.4	5.85	1.95
Sep	26.4	25.4	32.7	12.8	41.0	16.9	1.4	17.7	17.3	2.8	12.0	4.92	1.83
Oct	24.0	23.8	21.1	3.8	33.8	3.2	0.8	4.6	4.5	0.5	31.7	4.51	2.02
Kantchanaburi (Khao Laem-Remote Site)													
Yearly Base													
Min	<0.2	<0.2	<0.3	2.2	<0.5	1.3	<1	<03	<0.3	<0.2	0.6	5.10	0.22
Max	8.5	8.3	15.6	26.0	12.7	22.7	15.7	8.7	8.5	2.9	7.9	6.19	0.74
Average	2.7	2.3	6.5	10.8	5.0	8.0	3.7	3.3	3.1	1.0	2.7	5.70	0.44
Monthly Base Average													
Feb													
Mar													
Apr													
May	3.3	2.8	11.8	11.9	6.6	8.6	2.3	3.9	3.8	1.8	3.2	5.59	0.56
Jun	2.2	1.4	10.4	11.9	4.7	12.1	2.9	3.6	3.3	1.6	2.3	5.70	0.51
Jul	3.6	3.0	3.8	12.1	4.2	10.7	<1	4.2	4.0	0.9	1.6	5.85	0.44
Aug	0.9	0.6	2.6	11.8	3.7	5.9	9.2	1.6	1.5	0.5	1.1	5.98	0.29
Sep	8.5	8.3	6.9	6.5	12.7	2.7	4.8	3.2	3.1	0.7	7.8	5.11	0.67
Oct	2.4	2.3	5.5	4.0	4.3	1.8	3.4	3.0	3.0	0.4	5.9	5.24	0.37

Table 1.1.1.2(1) Brief Description of Deposition Amount

	SO_4^{2-} (umol/m^2)	nss-SO_4^{2-} (umol/m^2)	NO_3^- (umol/m^2)	Cl^- (umol/m^2)	NH_4^+ (umol/m^2)	Na^+ (umol/m^2)	K^+ (umol/m^2)	Ca_2^+ (umol/m^2)	nss-Ca_2^+ (umol/m^2)	Mg_2^+ (umol/m^2)	H^+ (umol/m^2)
Bangkok (OEPP-Urban Site)											
Yearly Base											
	13636	13455	11092	4319	21768	2998	1111	4698	4639	855	9124
	(38802)	(38350)	(31874)	(11195)	(61488)	(7497)	(2805)	(13113)	(12967)	(2296)	(24995)
Monthly Base											
Feb	-	-	-	-	-	-	-	-	-	-	-
Mar	153	151	162	74	210	27	-	50	50	10	149
	(165)	(163)	(174)	(79)	(226)	(30)		(54)	(53)	(11)	(160)
Apr	934	927	896	191	1624	126	7	366	364	63	269
	(8789)	(8718)	(8426)	(1799)	(15282)	(1189)	(70)	(3447)	(3421)	(590)	(2529)
May	5091	5052	3970	1068	9206	651	84	1647	1633	302	2511
	(11271)	(11184)	(8789)	(2364)	(20382)	(1442)	(186)	(3646)	(3615)	(668)	(5560)
Jun	1437	1373	1735	1067	3240	1059	182	999	976	247	123
	(2368)	(2263)	(2860)	(1759)	(5339)	(1745)	(301)	(1646)	(1608)	(407)	(202)
Jul	681	665	624	284	1507	271	100	314	308	73	58
	(1938)	(1892)	(1776)	(808)	(4289)	(771)	(284)	(894)	(877)	(209)	(166)
Aug	1153	1135	42	464	1180	297	-	24	24	-	768
	(3131)	(3083)	(113)	(1259)	(3205)	(807)		(66)	(64)		(2085)
Sep	2187	2171	1942	588	2531	280	377	906	900	124	1903
	(5402)	(5360)	(4795)	(1451)	(6249)	(691)	(932)	(2238)	(2223)	(306)	(4699)
Oct	2000	1982	1722	584	2271	287	360	391	385	37	3343
	(5738)	(5689)	(4941)	(1675)	(6517)	(823)	(1033)	(1122)	(1104)	(106)	(9594)
Samutprkan (TMD-Urban Site)											
Yearly Base											
	17848	17426	9550	7869	20944	7006	2208	7588	7437	1767	8147
	(24293)	(23745)	(14085)	(10375)	(28373)	(9094)	(3086)	(10394)	(10198)	(2405)	(12536)
Monthly Base											
Feb	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	-	-
Apr	79	77	52	47	80	42	9	15	14	3	77
	(79)	(77)	(52)	(47)	(80)	(42)	(9)	(15)	(14)	(3)	(77)
May	2420	2361	2205	1036	2838	985	340	1265	1244	271	898
	(3991)	(3893)	(3636)	(1708)	(4680)	(1625)	(561)	(2087)	(2052)	(447)	(1481)
Jun	2785	2708	1489	1349	3806	1281	312	806	778	242	973
	(2785)	(2708)	(1489)	(1349)	(3806)	(1281)	(312)	(806)	(778)	(242)	(973)
Jul	3652	3555	1260	1643	4261	1616	278	1844	1810	347	679
	(3689)	(3591)	(1273)	(1659)	(4304)	(1632)	(281)	(1863)	(1828)	(351)	(685)
Aug	1879	1840	288	869	2668	643	203	454	440	143	529
	(3196)	(3130)	(491)	(1478)	(4537)	(1094)	(345)	(772)	(749)	(243)	(900)
Sep	4950	4832	2233	2316	5106	1957	770	2209	2167	558	2578
	(5968)	(5826)	(2693)	(2793)	(6157)	(2360)	(929)	(2664)	(2613)	(672)	(3108)
Oct	2083	2054	2023	609	2185	481	294	993	983	203	2414
	(4584)	(4520)	(4452)	(1341)	(4808)	(1060)	(648)	(2186)	(2163)	(447)	(5313)
Patumuthani (ERTC-Rural Site)											
Yearly Base											
	7741	7414	6600	4711	15929	5428	735	4519	4402	762	1868
	(20698)	(19973)	(20840)	(10328)	(38594)	(12029)	(1613)	(12128)	(11868)	(1938)	(6802)
Monthly Base											
Feb	-	-	-	-	-	-	-	-	-	-	-
Mar	39	38	42	13	56	8	5	32	32	5	4
	(622)	(614)	(680)	(206)	(893)	(134)	(88)	(516)	(513)	(72)	(64)
Apr	123	121	163	27	258	24	7	27	27	-	119
	(742)	(733)	(988)	(163)	(1562)	(144)	(42)	(166)	(163)		(722)
May	2391	2306	1800	1838	6623	1422	378	1238	1207	219	66
	(2994)	(2887)	(2254)	(2302)	(8292)	(1781)	(474)	(1550)	(1511)	(275)	(83)
Jun	2275	2121	2168	1449	3708	2568	148	1133	1077	264	149
	(3846)	(3585)	(3665)	(2449)	(6268)	(4341)	(250)	(1915)	(1821)	(447)	(252)
Jul	1073	1014	688	921	2347	973	112	1377	1356	176	15
	(1291)	(1221)	(828)	(1109)	(2826)	(1171)	(135)	(1658)	(1632)	(212)	(18)
Aug	402	397	454	131	828	74	31	266	264	35	20
	(3222)	(3186)	(3645)	(1052)	(6644)	(593)	(250)	(2133)	(2120)	(282)	(162)
Sep	380	365	471	184	590	244	20	254	249	41	173
	(5625)	(5407)	(6970)	(2718)	(8728)	(3611)	(303)	(3764)	(3686)	(601)	(2563)
Oct	1059	1052	814	148	1519	114	32	192	189	22	1320
	(2356)	(2341)	(1811)	(330)	(3381)	(253)	(72)	(427)	(422)	(48)	(2939)

Upper column atates measured value

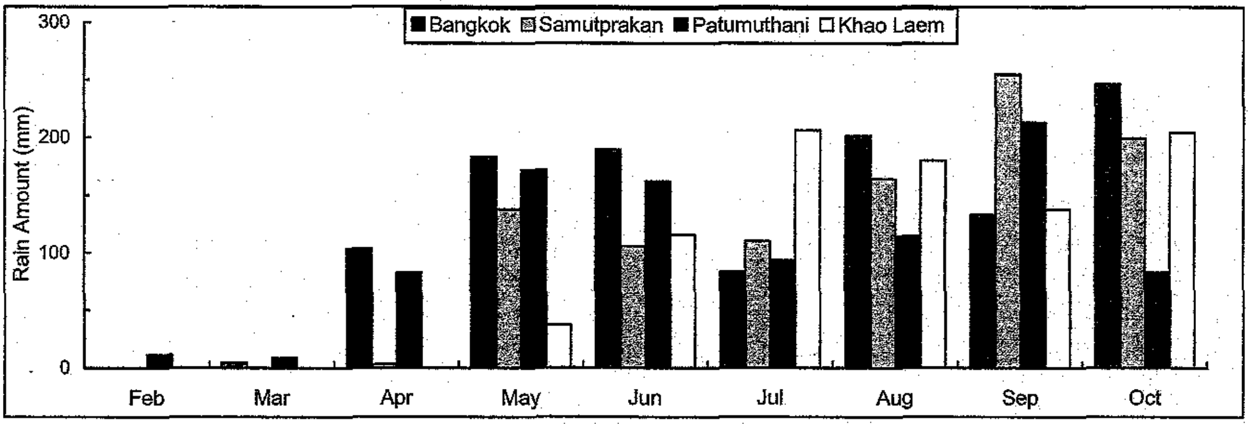
Lower column (within ( )) shows estimated value

Table 1.1.1.2(2) Brief Description of Deposition Amount

	SO_4^{2-} (umol/m^2)	nss-SO_4^{2-} (umol/m^2)	NO_3^- (umol/m^2)	Cl^- (umol/m^2)	NH_4^+ (umol/m^2)	Na^+ (umol/m^2)	K^+ (umol/m^2)	Ca_2^+ (umol/m^2)	nss-Ca_2^+ (umol/m^2)	Mg_2^+ (umol/m^2)	H^+ (umol/m^2)
Kantchanaburi (Khao Laem-Remote Site)											
Yearly Base											
	889	756	1677	2969	1558	2312	958	1002	960	221	905
	(2761)	(2486)	(4481)	(6814)	(4704)	(4838)	(3059)	(2531)	(2443)	(529)	(3202)
Monthly Base											
Feb	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	-	-
Apr	-	-	-	-	-	-	-	-	-	-	-
May	119	100	429	416	221	324	73	176	169	64	96
	(122)	(102)	(439)	(425)	(226)	(331)	(75)	(180)	(173)	(66)	(98)
Jun	83	57	483	420	277	429	100	159	150	52	115
	(197)	(136)	(1150)	(1000)	(658)	(1021)	(237)	(378)	(356)	(123)	(274)
Jul	410	348	247	1194	507	1028	0	379	360	54	225
	(694)	(589)	(419)	(2023)	(860)	(1742)	()	(643)	(610)	(92)	(381)
Aug	59	41	144	635	227	402	540	76	72	15	81
	(145)	(102)	(355)	(1567)	(560)	(993)	(1332)	(187)	(178)	(37)	(200)
Sep	115	113	93	88	172	36	65	43	42	10	105
	(1171)	(1149)	(951)	(896)	(1757)	(366)	(663)	(440)	(432)	(102)	(1070)
Oct	104	98	280	217	154	92	180	168	166	26	283
	(432)	(408)	(1168)	(904)	(643)	(385)	(752)	(702)	(694)	(108)	(1179)

Upper column states measured value
Lower column (within ( )) shows estimated value
Source: PCD, modified by the Study Team

The rain amount of each monitoring site is shown in Figure 1.1.1.1.



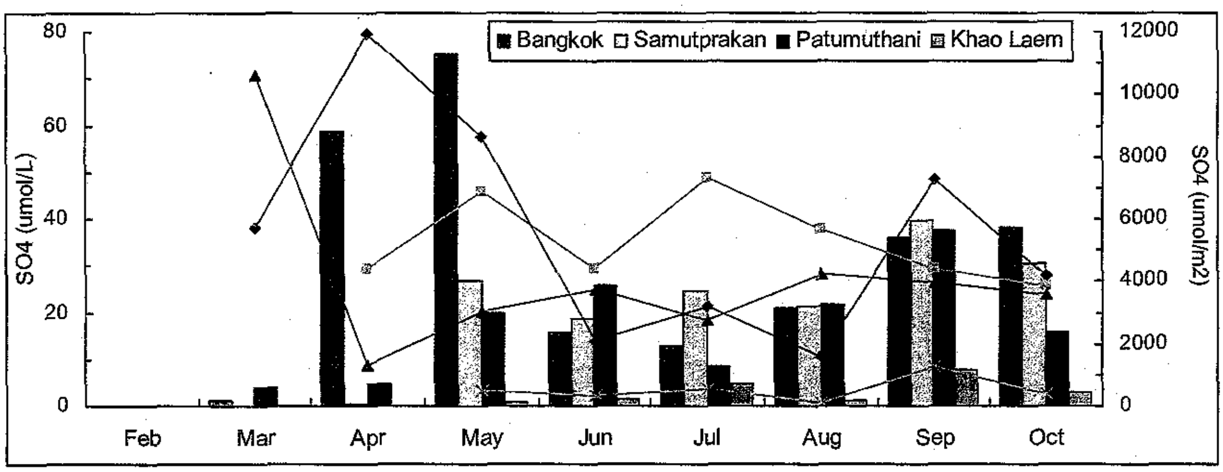
Source: PCD, modified by the Study Team

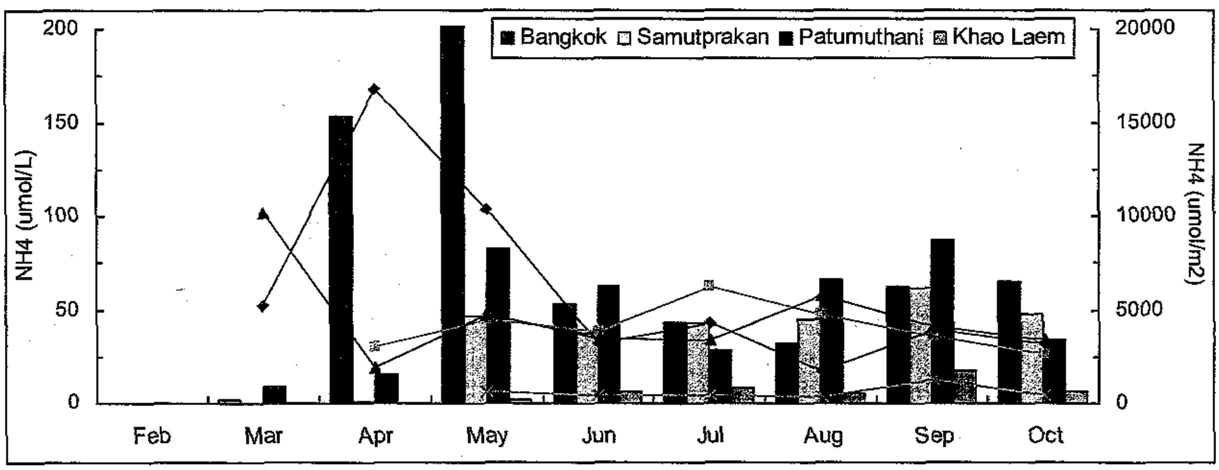
Figure 1.1.1.1 Rain Amount of Each Monitoring Site

The yearly rain amount of OEPP site (located in Bangkok) was approximately 1100 mm, and was the highest of all the monitoring sites. Those of the other sites were approximately 900 mm, therefore there was little difference. The rainy and dry seasons are clearly divided in Thailand, with the period of May to October being defined as the rainy season. On the other hand, there was no rain in the month of January and between November to December in 2000. The rain dose not continue a long time and usually falls intermittently.

Ion contents in rain indicate its source and condition, etc. Ions in rain can be classified into two types; one is sea salt origin and the other is non- sea salt origin. Generally speaking, Na, Mg and Cl ions are classified as sea salt origin, on the other hand Ca, NH_4, SO_4 and NO_3 ions are classified as non-sea salt origin. Ca will be mainly soil origin, and NH_4 mainly agriculture, stockbreeding and also industry. SO_4 ion may be mainly discharged from industrial zones, or in some areas by volcanic activity. The case of NO_3 ion is similar to SO_4 ion. However emission of NO_3 is concentrated in urban zones, and may be discharged from mobile sources.

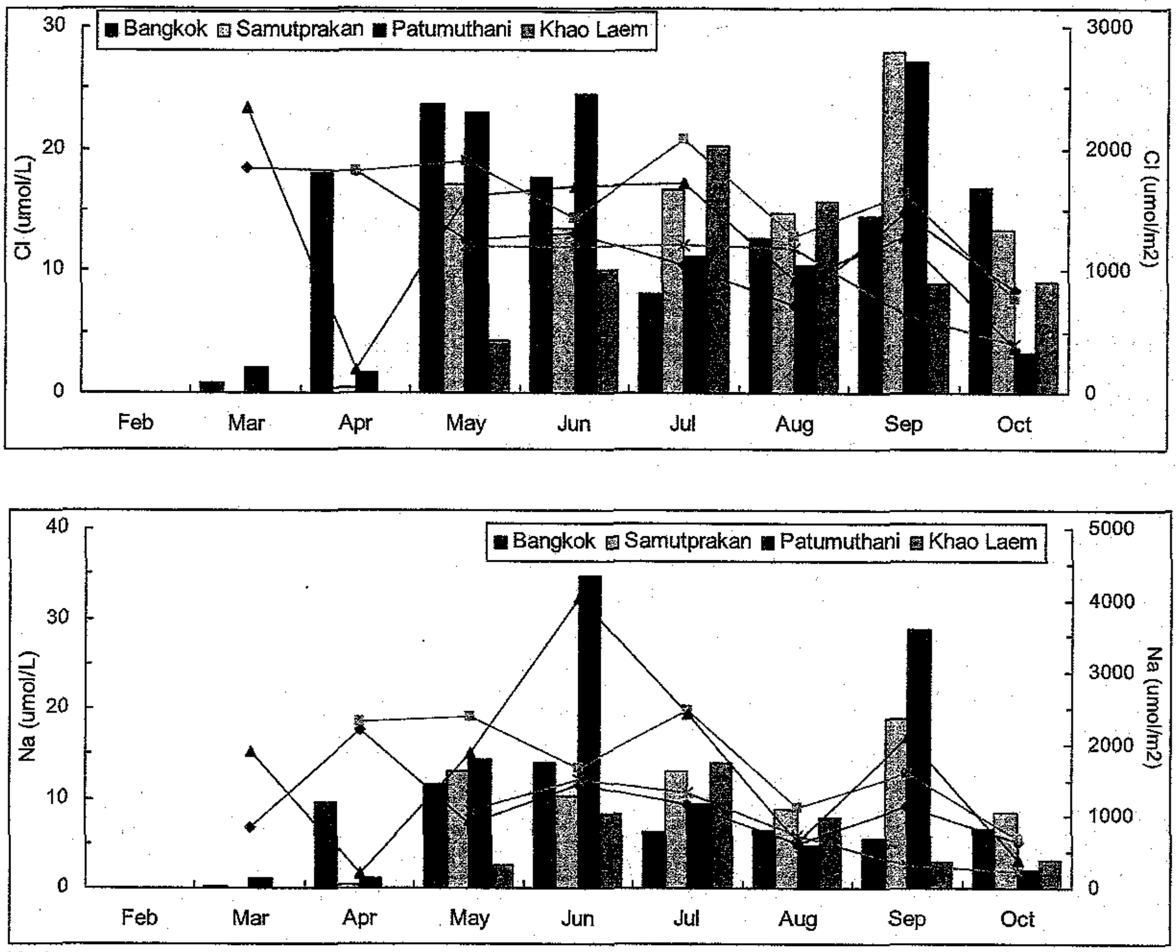
The monthly trends of SO_4, NH_4, Cl and Na ions are shown in Figure 1.1.1.2. As mentioned above the SO_4 and NH_4 ions have roots in human activity, and the CL and Na ions are of sea salt origin.





Notice:
Line graphs atate concentration, bar graphs state total amount.
Source: PCD, modified by the Study Team

Figure 1.1.1.2(1) Monthly Trends of SO_4 and NH_4



Notice:
Line graphs mean concentration, bar graphs mean total amount.
Source: PCD, modified by the Study Team

Figure 1.1.1.2(2) Monthly Trend of Cl and Na

Concerning the concentration for the yearly averages of SO_4 ion, TMD site (located in an urban area) showed the highest value, 36.0 umol/L, next OEPP site (also located in an urban area) was 33.6 umol/L. On the other hand, Khao Laem site (located in a remote area) was 2.7 umol/L, the value was below 1/10 of the urban area. NH_4 ion had the same trend of SO_4 ion, that is, concentrations in the urban sites were higher than those in the remote site. In particular SO_4 ion concentration of OEPP site between March to May were high values which decreased in June. On the other hand, Cl and Na ion concentrations showed similar trends in all 4 monitoring sites.

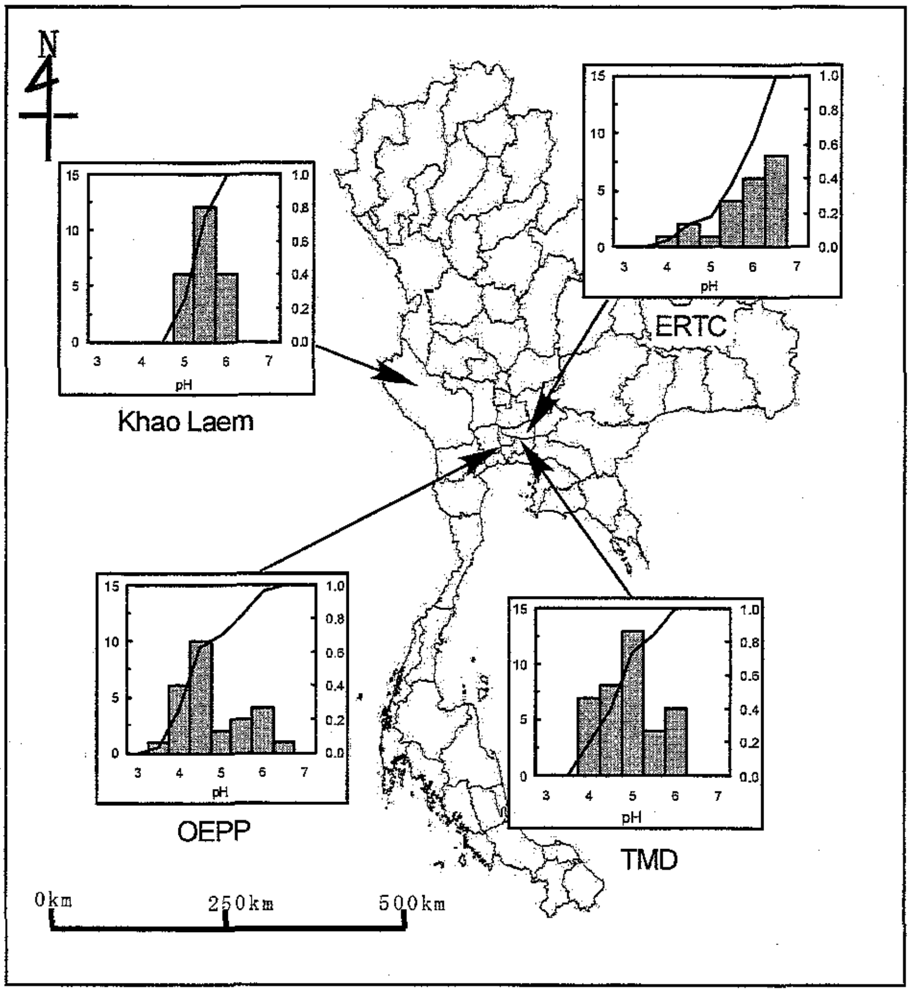
This is the case because human activities do not affect Cl and Na ion concentrations generally. That said, human activity has influences on increasing the sulfur and nitrogen concentrations in rain, and as a result it causes acid deposition.

Let us analyze the most important parameter, the pH. Table 1.1.1.3 shows a brief description of the pH. And Figure 1.1.1.3 shows frequency distribution of pH.

Table 1.1.1.3 Brief Description of pH

Site Name	OEPP	TMD	ERTC	Khao Laem	For 4 sites
Min	3.91	4.18	4.43	5.10	3.91
Max	6.99	6.42	6.95	6.19	6.99
Mean	5.10	5.19	6.07	5.72	5.44
Median	4.89	5.15	6.19	5.77	5.38

Source: PCD, modified by the Study Team



Source: PCD, modified by the Study Team

Figure 1.1.1.3 Frequency Distribution of pH

The pH distribution in Thailand in 2000 was 3.91 to 6.99, its median value was 5.38. The pH in OEPP site (urban site) was lower than the other 3 sites, in particular pH value showed the lowest value, 3.91, on 19th September. Similarly TMD site showed a lower value.

Comparing ERTC site and Khao Laem site, the pH in Khao Laem site was lower than ERTC site.

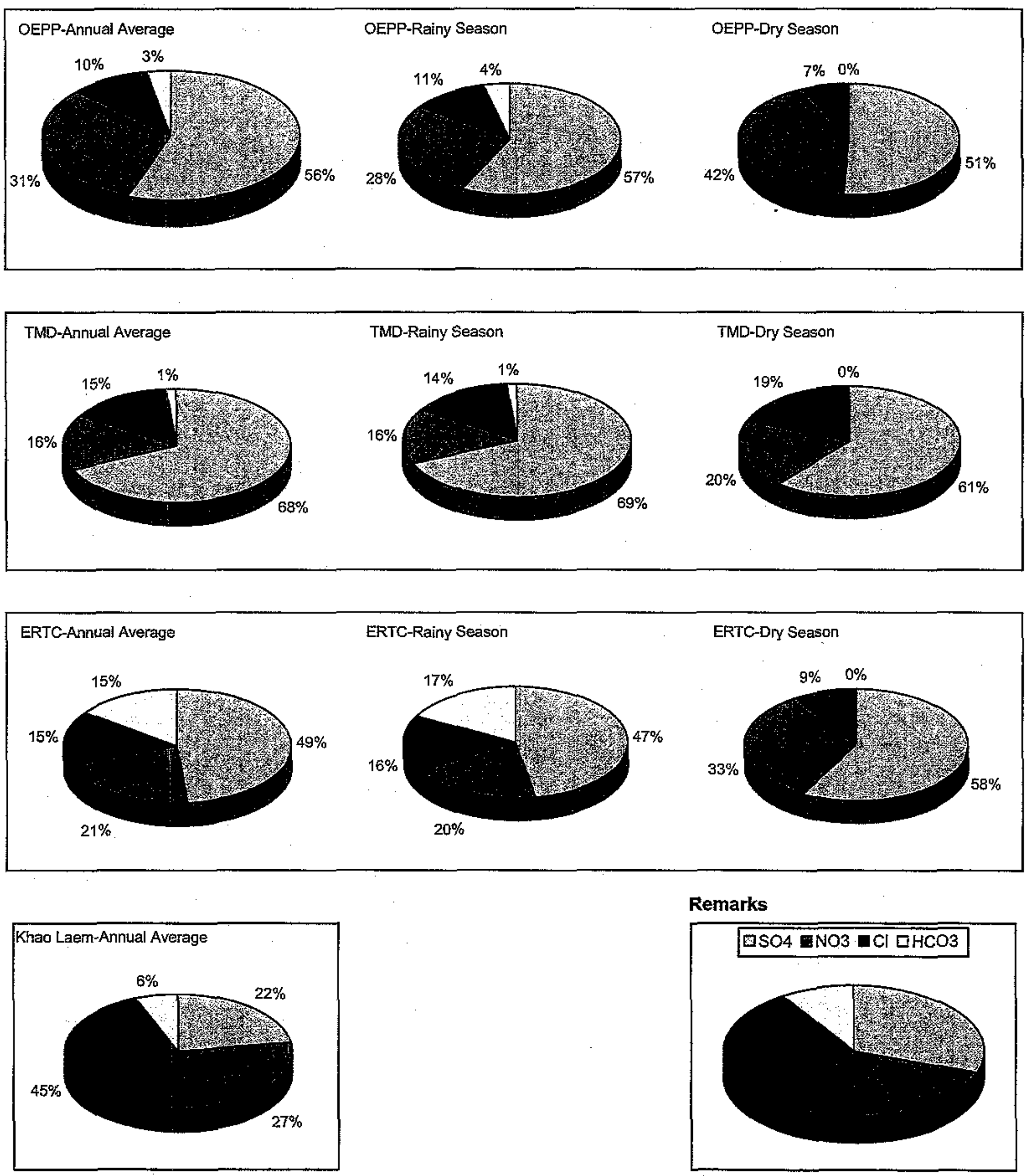
Frequency distributions could be classified into 3 types. OEPP and TMD sites show similar frequency distribution. Two peaks, a lower pH and a higher pH are observed. At ERTC, the higher pH shows the higher frequency. At Khao Laem, the distribution shape is like the normal distribution.

These results lead us to following findings:

- SO_4 ion concentration of urban sites was higher than rural and remote site;
- NH_4 and NO_3 ions also showed the same characteristics as SO_4;
- ERTC site showed an intermediate position between urban and remote site;
- On the other hand, these concentration in Khao Laem site were not high;
- It may be regarded that the main source of SO_4 ion in near urban areas is human activity. And also it causes increased sulfur and nitrogen deposition;
- Concentrations of Cl ion and cation were almost the same value in all 4 monitoring sites. Generally speaking these ions are not influenced by human activity so much;
- The pH in urban site was lower than in rural and remote sites.
- The pH in Khao Laem site was lower than ERTC. It is necessary to investigate the reason for this, and
- The decrease of pH may be caused by human activities.

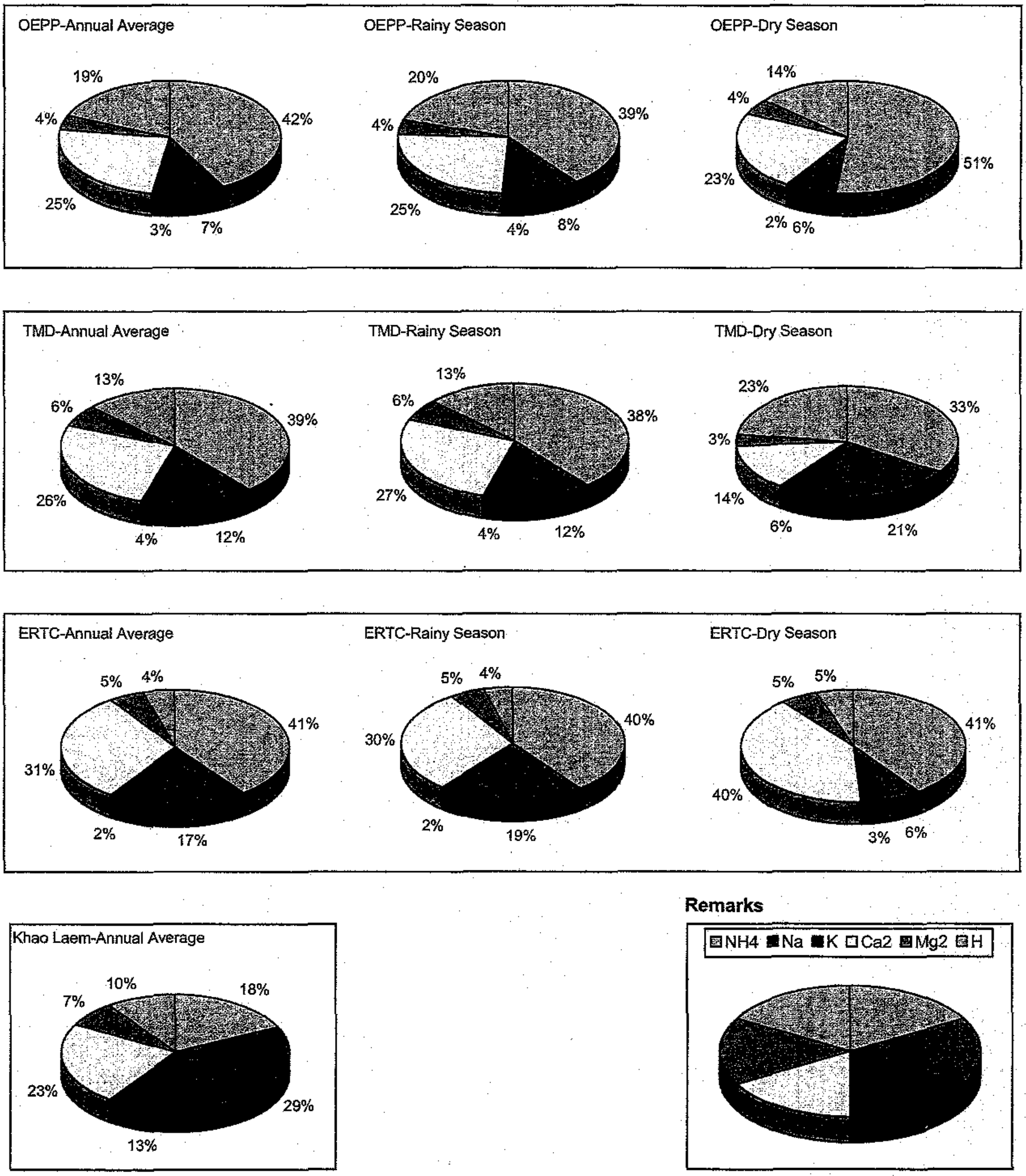
1.1.2 Ion Composition

As mentioned before, ion composition shows the rain condition and ion source. Figure 1.1.2.1 shows the anion composition, and Figure 1.1.2.2 shows the cation composition.



Source: PCD, modified by the Study Team

Figure 1.1.2.1 Anion Composition of Each Monitoring Site



Source: PCD, modified by the Study Team

Figure 1.1.2.2 Cation Composition of Each Monitoring Site

1.1.2.1 Anion

SO_4 ion accounted for over 50 % of anion in OEPP and TMD sites located in urban areas. Next, NO_3 ion accounted for approximately 20 to 50 %. As mentioned previously, SO_4 and NO_3 ions are mainly originated by human activities such as emission gases from mobile and industrial sources.

Although ERTC site is located in a rural site, it showed similar trends as urban site, that is to say, the ratio of SO_4 ion was higher than any other anion.

On the other hand, the ratio of SO_4 and NO_3 ions in Khao Laem site were not so high, Cl ion accounted for 45 % of anion. Generally speaking, Cl ion does not depend on human activity and is regarded as being of sea salt origin.

1.1.2.2 Cation

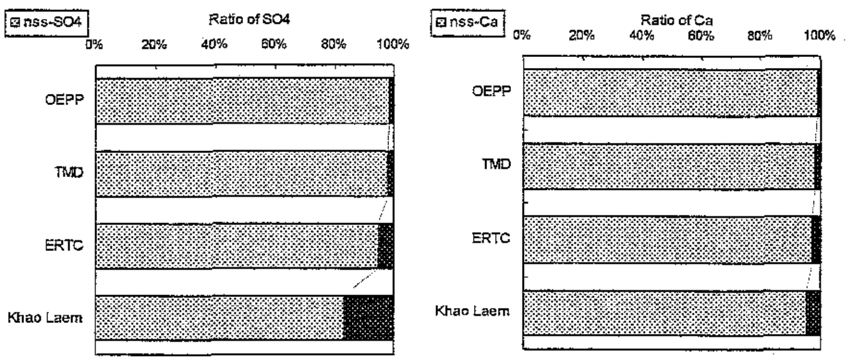
NH_4 ions ratio showed a similar distribution as with SO_4 and NO_3 ions, that is to say, NH_4 ion ratio of OEPP, TMD and ERTC sites were about 40 to 50 % of cation. Ca ion occupied the second highest part of cation apart from with TMD site during the dry season. On the other hand, Khao Laem site showed different distributions. NH_4 ratio was not so high, Na and Ca ion occupied the major parts.

1.1.2.3 Findings

According to the descriptions above, the following findings are derived.

OEPP and TMD sites located in urban areas are influenced by human activity. Such SO_4, NO_3 and NH_4 ions as emitted by human activities has serious effects on the acidity of precipitation. ERTC site, however which is located in rural area, has a similar distribution. On the other hand, Khao Laem site does not show as much influence on SO_4, NO_3 and NH_4 ions because of the low impact from human activity. The relative ratio of Cl, Na and Ca ions were bigger than other 3 sites.

Sea salt impact in Khao Laem site appeared stronger than the other sites, however the degree of impact was not so high as shown in Figure 1.1.2.3. The sea salt impact may be small even if the distance from the sea coast is not so far. It will be important to compare with the data of an inland area such as Chiang Mai site in a further study.



Source: PCD, modified by the Study Team

Figure 1.1.2.3 Ratio of non Sea Salt SO_4 and Ca

1.1.3 Tendency of Acidity

For evaluating the differences of acidity, the following analysis was tried. The analysis was based on the report by Dr. Tsuruta [1]. In the report, some of the ions are classified into two groups. One group has Acidification Potential (AP), which makes acidity of precipitation high. That to say, nss-SO_4 and NO_3 ions have AP. Another group has Neutralization Potential (NP), which makes acidity of precipitation low. Both nss-Ca and NH_4 ions have NP.

Table 1.1.3.1 shows the annual average of NP/AP. NP/AP indicates tendency of the change of acidity. Namely, when NP/AP is high, rain frequently shows lower acidity. On the other hand, if NP/AP is below 1.0, precipitation may easily be of higher acidity.

Table 1.1.3.1 Annual Average of NP/AP

Monitoring Site	NP/AP
OEPP	1.21
TMD	1.17
ERTC	0.92
Khao Laem	0.82

Source: The Study Team

Briefly speaking, NP/AP of OEPP and TMD sites was higher than ERTC and Khao Laem sites. The value of Khao Laem site was the lowest . As mentioned before, the ratio of NH_4 ion concentration at Khao Laem was lower than OEPP and TMD (see Figure 1.1.2.2), and the portion of nss-Ca ion in cation might also be small. As, NP at Khao Laem site was lower than AP, precipitation on Khao Laem area might be influenced by high acidification potential materials, and apt to show lower pH.

[1] TSURUTA H., Acid Deposition in East Asia, Kagaku, 59, 305-315, 1989

1.1.4 Comparison with Wet Deposition of Other Countries

EANET is an international monitoring network system for acid deposition. After steady preparation, it officially started in 2001. At present the following 12 countries participate in EANET.

China, Indonesia, Japan, Lao P.D.R., Malaysia, Mongolia Philippines, Republic of Korea, Russia, Thailand, Vietnam, and Cambodia

The JCA Study Team obtained EANET data for the year 1999. Therefore comparisons with some countries, near to Thailand and Japan, were carried out. Table 1.1.4.1 shows the monthly average/amount of wet deposition parameters in the year 1999. Also Figure 1.1.4.1 indicates the monthly rain amounts for each country.

Table 1.1.4.1(1) Monthly Average/Amount of Wet Deposition Parameters in the year 1999

Parameter	Country	Site Name	Month Classification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Aberage
Rain (mm)	Thailand	OEPP	Urban				145.1	329.2	194.7	115.0	154.9	115.7	49.2			1103.8
		ERTC	Rural			19.4	153.6	254.5	123.7	173.4	102.6	159.2	64.5			1050.9
		Khao Laem	Remote				13.8	40.9	41.5	84.9	23.9	7.8	255.4	53.0		521.2
	Vietnam	Hanoi	Urban								97.1	170.9	184.8	81.0	73.5	607.3
		Hoa Binh	Rural								81.1	270.7	202.3	102.8	104.2	761.1
	Malaysia	Petaling Jaya	Urban	143.3	222.2	388.8	174.9	411.1	38.9	203.5	145.3					1728.0
		Tanah Rata	Remote	113.1	128.9	374.4	349.0	83.3	104.9	215.6	396.6	242.6	326.4	114.5	293.5	2742.8
	China	Jiancexhan	Urban					120.0	93.5	43.4	185.7	99.6		22.2	12.7	577.1
		Xiaoping	Remote				24.0	299.0	165.0	142.1	268.0	169.6				1067.7
	Japan	Ashiruri	Remote	34.0	115.8	225.0	214.9	247.5	264.0	392.0	220.5	405.0				2118.7
		Lake Ijira	Rural						294.5	353.0	258.0	764.0				1669.5
		Lake Banryu	Urban					143.0	244.0	371.0	109.5	176.5				1044.0
pH	Thailand	OEPP	Urban				4.8	5.5	5.5	5.2	5.7	4.8	5.0			5.2
		ERTC	Rural			4.5	4.5	4.7	5.4	5.2	4.9	4.6	4.8			4.8
		Khao Laem	Remote				5.7	6.0	5.7	5.9	5.7	5.6	5.5	5.3		5.7
	Vietnam	Hanoi	Urban								6.3	5.9	5.3	5.2	5.3	5.6
		Hoa Binh	Rural								5.6	5.5	5.1	5.7	5.2	5.4
	Malaysia	Petaling Jaya	Urban	4.3	4.2	4.3	4.3	4.4	4.2	4.3	4.3					4.3
		Tanah Rata	Remote	4.9	5.0	5.0	5.0	4.7	4.8	5.0	5.0	4.8	5.0	5.0	4.9	4.9
	China	Jiancexhan	Urban					5.3	6.1	6.0	5.3	5.2		6.1	6.7	5.8
		Xiaoping	Remote				4.8	4.9	4.8	4.9	5.4	5.0				5.0
	Japan	Ashiruri	Remote	4.1	4.5	4.6	5.1			5.4	5.2	5.0				4.8
		Lake Ijira	Rural						4.7	4.3	4.6	4.9				4.6
		Lake Banryu	Urban					4.9	4.9	5.0	4.8	4.9				4.9
nss-SO_4 (umol/L)	Thailand	OEPP	Urban				15.2	20.8	17.1	16.9	17.2	16.7	22.5			18.1
		ERTC	Rural			58.5	17.7	17.2	20.6	18.5	24.9	24.3	21.7			25.4
		Khao Laem	Remote				10.7	3.5	<1.0	2.3	1.2	4.0	2.0	1.5		3.6
	Vietnam	Hanoi	Urban								5.3	14.5	31.6	10.5	7.2	13.8
		Hoa Binh	Rural								5.3	4.4	26.0	26.4	7.5	13.9
	Malaysia	Petaling Jaya	Urban	18.5	25.2	20.8	16.6	15.7	29.2	23.3	20.0					21.2
		Tanah Rata	Remote	1.5	2.8	2.6	2.4	3.5	6.4	2.9	5.8	4.8	<1.0	1.9	1.2	3.3
	China	Jiancexhan	Urban					17.1	21.8	204.0	25.2			101.0	69.1	73.0
		Xiaoping	Remote				15.5	18.2	26.0	12.3	14.6	21.7				18.1
	Japan	Ashiruri	Remote	26.5	17.6	16.4	11.4			<1.0	2.3	3.0				12.9
		Lake Ijira	Rural						8.6	16.3	13.5	8.0				11.6
		Lake Banryu	Urban					5.1	6.5	4.6	4.8	5.1				5.2
NO_3 (umol/L)	Thailand	OEPP	Urban				6.8	9.9	18.3	17.7	16.8	26.0	27.8			17.6
		ERTC	Rural			49.9	28.5	15.5	14.4	11.6	23.6	19.8	27.6			23.9
		Khao Laem	Remote				27.8	3.9	1.8	5.1	1.2	4.5	3.1	2.3		6.2
	Vietnam	Hanoi	Urban								10.1	9.9	11.2	8.2	10.0	9.9
		Hoa Binh	Rural								10.4	10.2	10.6	11.2	10.9	10.7
	Malaysia	Petaling Jaya	Urban	13.6	18.3	12.9	8.6	9.5	17.3	18.4	25.8					15.6
		Tanah Rata	Remote	2.1	4.5	3.7	3.3	5.8	8.8	3.9	8.3	5.1	<1.0	1.8	<1.0	4.7
	China	Jiancexhan	Urban					17.3	10.8	17.9	30.1	35.0		104.0	65.8	40.1
		Xiaoping	Remote				16.2	17.5	17.1	9.9	12.0	13.2				14.3
	Japan	Ashiruri	Remote	59.3	9.8	16.0	13.8			1.9	2.9	3.4				15.3
		Lake Ijira	Rural						15.0	36.0	24.5	13.2				22.2
		Lake Banryu	Urban					6.0	8.4	3.6	9.1	6.0				6.6

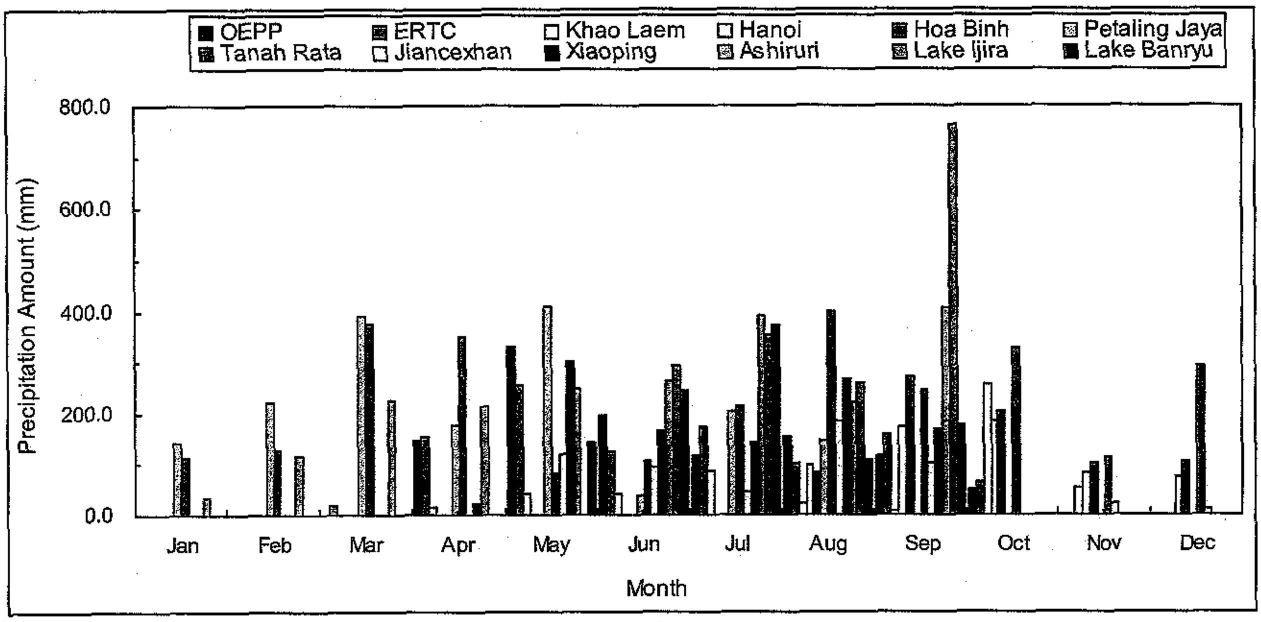
Table 1.1.4.1(2) Monthly Average/Amount of Wet Deposition Parameters in the year 1999

Parameter	Country	Site Name	Month / Classification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Aberage
NH_4 (umol/L)	Thailand	OEPP	Urban				34.0	42.2	59.8	49.6	40.5	40.4	34.2			43.0
		ERTC	Rural			68.1	37.9	17.8	34.6	30.9	38.7	40.5	42.9			38.9
		Khao Laem	Remote				57.0	8.8	9.4	12.9	4.8	9.1	4.3	2.8		13.6
	Vietnam	Hanoi	Urban								9.3	8.5	3.2	1.3	8.1	6.1
		Hoa Binh	Rural								5.5	4.4	2.3	4.0	8.2	4.9
	Malaysia	Petaling Jaya	Urban	4.2	12.3	8.0	2.9	5.0	10.7	14.9	13.6					9.0
		Tanah Rata	Remote	5.2	6.5	8.0	9.8	10.6	19.4	12.9	13.6	4.2	<1.0	<1.0	<1.0	10.0
	China	Jiancexhan	Urban					9.6	3.1	19.5	39.5	13.3		95.6	149.0	47.1
		Xiaoping	Remote				35.9	37.0	49.1	23.2	52.2	15.5				35.5
	Japan	Ashiruri	Remote	29.1	10.2	14.6	12.0			<1.0	2.0	1.3				11.5
		Lake Ijira	Rural						6.1	18.6	17.9	11.1				13.4
		Lake Banryu	Urban					9.1	17.0	14.8	5.3	5.3				10.3
nss-Ca (umol/L)	Thailand	OEPP	Urban				11.6	14.5	15.0	11.1	11.5	10.0	15.8			12.8
		ERTC	Rural			30.0	7.6	4.8	12.6	13.3	12.1	7.6	11.4			12.4
		Khao Laem	Remote				7.1	4.7	1.4	1.6	<0.2	0.6	1.2	1.1		2.5
	Vietnam	Hanoi	Urban								21.1	21.4	33.4	8.6	13.8	19.7
		Hoa Binh	Rural								7.8	13.1	27.3	42.7	14.4	21.1
	Malaysia	Petaling Jaya	Urban	3.0	4.7	3.9	3.8	1.9	5.2	3.0	6.1					4.0
		Tanah Rata	Remote	1.3	1.6	0.8	1.0	1.1	3.5	2.8	2.9	1.3	0.3	1.0	0.4	1.5
	China	Jiancexhan	Urban					42.6	184.0	182.0	27.1	46.9		180.0	102.0	109.2
		Xiaoping	Remote				2.4	10.8	19.9	0.7	0.4	6.1				6.7
	Japan	Ashiruri	Remote	2.2	0.8	5.1	5.8			1.6	1.7	0.2				2.5
		Lake Ijira	Rural						8.0	6.9	6.6	4.7				6.6
		Lake Banryu	Urban					0.6	0.3	<0.2	0.3	0.2				0.4

Table 1.1.4.1(3) Monthly Average/Amount of Wet Deposition Parameters in the year 1999 (Precipitation Amount)

Parameter	Country	Site Name	Month / Classification	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Aberage
$nss\text{-}SO_4$ ($mmol/m^2$/month)	Thailand	OEPP	Urban				2.2	6.9	3.3	1.9	2.7	1.9	1.1			20.1
		ERTC	Rural			1.1	2.7	4.4	2.5	3.2	2.6	3.9	1.4			21.8
		Khao Laem	Remote				0.2	0.1	0.0	0.2	0.0	0.0	0.5	0.1		1.2
	Vietnam	Hanoi	Urban								0.5	2.5	5.8	0.9	0.5	10.2
		Hoa Binh	Rural								0.4	1.2	5.3	2.7	0.8	10.4
	Malaysia	Petaling Jaya	Urban	2.6	5.6	8.1	2.9	6.5	1.1	4.7	2.9					34.5
		Tanah Rata	Remote	0.2	0.4	1.0	0.9	0.3	0.7	0.6	2.3	1.2	0.3	0.2	0.3	8.3
	China	Jiancexhan	Urban					2.1	2.0	8.8	4.7			2.2	0.9	20.7
		Xiaoping	Remote				0.4	5.4	4.3	1.7	3.9	3.7				19.4
	Japan	Ashiruri	Remote	0.9	2.0	3.7	2.5			0.3	0.5	1.2				11.1
		Lake Ijira	Rural						2.5	5.8	3.5	6.1				17.9
		Lake Banryu	Urban					0.7	1.6	1.7	0.5	0.9				5.4
nss-Ca ($mmol/m^2$/month)	Thailand	OEPP	Urban				1.7	4.8	2.9	1.3	1.8	1.2	0.8			14.4
		ERTC	Rural			0.6	1.2	1.2	1.6	2.3	1.2	1.2	0.7			10.0
		Khao Laem	Remote				0.1	0.2	0.1	0.1	0.0	0.0	0.3	0.1		0.9
	Vietnam	Hanoi	Urban								2.1	3.7	6.2	0.7	1.0	13.6
		Hoa Binh	Rural								0.6	3.6	5.5	4.4	1.5	15.6
	Malaysia	Petaling Jaya	Urban	0.4	1.1	1.5	0.7	0.8	0.2	0.6	0.9					6.1
		Tanah Rata	Remote	0.1	0.2	0.3	0.4	0.1	0.4	0.6	1.1	0.3	0.1	0.1	0.1	3.9
	China	Jiancexhan	Urban					5.1	17.2	7.9	5.0	4.7		4.0	1.3	45.2
		Xiaoping	Remote				0.1	3.2	3.3	0.1	0.1	1.0				7.8
	Japan	Ashiruri	Remote	0.1	0.1	1.1	1.3			0.6	0.4	0.1				3.6
		Lake Ijira	Rural						2.4	2.4	1.7	3.6				10.1
		Lake Banryu	Urban					0.1	0.1	0.0	0.0	0.0				0.3

Source: PCD and ADORC, modified by the Study Team



Source: PCD and ADORC, modified by the Study Team

Figure 1.1.4.1 Rain Amount of Each Country

The highest total rain amount in 1999 appeared in Tanah Rata located in Malaysia, and was over 2700 mm. The second one appeared in Ashizuri of Japan. This would be influenced by a typhoon.

Figure 1.1.4.2 shows the monthly trend of pH, nss-SO_4 and NO_3 ions in 1999. These Figures are compared by urban, rural and remote areas.

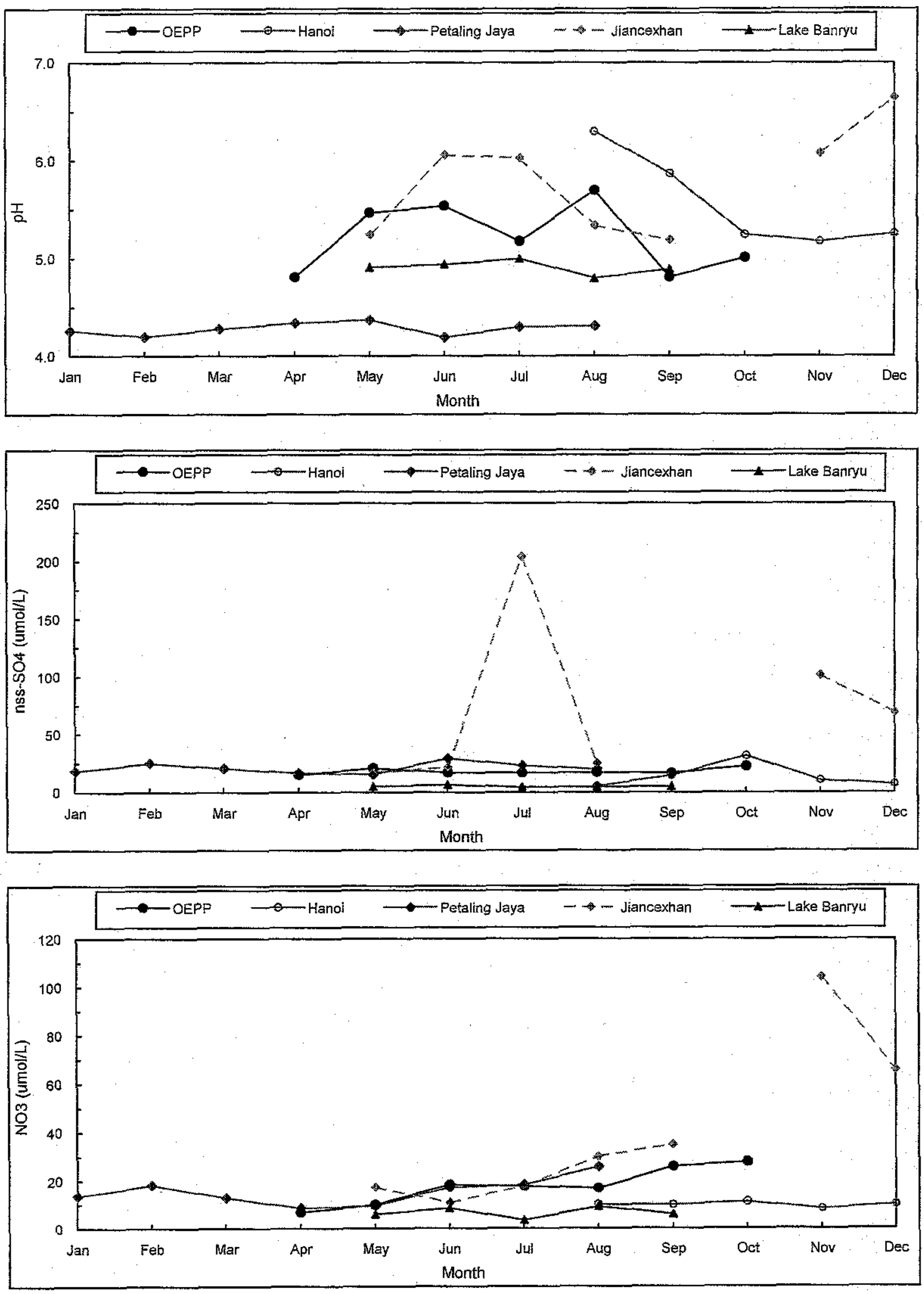


Figure 1.1.4.2(1) Monthly Trend of pH, nss-SO_4 and NO_3 in Urban Area

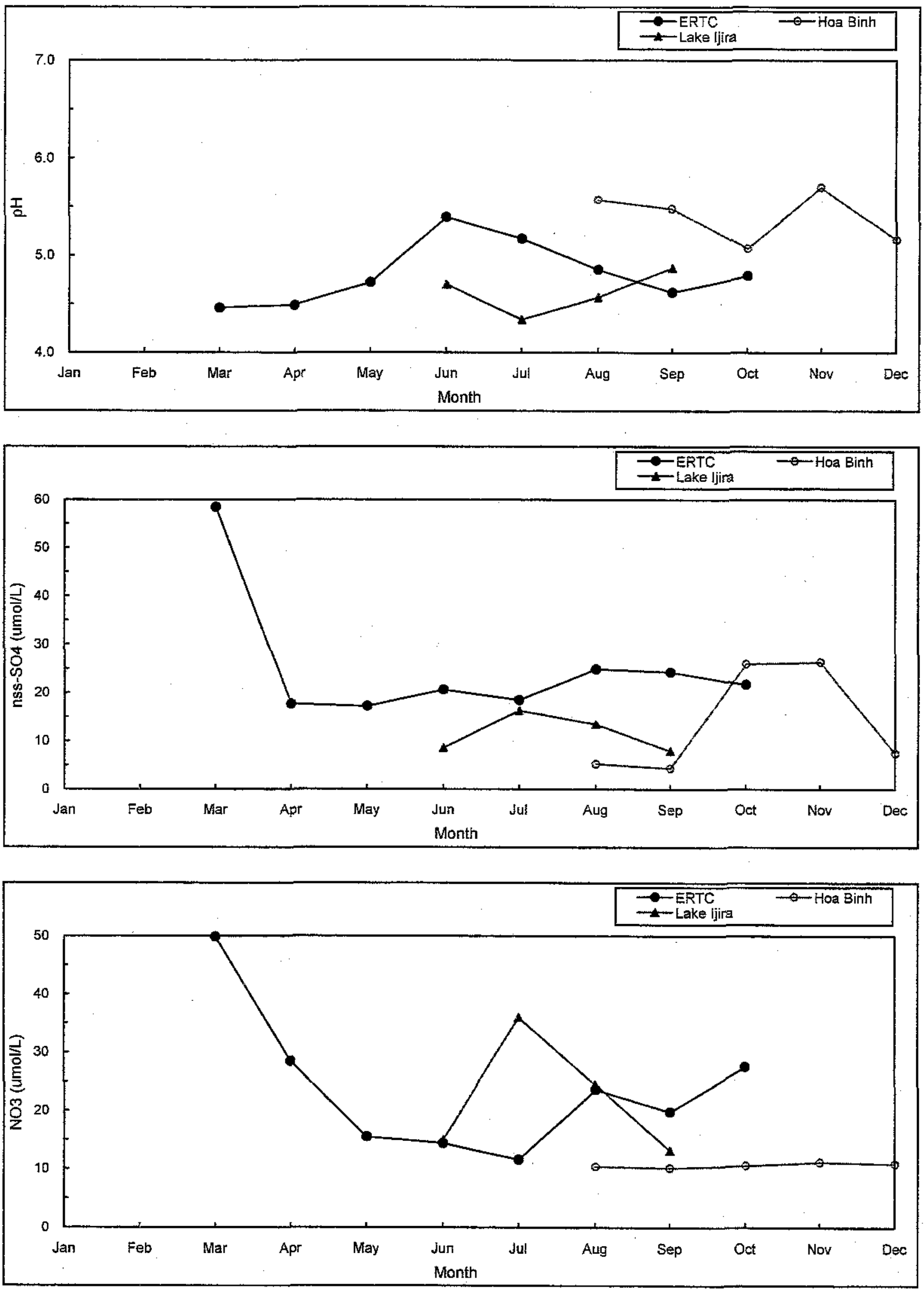
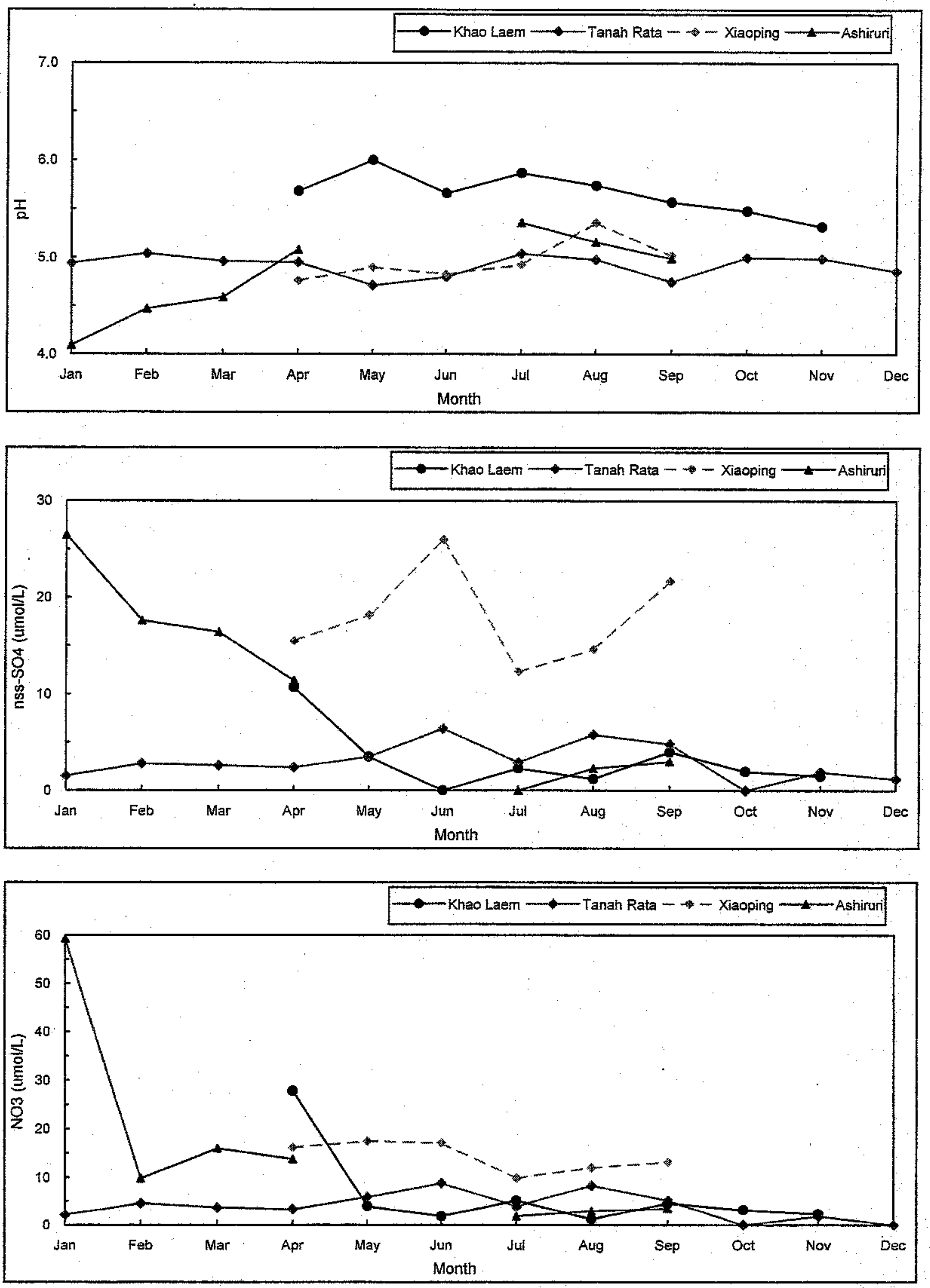


Figure 1.1.4.2(2) Monthly Trend of pH, nss-SO_4 and NO_3 in Rural Area



Source: PCD and ADORC, modified by the Study Team

Figure 1.1.4.2(3) Monthly Trend of pH, nss-SO_4 and NO_3 in Remote Area

1.1.4.1 Urban Area

The lowest pH appeared at Petaling Jaya located in Malaysia, all the monthly averages were below 5.0. The second lowest value was at Lake Banryu in Japan where values were approximately 5.0. pH in Thailand was not as low, these values were almost normal compared to other countries.

The concentrations of Nss-SO_4 and NO_3 ions were of lowest value in Japan. However the differences between other countries was not so large and monthly trends of each country were similar apart from some months in China.

1.1.4.2 Rural Area and Remote Area

The pH trends of rural/remote areas in Thailand did not show much difference from other countries, Khao Laem site was higher than other countries.

Nss-SO_4 and NO_3 ion concentrations at ERTC appeared higher in March and April, in the Dry Season. However the values in the Rainy Season were not so different.

1.2. Result of Air Quality Monitoring

1.2.1 Brief Description of Air Quality

PCD carried out an air quality survey at 44 points in the year 2000. Table 1.2.1.1 shows a brief result of the hourly and daily data of each monitoring point. Processing of daily data was carried out for the valid day, which demanded hourly 20 or more valid data per day.

In Japan, the attainment of some air quality standards is evaluated by 98 percentile value. The reason of adoption of this method is to reject abnormally high values. However, this method is not adopted in Thailand, air quality hourly and daily monitoring data are evaluated by this method tentatively.

Figure 1.2.1.1 shows the average of hourly and daily data, and 98 % percentile value of hourly data.