SECOND PERIODIC REPORT ON THE STATE OF ACID DEPOSITION IN EAST ASIA

Part II National Assessments

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

Acid Deposition Monitoring Network in East Asia
(EANET)

The Second Periodic Report
on the State of Acid Deposition in East Asia

Part II: National Assessments

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Preface

The present report is the National Assessments, Part II of Second Periodic Report on the State of Acid Deposition in East Asia (PRSAD2).

The National Assessments of PRSAD2 was prepared by each participating country according to the format for national assessments that prepared by the Drafting Committee of the PRSAD2. The Acid Deposition Monitoring Network in East Asia (EANET) data and other domestic data of each participating country was used for the national assessments. The period of monitoring data to be analyzed is 2005 - 2009. While for its own needs, data in 2000 - 2004 has also been used for trend analysis.

Three chapters are included in this national assessment report, i.e. Basic Information on National Monitoring Activities, State of Acid Deposition in Each Participating Country and Review of National Measures against Acid Deposition. 13 participating countries, namely Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Russia, Thailand, and Vietnam, shared the progress of their national monitoring activities, state of acid deposition in their respective country and the national measures implemented.

As a detailed complementary of Regional Assessment, the report includes the national information on acid deposition. This is a unique output of an assembling report on East Asia countries in the area of acid deposition during 2005 - 2009.

National Assessment on Acid Deposition Report in Cambodia

1.1. Base Information on National Monitoring Activities

1.1.1 Outline of the activities on acid deposition and national monitoring plan

Cambodia, as a developing country has embarked on the industrialization since 1993's coupled with the growing population and urbanization processes. Rapid growth of industrialization and urbanization in certain areas in Cambodia has brought about air pollution problem to certain extent the factories and motor vehicles emit harmful gases such as CO, HC, NOx, SO_2 and particulates causing the ambient air quality industrialized and confected urban areas to deteriorate although the overall air quality in the country is generally good, but air pollution is still concern. Therefore, Cambodia participated in East Asia Acid Deposition Network (EANET) in 2001 and implemented regular monitoring activities together with twelve other countries. The national monitoring plan developed in 2004 for wet deposition monitoring.

1.1.2 Monitoring program from 2005-2010

Cambodia started monitoring wet deposition in 2004 at one site, Phnom Penh City. The measurement parameters and monitoring intervals are tabulated below:

Table 1.1.1. Measurement parameters and monitoring intervals.

Item	Measurement parameters	Monitoring intervals
Wet deposition	pH, EC, SO_4^{2-}, NO_3^- , Cl^- NH_4^+ , K^+, Na^+, Ca^{2+}, Mg^{2+}	weekly

1.1.3 Monitoring station

Nowadays, there is only one monitoring site for wet deposition in Cambodia. There are no remote and rural for monitoring of acid deposition yet. The information of site is shown below:

Site category	Site classification	Location
Wet deposition	Urban	Phnom Penh

Phnom Penh monitoring site is located in Chamkarmon district, Phnom Penh city, on the top of Ministry of Environment building, 11° 33′ N, 104° 50′ E, the altitude is 10 m. This site is surrounded by residential area, shops, parking place and roads.

1.1.4 Sampling and measurements

The site use automatic rainwater collector for sampling. The measurement must be carried out according the technical manual for wet deposition monitoring adopted by EANET.

Table 1.1.2. Sampling and measurement method

Sampling site	Monitoring parameters	Measurement method
Phnom Penh	pH	Glass electrode method
	EC	electrode method
	NH_4^+ , K^+, Na^+, Ca^{2+}, Mg^{2+},	IC
	NO_3^- , SO_4^{2-}, Cl^-	IC

1.2. State of Acid Deposition in Cambodia

1.2.1 Atmospheric deposition

1.2.1.1 State of wet deposition

From 2005 to 2010, the monitoring results of pH, EC and ion concentration from the wet deposition monitoring sites were shown in figure below:

Figure 1.2.1. is annual average of pH in 2005-2010, pH annual average of wet deposition monitoring site is between 5.84 – 6.69.

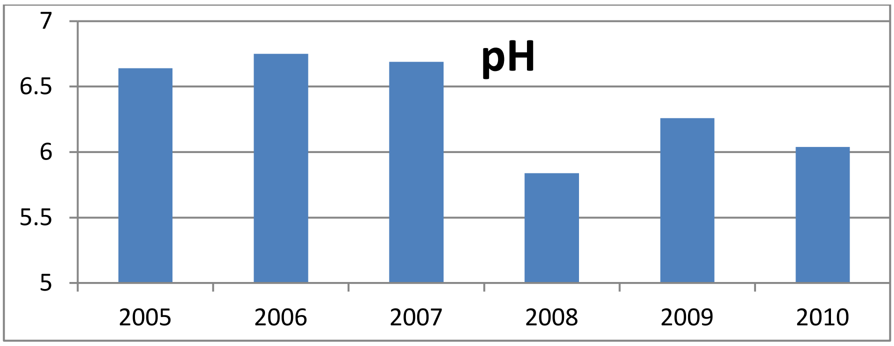

Figure 1.2.1. Annual average of pH in 2005-2010.

EC annual average of wet deposition monitoring site is between 1.00 - 1.53 mS.m^{-1}.

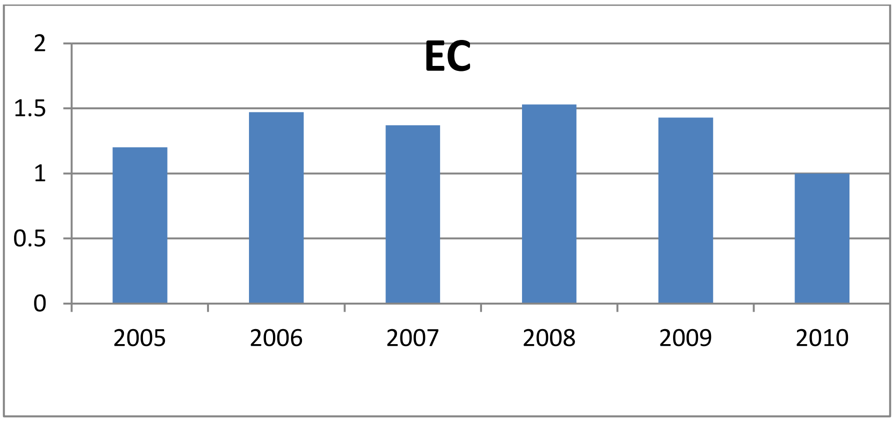

Figure 1.2.2. Annual average of EC in 2005-2010.

SO_4^{2-} annual average of wet deposition monitoring site is between 9.84-11.6 µmol.l^{-1}

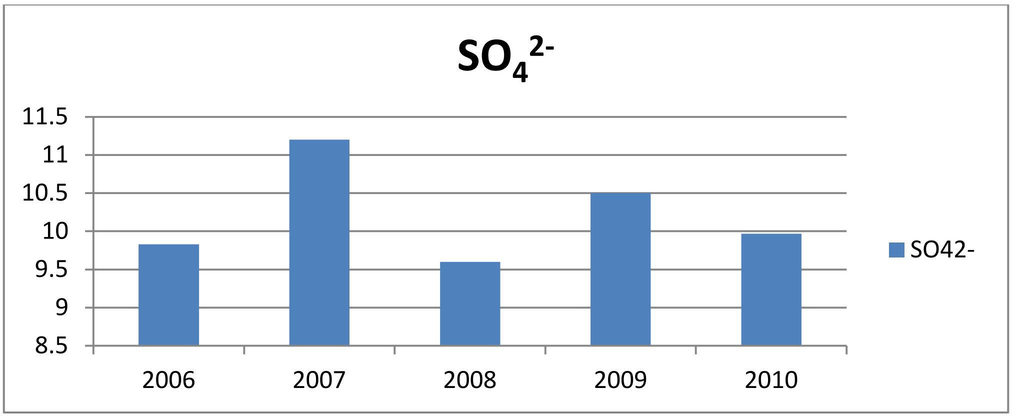

Figure 1.2.3. Annual average of SO_4^{2-} in 2005-2010.

NO_3^- annual average of wet deposition monitoring site is between 8.3-11.36 µmol.l^{-1}

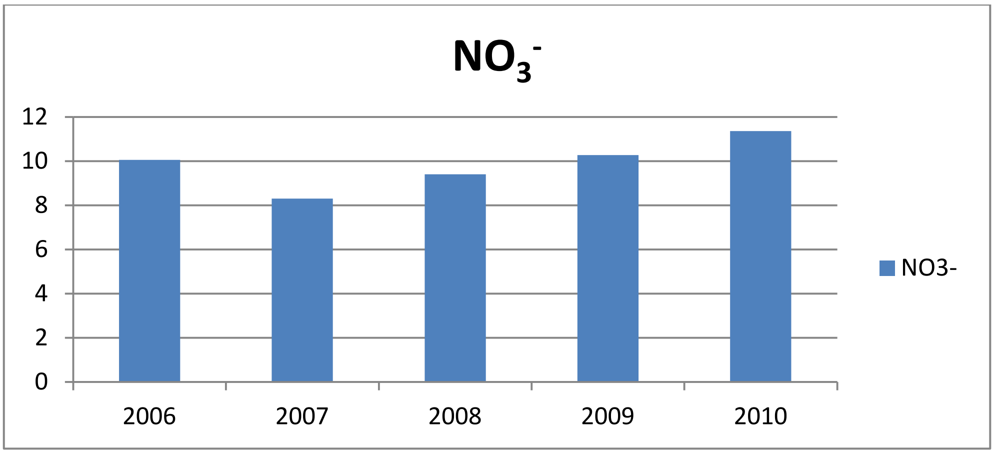

Figure 1.2.4. Annual average of NO_3^- in 2005-2010.

Cl^- annual average of wet deposition monitoring site is between 6.3 – 9.86 µmol.l^{-1}

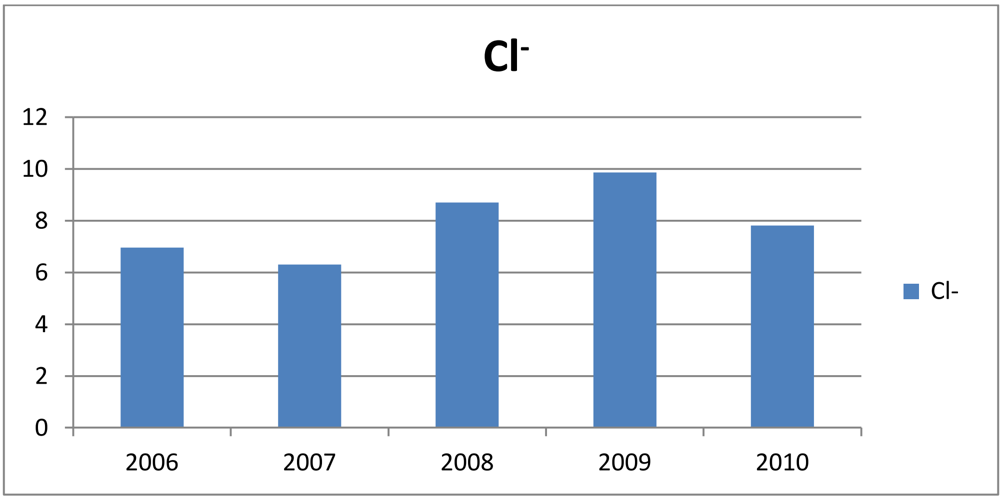

Figure 1.2.5. Annual average of Cl^- in 2005-2010.

NH_4^+ annual average of wet deposition monitoring site is between 17.8 - 23.13 µmol.l^{-1}.

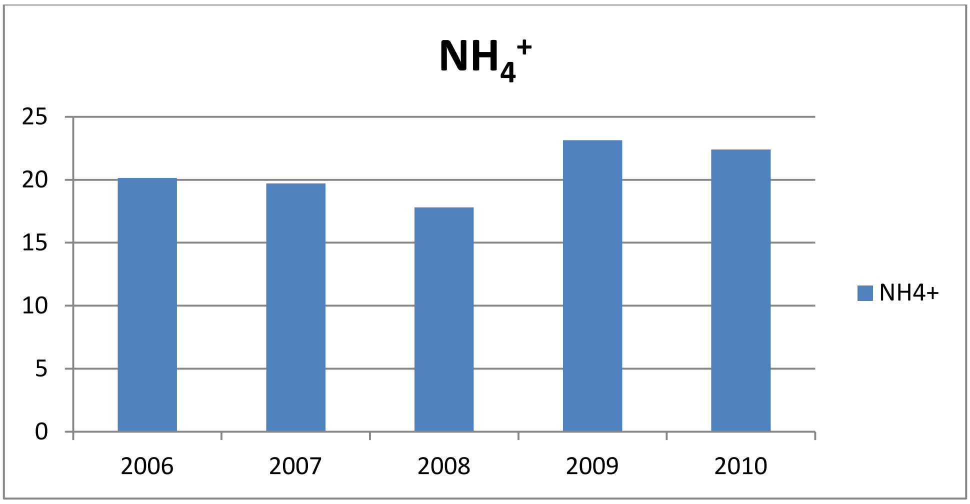

Figure 1.2.6. Annual average of NH_4^+ in 2005-2010.

Na^+ annual average of wet deposition monitoring site is between 4.1-6.25 µmol.l^{-1}.

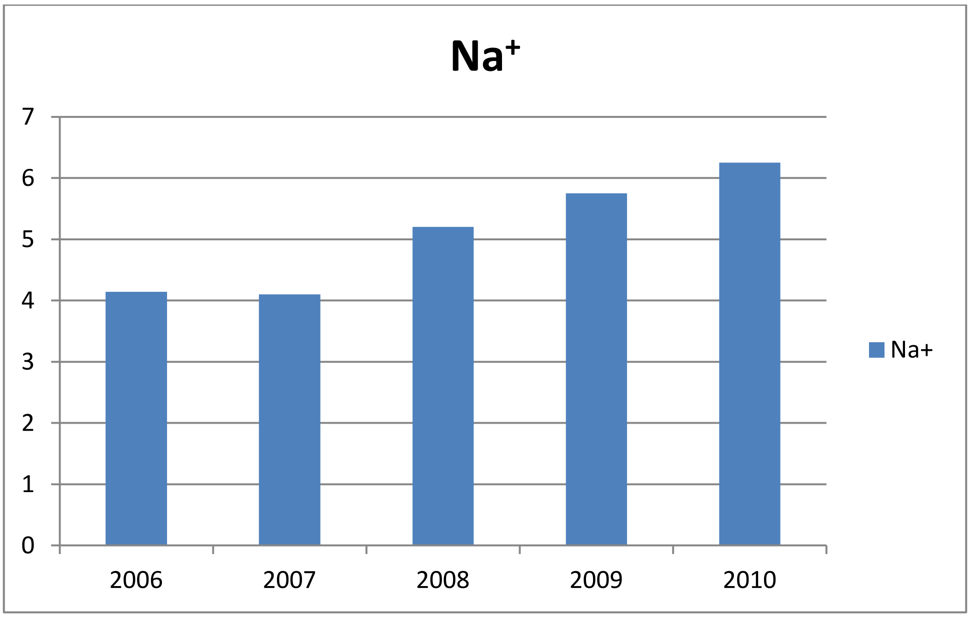

Figure 1.2.7. Annual average of Na^+ in 2005-2010.

K^+ annual average of wet deposition monitoring site is between 1.65 - 2.2 µmol.l^{-1}

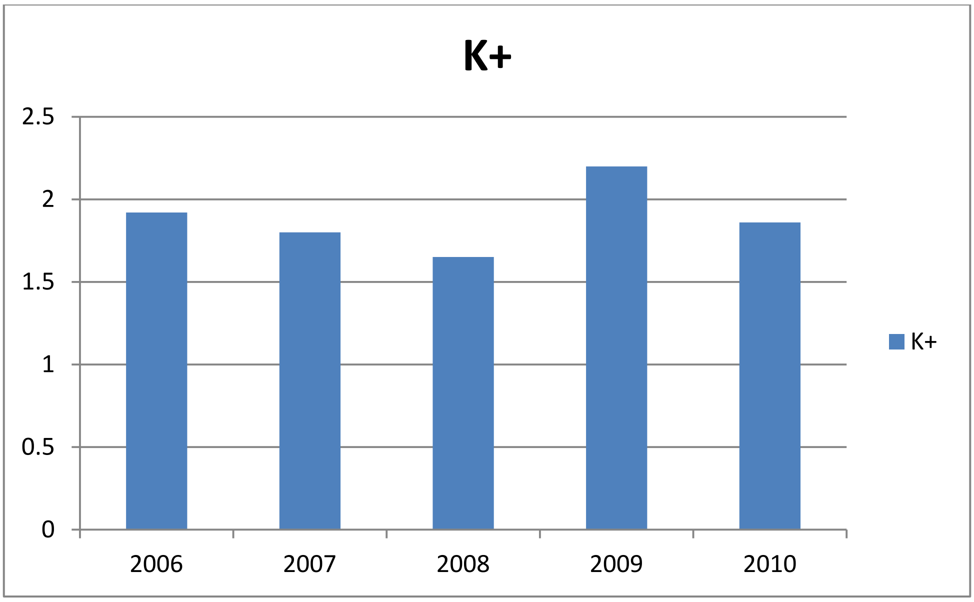

Figure 1.2.8. Annual average of K^+ in 2005-2010.

Ca^{2+} annual average of wet deposition monitoring site is between 9.6 - 17.55 µmol.l^{-1}.

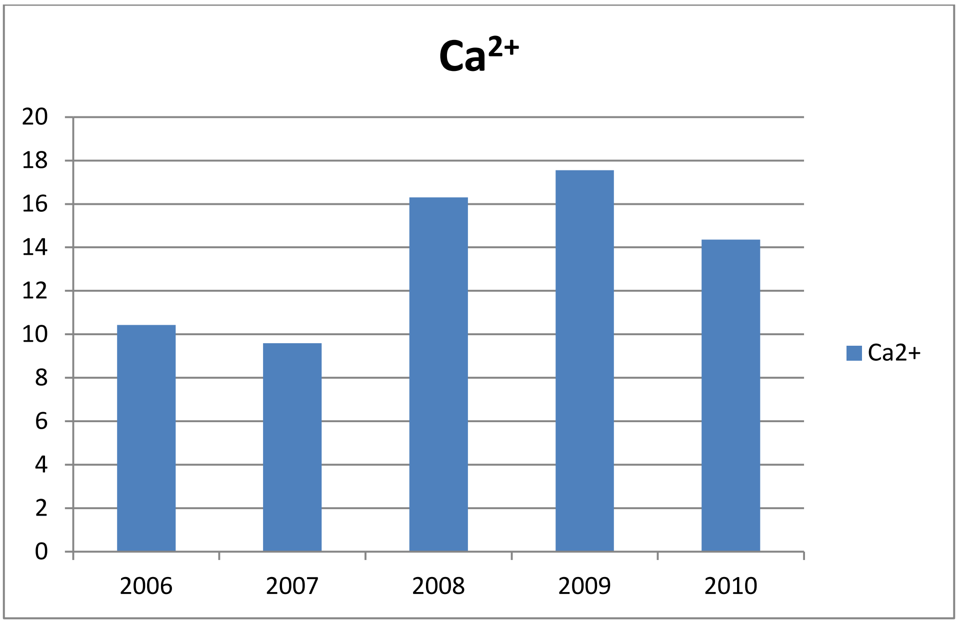

Figure 1.2.9. Annual average of Ca^{2+} in 2005-2010.

Mg^{2+} annual average of wet deposition monitoring site is between 1.31 – 2 µmol.l^{-1}.

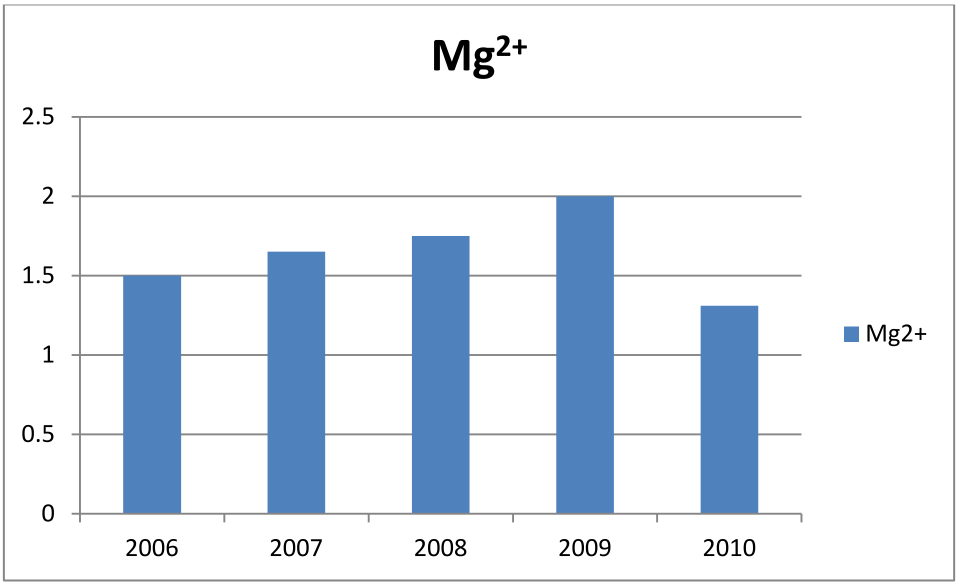

Figure 1.2.10. Annual average of Mg^{2+} in 2005-2010.

1.2.1.2 State of dry deposition

Cambodia was installed the monitoring of dry deposition in Phnom Penh city in February 2010 to follow the requirements for EANET activities.

Filter pack method is available for the measurement of SO_2, HNO_3, HCl, NH_3, and particulate component (SO_4^{2-}, NO_3^-, Cl^-, Na^+, K^+, NH_4^+, Ca^{2+}, Mg^{2+}). The four-stage filter pack method can measure all of these parameters at the same time.

Reactions on filters in four-stage filter pack

Stage	Reaction	Collected species
1st (F0)	Filtration	aerosols
2nd (F1)	Adsorption	HNO_3, partial SO_2, partial HCl
	Neutralization by collected acid gases	partial NH_3
3rd (F2)	Neutralization by alkali impregnated cellulose filter	SO_2, HCl
4th (F3)	Neutralization by acid impregnated cellulose filter	NH_3

Table 1.2.1. Data of dry monitoring in 2010 by filter pack method.

Month	Gas				Particle							
	SO_2 nmol. m^{-3}	HNO_3 nmol. m^{-3}	HCl nmol. m^{-3}	NH_3 nmol. m^{-3}	SO_4^{2-} nmol. m^{-3}	NO_3^- nmol. m^{-3}	Cl^- nmol. m^{-3}	NH_4^+ nmol. m^{-3}	Na^+ nmol. m^{-3}	K^+ nmol. m^{-3}	Mg^{2+} nmol. m^{-3}	Ca^{2+} nmol. m^{-3}
Feb	56.81	12.39	33.58	731.6	40.49	36.94	13.36	39.42	57.51	21.01	10.01	27.33
Mar	70.28	18.61	49.59	654.0	49.36	43.64	14.47	49.52	55.12	37.64	9.37	30.71
Apr	69.19	23.23	38.65	742.3	50.33	33.15	6.07	62.25	34.64	26.54	6.18	24.96
May	67.38	10.08	19.42	840.4	19.17	22.89	5.71	20.78	20.28	13.37	4.80	27.30
Jun	58.16	10.06	10.01	534.4	10.48	12.51	2.62	11.95	9.09	8.15	4.22	17.42
Jul	70.45	6.72	15.79	574.4	13.38	14.50	9.90	5.18	13.84	13.37	4.18	23.56
Aug	26.63	7.21	8.41	456.5	15.70	14.84	4.41	13.47	11.88	9.40	3.46	17.40
Sep	57.76	10.95	13.36	475.5	13.69	12.49	2.01	14.79	8.54	9.79	3.12	16.73
Oct	74.66	10.68	14.52	346.5	25.23	9.25	1.59	32.31	8.22	7.36	2.16	13.56
Nov	96.57	6.52	0.31	300.8	27.07	7.18	-0.53	40.78	8.09	4.85	1.53	7.26
Dec	69.97	15.18	21.31	340.1	36.37	12.37	0.34	50.83	21.42	11.04	2.91	11.72

1.2.2 State of inland aquatic environment

Cambodia was started the monitoring of inland aquatic environment in June 2011 in order to follow the requirements for EANET activities.

- At KIRIRUM national Park, Kampong Speu province, from Phnom Penh city about 165 km
- Water sample take 4 times a year
- Monitoring items :

  Water temperature, pH, EC, SO_4^{2-}, NO_3^-, Cl^-, Na^+, K^+, NH_4^+, Ca^{2+}, Mg^{2+}.

1.2.3 State of soil and vegetation

The monitoring activities for soil and vegetation have not yet been decided at this time in Cambodia due to constraints for instruments supply and capacity building. However, Cambodia will also plan to monitor soil and vegetation in the near future.

1.2.4 Overall analysis

From the data obtained in 2005 to 2010, in generally there was no obvious changing tendency of the pH, EC and ion concentration in the wet deposition monitoring site, the overall analysis described that the annual concentrations and annual mean precipitation are evaluated as the followings.

Table 1.2.2. Annual average data on wet deposition in Phnom Penh in 2005-2010.

Year	SO_4^{2-} µmol.l^{-1}	NO_3^- µmol.l^{-1}	Cl^- µmol.l^{-1}	NH_4^+ µmol.l^{-1}	Na^+ µmol.l^{-1}	K^+ µmol.l^{-1}	Ca^{2+} µmol.l^{-1}	Mg^{2+} µmol.l^{-1}	pH	EC mS.m^{-1}	Amount of Precipitation (mm)
2005	-	-	-	-	-	-	-	-	6.64	1.20	1,309.60
2006	9.84	10.06	6.96	20.13	4.14	1.92	10.43	1.50	6.31	1.47	1,486.00
2007	11.20	8.30	6.30	19.70	4.10	1.80	9.60	1.65	6.69	1.37	1,373.90
2008	9.60	9.40	8.70	17.80	5.20	1.65	16.30	1.75	5.84	1.53	1,834.40
2009	10.50	10.19	9.86	23.13	5.73	2.20	17.55	2.00	6.26	1.43	1,357.90
2010	9.97	11.36	7.81	22.40	6.25	1.86	14.36	1.31	6.04	1.00	1,850.70

1.3. Review of National Measurement Against Acid Deposition

Based on monitoring result of wet deposition from 2005-2010, status and its negative impacts has not yet evidenced in Cambodia. However, Department of Environmental Pollution Control as agency responsible for environmental protection is in the process of revising environmental quality standards at the national level included air quality standards. In addition, it is recommended to expand the monitoring site to evaluate the state of acid deposition in Cambodia more accuracy. Cambodia need be supported to provide the monitoring station of acid deposition. Cambodia also need be assisted in fiancé to research on acid deposition.

State of Acid Deposition in China

2.1. Basic Information on National Monitoring Activities

2.1.1. Outline of the activities on acid deposition and national monitoring plan

China is one of participating countries of EANET and started monitoring activities since the commencement of Regular Phase Activities of EANET from 2001, with the common aim to understand the state and effects of acid deposition in East Asia.

Monitoring projects, including wet deposition, dry deposition, inland water, soil and vegetation, have being carried out in the 4 participating cities of EANET in China, namely Chongqing, Xiamen, Xi’an and Zhuhai cities. As the national center for EANET, China National Environmental Monitoring Center (CNEMC) organized the monitoring activities in China according to the technical manuals for EANET.

Xiamen city started to carry out dry deposition monitoring by using filter pack method since 2007.

2.1.2. Monitoring sites

Most monitoring sites kept unchanged since the beginning of EANET monitoring activities, but a few sites had to be stopped or moved because they were no longer suitable for the sitting criteria of EANET.

Chongqing: Guanyinqiao (urban site) from 2001 to 2007, and Haifu (urban site) from 2008 to 2009, Jinyunshan (rural site) from 2001 to 2009.

Guanyinqiao: located in Jiangbei district, Chongqing, on the top of main building of Chongqing Environmental Monitoring Center, 106° 31' 45" E, 29° 34' 32" N, the altitude is 262 m. This site is surrounded by residential area and shopping centers, there is a high building located in the northeast of the site, and the distance is about 150~200 meters. There is a main street about 150 meters away from the site. The sampling operation was stopped since 2008 due to the location change of the main building of Chongqing Environmental Monitoring Center.

Jinyunshan: located in Beibei district, Northwest of Chongqing, about 40 km from the urban area of Chongqing, 106° 22´ E and 29° 49´ N. Jinyunshan is one of the natural protection region of Chongqing. The Jinyunshan Mountain is the West border of the parallel mountains and valleys in the East part of Si Chuan Province, with NW-SE tending towards and about 16 km length. The altitude of the Mountain is about 700~900 meters, and the summit is 952 m. The physiognomy is typical low mountains. The climate in Jinyunshan is suitable for the growth of diversified plants, due to plenty of precipitation amounts and high humidity of air and soil. The dominant plants are the evergreen vegetations with stable structure and good conservation. As a natural protection region, there're no industrial factories, only a few farming houses, vacationer's village and microwave transmission station scatter in different places. In recent years, on the North side of the mountain, some cement factories appeared，on the South side of the mountain, some residential areas have been developed, which may affect the air quality around the mountain area.

Haifu: In 2007, the Chongqing Environmental Monitoring Center, where the Guanyinqiao site located, was moved to another new building, so the site had to stop running at the end of 2007. To ensure the continuity of the wet deposition in urban area in Chongqing, Chongqing Center selected a new wet deposition monitoring site, namely Haifu, which is 6 km away from former Guanyinqiao site. It is located at No.1 Qingsong road, Yubei district, Chongqing city, 106°30´E and 29°37´N, the altitude is 317 m. It is on the top of a 5-storey building. There are no major pollution sources around the site, there is a botanical park located to the North of the site, and the inner ring highway is about 1 km to the South of the site. Sampling activities was started since January 2008.

Xi'an: Shizhan (urban site) from 2001 to 2009, Jiwozi (remote sites) from 2001 to 2009, and Weishuiyuan (rural site) from 2001 to 2006.

Shizhan: located in the South of Xi'an, 108°57'E and 34°14'N, the altitude is 400 meters, there are residential areas, shopping centers and urban roads around the site.

Weishuiyuan: located in Weishuiyuan vacation resort, which is about 18 km away from Xi'an city, 108°52'E and 34°22'N, the altitude is 360 meters, surrounded by open farmland. Monitoring activities were stopped in Weishuiyuan site since 2007 because the circumstance around the site was changed, and couldn't be used as a rural site considering the siting criteria of EANET.

Jiwozi: located in the Southern mountain of Chang'an county of Xi'an, 108° 48´ E and 33° 50´ N, which is about 60 km away from the center of Xi'an. The altitude of the site is 1800 m. This area is dominated by temperate continental climate, average annual air temperature is 13.2℃, average annual rainfall is 687 mm and non-frost season is around 150 days. Vegetations are mainly shrubbery and arbors. Major man-made plants are Huashan pine, larch and Chinese pine.

Xiamen: 2 sites, named Hongwen (urban site) and Xiaoping (remote site) from 2001-2009.

Hongwen: located in the Xiamen Island, 118° 8' E and 24° 28' N. Yundingyan, which is the highest mountain of Xiamen Island, located to the South of Hongwen site. 90% area of Yundingyan is covered by forest. Hubian reservoir is the largest spare water source of Xiamen island, located to the North of Hongwen site. The altitude of Hongwen is 50 meters.

Xiaoping: located in the remote forest of Xiamen, 118° 2' E and 24° 51' N, far away from highway, railway, town and there are no large emission sources and intensive human activities around the site. The altitude is 686 meters.

Zhuhai: 2 sites, named Xiangzhou (urban site) and Zhuxiandong (urban site) from 2001 to 2009, Zhuxiandong site was suspended for one year (2006) due to the maintenance of Zhuxiandong reservoir.

Xiangzhou: located in the center of Zhuhai, on the top of the office building of Zhuhai Environmental Monitoring Center, 113° 34' E, 22° 16' N. It is located in local administration area and there are no industrial emissions nearby. The pollution sources mainly come from motor vehicles and life pollution sources. The site is adjacent to the Binhaibeilu road. The altitude is 40 meters.

Zhuxiandong: located in the Zhuxi**an**dong park, 113° 31' E, 22° 12' N, Nanping town, which is 15 km away from the downtown area. Lizhi Hill is located to the South of Zhuxiandong site, and Nanwan road is located to the north. The altitude is 45 meters.

Table 2.1.1. The information of monitoring sites of EANET China.

City name	Site class	Site name	Longitude (E)	Latitude (N)	Altitude (m)
Chongqing	Urban site	Guanyinqiao	106° 31′	29° 34′	262
	Rural site	Jinyunshan	106° 22′	29° 49′	800
	Urban site	Haifu	106° 30´	29° 37´	317
Xi’an	Urban site	Shizhan	108° 57′	34° 14′	400
	Rural site	Weishuiyuan	108° 51′	34° 22′	366
	Remote site	Jiwozi	108° 48′	33° 50′	1,800
Xiamen	Urban site	Hongwen	118° 08′	24° 28′	50
	Remote site	Xiaoping	118° 02′	24° 51′	686
Zhuhai	Urban site	Xiangzhou	113° 34′	22° 16′	40
		Zhuxiandong	113° 31′	22° 12′	45

Table 2.1.2. The monitoring programs of the monitoring sites.

City name	Site class	Site name	Wet deposition	Dry deposition	Soil and vegetation	Inland water
Chongqing	Urban site	Guanyinqiao	√			
	Rural site	Jinyunshan	√	√	√	√
	Urban site	Haifu	√			
Xi’an	Urban site	Shizhan	√			
	Rural site	Weishuiyuan	√	√		
	Remote site	Jiwozi	√		√	√
Xiamen	Urban site	Hongwen	√	√		
	Remote site	Xiaoping	√		√	√
Zhuhai	Urban site	Xiangzhou	√	√		
		Zhuxiandong	√		√	√

2.1.3 Monitoring program from 2001 to 2009

The annual national monitoring plan is developed by the national center, CNEMC every year. The 4 participating cities carry out the monitoring activities according to the EANET guideline, and send the data report to CNEMC according to the national plan.

2.1.3.1 Wet deposition monitoring

The wet deposition monitoring parameters are precipitation, pH, EC, SO_4^{2-}, NO_3^- , Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, and Mg^{2+}. Frequency of monitoring is 24 hours, start from 9:00 a.m. to 9:00 a.m. the next day.

2.1.3.2 Dry deposition monitoring

The dry deposition monitoring parameters are SO_2, NO_2, and PM_{10} in the ambient air. Frequency of monitoring is 1 hour.

Four stage filter pack method is used for dry deposition monitoring at Hongwen site in Xiamen city. Network Center provided filter pack monitoring instrument to Xiamen in September 2006. It was installed at the end of 2006. Samples are collected weekly; air flow rate is about 1 $l.min^{-1}$. The monitoring parameters are gases (SO_2, HCl, HNO_3 and NH_3), and particulate matter (NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^- and Cl^-).

2.1.3.3 Monitoring on inland aquatic environment

The monitoring parameters include: pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, alkalinity, monitoring every 3 months; water color, transparency, COD, NO_2^- and PO_4^{3-}, monitoring annually.

2.1.3.4 Monitoring on soil and vegetation

In 2001, Zhuhai Monitoring Center and Xi'an Monitoring Center carried out soil monitoring. All of the 4 participating cities carried out soil monitoring and vegetation survey every 3 years since 2003 according to the national monitoring plan.

Soil monitoring parameters: pH (H_2O), pH (KCl), exchangeable Na^+、K^+、Ca^{2+}、Mg^{2+}, ECEC (valid cation exchanging ability), exchangeable acidity, P,T-N, and T-C.

Vegetation survey parameters: description of trees, understory vegetation survey and observation of tree decline.

Frequency of tree decline observation was changed to every year since 2008 according to the revised EANET monitoring plan.

Table 2.1.3. Monitoring parameters and frequency of EANET China.

Content	Monitoring parameters	Frequency
Wet deposition	pH, EC, rainfall， SO_4^{2-}, NO_3^- ,Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, $Mg^{2+,}$	24h, 09:00-09:00
Dry deposition	SO_2, NO_2, PM_{10}	1h
Inland water	pH, EC, SO_4^{2-}, NO_3^- ,Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, alkalinity	Four times per year
	Water color、transparancy、COD、NO_2^-、PO_4^{3-}	Once per year
Soil	pH (H_2O), pH (KCl), exchangeable Na^+、K^+、Ca^{2+}、Mg^{2+}, ECEC(valid cation exchanging ability), exchangeable acidity, P, T-N, T-C	Once three years
Vegetation	description of trees, understory vegetation survey	Once three years
	observation of tree decline	Every year

2.1.4 Outline of sampling and measurements

2.1.4.1 Collection and handling of samples

All the wet deposition monitoring sites use automatic precipitation collector for sampling. Frequency of monitoring is 24 hours, start from 9:00 a.m. to 9:00 a.m. the next day.

Table 2.1.4. Sampling method, instrument information of the monitoring sites.

City name	Monitoring site	Sampling method	Instrument information	Note
Chongqing	Guanyinqiao	auto	PSC-1(Puren Qingdao)	Monitoring stopped from 2008
	Jinyunshan	auto	PSC-1 (Puren Qingdao)	
	Haifu	auto	US-320H (Ogasawara)	
Xi’an	Shizhan	auto	XHARS30A(Hebei Sailhero)	
	Weishuiyuan	auto	XHARS30B (Hebei Sailhero)	Monitoring stopped from 2008
	Jiwozi	auto	XHARS30A(Hebei Sailhero)	
Xiamen	Hongwen	auto	ZJC-Ⅱ(Hengda, Hangzhou)	
	Xiaoping	auto	ZJC-Ⅱ(Hengda, Hangzhou)	
Zhuhai	Xiangzhou	auto	US-320H (Ogasawara)	
	Zhuxiandong	auto	ZJC-III (Hengda, Hangzhou)	

Precipitation amount should be measured and recorded at the sampling site. After the EC and pH have been measured, the rest samples should be stored in polyethylene bottles and refrigerated at 4℃ before shipment to the laboratory.

2.1.4.2 Samples analysis

Sample solutions received at a laboratory must be well documented at the sampling sites. And the staff in laboratory should filter the samples with 0.45 μm filterable membrane for ion measurements. The ions should be measured within one week.

Table 2.1.5. Measurement method, instrument information of the laboratory.

City name	Monitoring parameters	Measurement method	Instrument information
Chongqing	pH	Glass electrode method	METTLER TOLEDO 320
	EC	electrode method	TOA-DKK
	F^- Cl^- NO_3^- SO_4^{2-}	IC	DX-120
	Na^+ NH_4^+ K^+ Mg^{2+} Ca^{2+}	IC	DX-500
Xi’an	pH	Glass electrode method	Leici PHS-3C
	EC	electrode method	Rex Electric
	NH_4^+、Na^+、K^+ Mg^{2+}、Ca^{2+}、Cl^- NO_3^-、SO_4^{2-}	IC	DIONEX 120
Xiamen	pH	Glass electrode method	Mettler Toledo
	EC	electrode method	Mettler Toledo
	Cl^- NO_3^- SO_4^{2-}	IC	DX-320
	Na^+ NH_4^+ K^+ Mg^{2+} Ca^{2+}	IC	DX-320
Zhuhai	pH	Glass electrode method	ORION 420A
	EC	electrode method	Rex Electric
	NH_4^+、Na^+、K^+ Mg^{2+}、Ca^{2+}、Cl^- NO_3^-、SO_4^{2-}	IC	DX-ICS-1000

2.1.4.3 QA/QC of wet deposition monitoring

QA/QC programs are carried out at all stages of the monitoring activities according to the Technical Manual for Wet Deposition Monitoring in East Asia and QA/QC Program for Wet Deposition Monitoring in the 4 participating cities in China. The laboratories in the 4 participating cities were involved in the Network Center’s inter-laboratory comparison projects (on wet deposition, dry deposition, soil and inland aquatic environment monitoring).

The R1 and R2 improved gradually form 2001 to 2009, as shown in Figure 2.1.1

The pH meter should be calibrated before and after each set of precipitation samples at a minimum of two points in the excepted pH range, as most precipitation samples have a pH value in the range of 3.0 ~ 7.5, pH 4.0 and 7.0 buffer solutions are therefore used. The buffer solutions should be refrigerated at 4℃ and replaced periodically (usually every 2-3 months).

Calibration for conductivity measurement is multipoint. With each set of precipitation samples, a set of 0.0001M-, 0.0005M-, and 0.001M- KC1 solutions should be prepared from 0.01 M- KC1 stock solution by dilution with deionized water. The conductivity of the deionized water should also be measured. The samples and the standard solutions are recommended to be measured at 25°C in a water bath if available. If the temperature of the sample is not 25°C, correct the measured value to 25°C. The solution should be replaced periodically (quarterly).

During the measurements of the ion constitution by IC method, calibration curve should be constructed from at least 5 working standard solutions. 5 percent of samples should be random selected for parallel analysis in the laboratory.

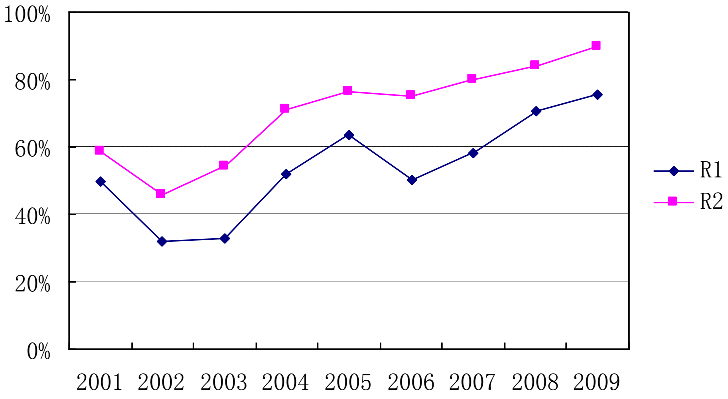

Figure 2.1.1. Comparison of R1 and R2, EANET China.

2.2. State of Acid Deposition in China

2.2.1 Atmospheric deposition

2.2.1.1 State of wet deposition

The monitoring results of pH, EC and ion concentrations of 10 wet deposition monitoring sites were shown from Figures 2.2.1-2.2.13.

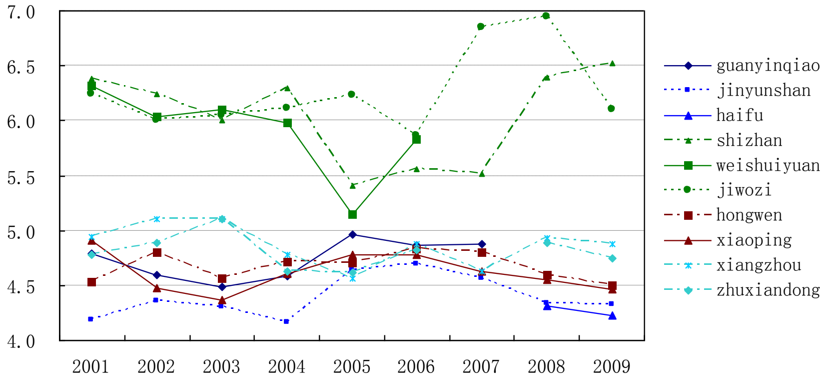

Figure 2.2.1. Trends of annual average of pH of the monitoring sites, EANET China.

From 2001 to 2009, the pH annual average of the 10 wet deposition monitoring sites is between 4.16 (Jinyunshan 2004) ~6.94 (Jiwozi 2008). The pH of the sites in Xi'an is highest, and Jinyunshan in Chongqing is lowest. Trends of pH in Shizhan site in Xi'an, Xiangzhou and Zhuxiandong sites in Zhuhai showed downward trend from 2001 to 2005, and showed upward trend from 2005 to 2009. Guanyinqiao, Hongwen, Xiaoping, Jinyunshan sites showed downward trend from 2005 to 2009.

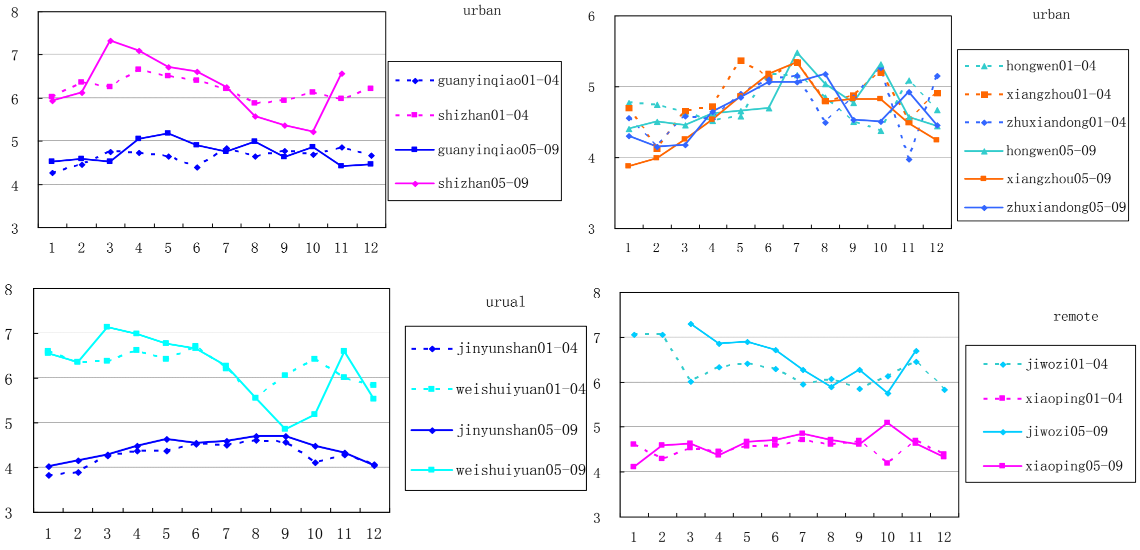

Figure 2.2.2. Trends of monthly averages of pH on wet deposition for two periods of the monitoring sites, EANET China.

The monitoring results of wet deposition at the sites from 2001 were divided into 2 periods (2001-2004, 2005-2009). The monthly averages of pH of each period were calculated, the results were shown in Figure 2.2.3. There were no obvious trends of the monthly pH of the two periods in all these sites. The monthly averages of pH were higher in the spring and lower in the autumn in Shizhan (urban sites), Weishuiyuan (rural site) in Xi'an. The monthly averages of pH were higher in the winter and lower in the autumn in Jiwozi (remote site). The monthly averages of pH were higher in the summer in the coastal urban sites in Xiamen and Zhuhai.

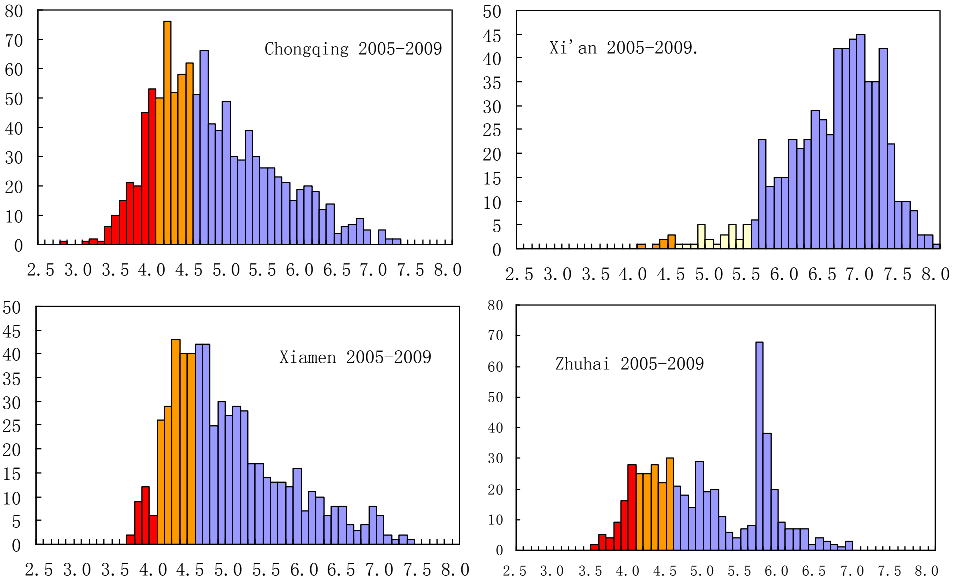

Figure 2.2.3. pH distribution of daily precipitation of each participating city in China from 2005 to 2009.

The Figure 2.2.4 showed the pH distribution of daily precipitation of the 4 participating cities of China from 2005 to 2009. Precipitation pH values were ranged from 2.84 to 8.21, with the arithmetic average of 5.27. At Chongqing city, the percentage of precipitation with observed pH values lower than 4.5 was 40.0%, at Xi'an city percentage was 0.8%, at Xiamen city percentage was 30.0% and at Zhuhai city percentage was 34.5%. Precipitation with pH 2.84, which less than 3.0 may cause acute damage to plants, was observed once at Haifu Site in Chongqing city in September 2008.

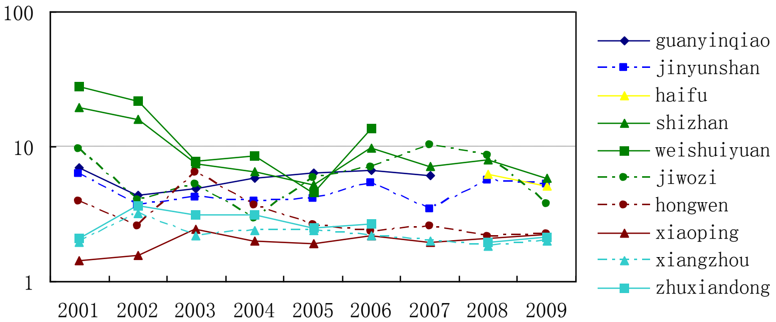

Figure 2.2.4. Trends of annual average of EC of the monitoring sites, EANET China.

From 2001 to 2009, the annual average of EC of the 10 wet deposition monitoring sites was between 1.42 (Xiaoping, 2001) ~27.68 (Weishuiyuan, 2001) mS.m^{-1}. The annual average of EC of Weishuiyuan and Shizhan in Xi'an decreased sharply in 2002 and 2003, that's mainly for that the sampling method changing from manually to automatic. The annual average of EC of Xiangzhou and Zhuxiandong decreased from 2002 to 2009 year by year. The annual average of EC of Hongwen decreased from 2003 to 2009 year by year. There was no obvious trend in other sites.

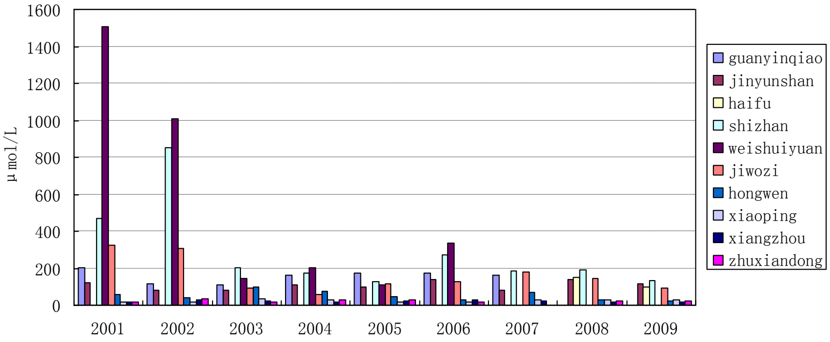

Figure 2.2.5. Trends of annual average of SO_4^{2-} concentration of the monitoring sites, EANET China.

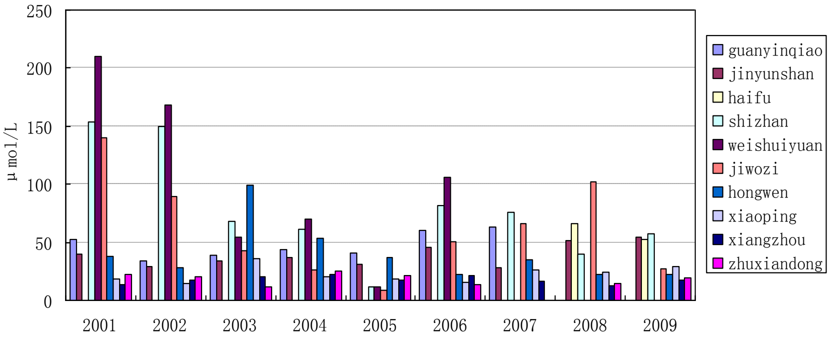

Figure 2.2.6. Trends of annual average of NO_3^- concentration of the monitoring sites, EANET.

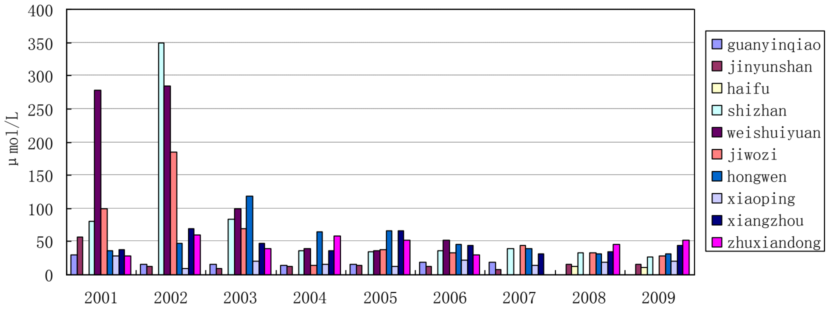

Figure 2.2.7. Trends of annual average of Cl^-concentration of the monitoring sites, EANET China.

From 2001 to 2009, there was no obvious trend of the ion concentration in the monitoring sites. The ion concentration of the sites in Xi’an decreased obviously from 2001 to 2003, that’s mainly for that the sampling method changing from manually to automatic.

The SO_4^{2-} concentration of inland cities Xi’an and Chongqing was higher than coastal cities Xiamen and Zhuhai. The SO_4^{2-} concentration of urban sites Shizhan and Weishuiyuan in Xi’an was obvious higher than the remote site Jiwozi. There was the same situation in Chongqing and Xiamen.

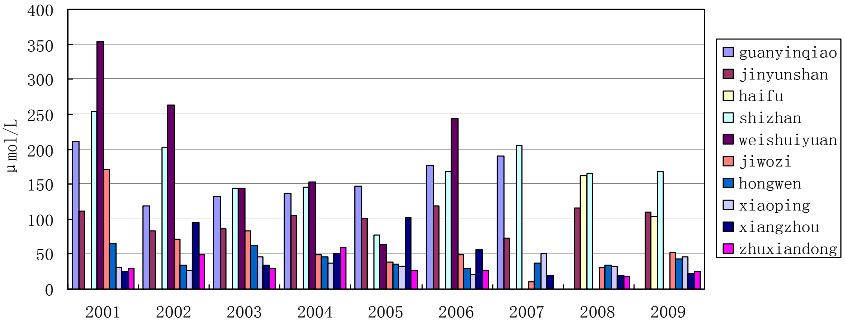

Figure 2.2.8. Trends of annual average of NH_4^+ concentration of the monitoring sites, EANET China.

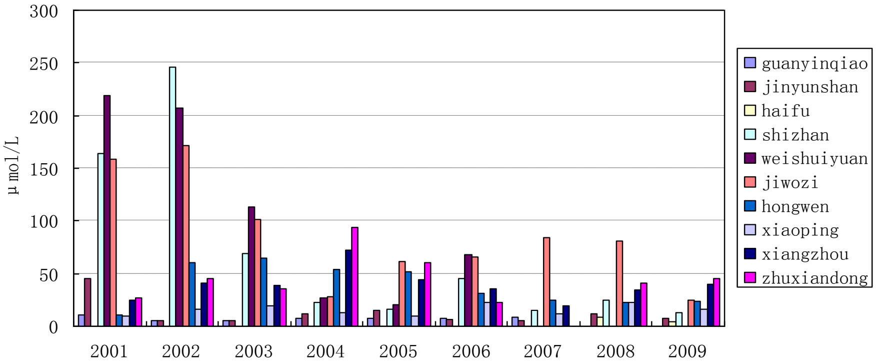

Figure 2.2.9. Trends of annual average of Na^+ concentration of the monitoring sites, EANET China.

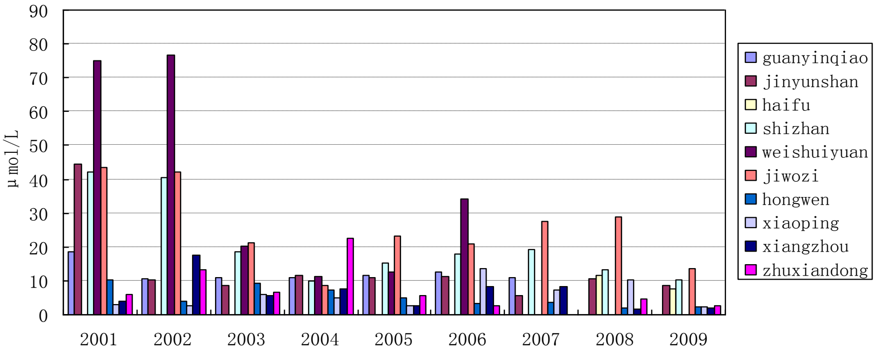

Figure 2. 2.10. Trends of annual average K^+ of concentration of the monitoring sites, EANET China.

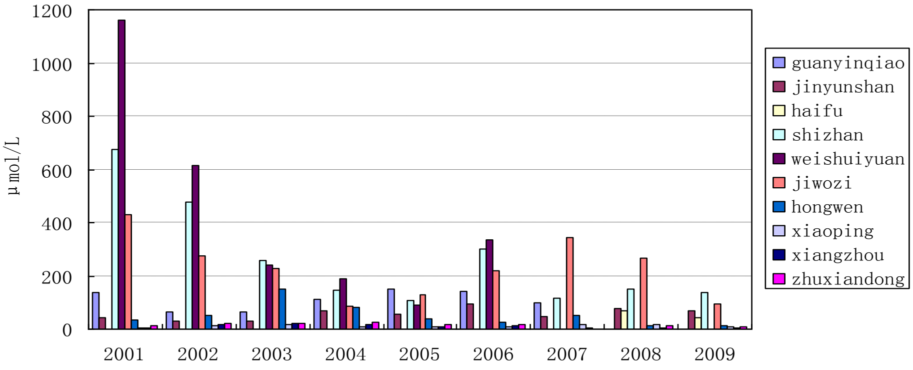

Figure 2.2.11. Trends of annual average of Ca^{2+} concentration of the monitoring sites, EANET China.

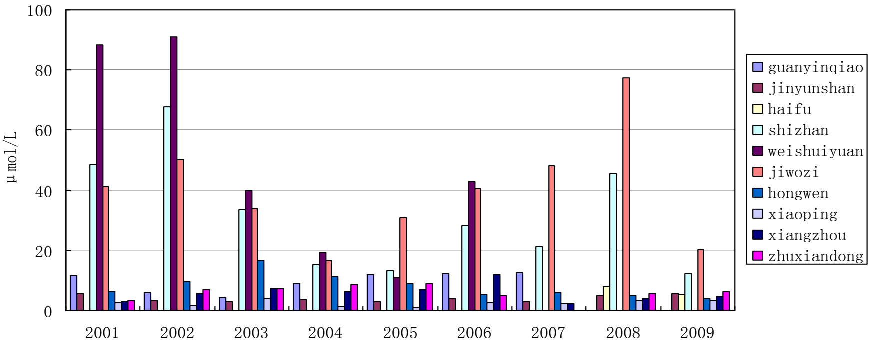

Figure 2.2.12. Trends of annual average of Mg^{2+} concentration of the monitoring sites, EANET China.

2.2.1.2 State of dry deposition

Jinyunshan site in Chongqing, Xiaoping site in Xiamen, Xiangzhou site in Zhuhai carried out dry deposition monitoring from 2001 to 2009. Weishuiyuan site in Xi'an carried out dry deposition monitoring from 2001 to 2006. The monitoring parameters are SO_2, NO_2 and PM_{10}. All of the parameters were measured by automatic systems. The trends of annual average concentration of the monitoring sites are presented in Figures 2.2.13-2.2.16.

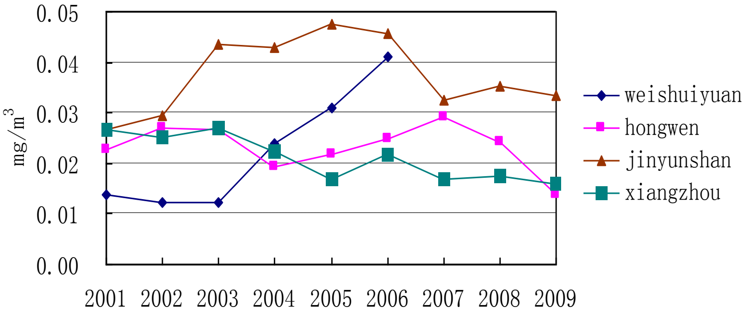

Figure 2.2.13. Trends of annual average of SO_2 concentration of the monitoring sites.

The annual concentration of SO_2 in Jinyunshan site was higher than other sites, from 2001~2005, it showed upward trend, and after 2005, it showed downward trend. The annual concentration of SO_2 in Xiangzhou site decreased since 2006. Since 2007, the annual concentration of SO_2 in Hongwen site decreased obviously.

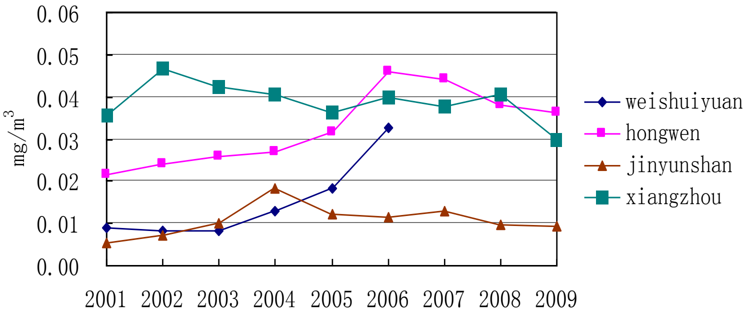

Figure 2.2.14. Trends of annual average of NO_2 concentration of the monitoring sites.

From 2001~2009, the annual concentration of NO_2 in urban sites (Xiangzhou and Hongwen), was higher than the rural sites (Jinyunshan and Weishuiyuan). The annual concentration of NO_2 increased in Hongwen and Weishuiyuan from 2001 to 2006, and decreased year by year after 2006. The annual concentration of NO_2 of Jinyunshan increased from 2001 to 2004, and decreased from 2004 to 2009. The annual concentration of NO_2 of Xiangzhou showed downward trend on the whole from 2002 to 2009.

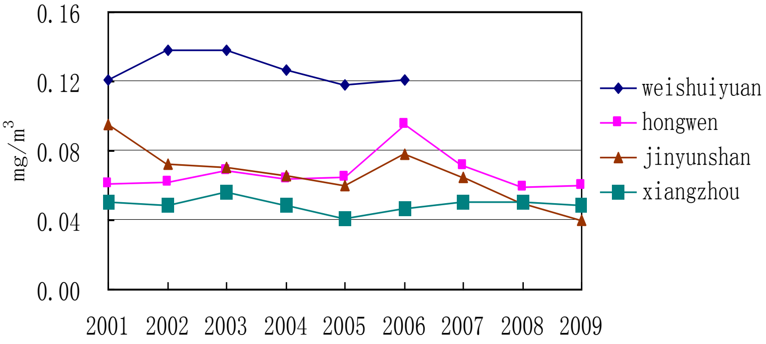

Figure 2. 2.15. Trends of annual average of PM_{10} concentration of the monitoring sites.

From 2001~2009, the annual concentration of PM_{10} in Weishuiyuan was higher than the other sites. The annual concentration of PM_{10} had downward trend in Weishuiyuan and Jinyunshan sites on the whole. There were no obvious trends in Hongwen and Xiangzhou sites.

As shown in Figure 2.2.16, the monthly averaged concentrations of PM_{10} were higher than SO_2 and NO_2. The SO_2, NO_2 and PM_{10} concentrations were ranged from 0.003~0.112 $mg.m^{-3}$, 0.002~0.092 $mg.m^{-3}$, 0.024~0.236 $mg.m^{-3}$ respectively. There were the same monthly trends of the three parameters, the higher concentrations were observed mainly in the winter and lower in the summer. The monthly averaged concentrations of PM_{10} at Jinyunshan Site showed downward trend from 2001 to 2009.

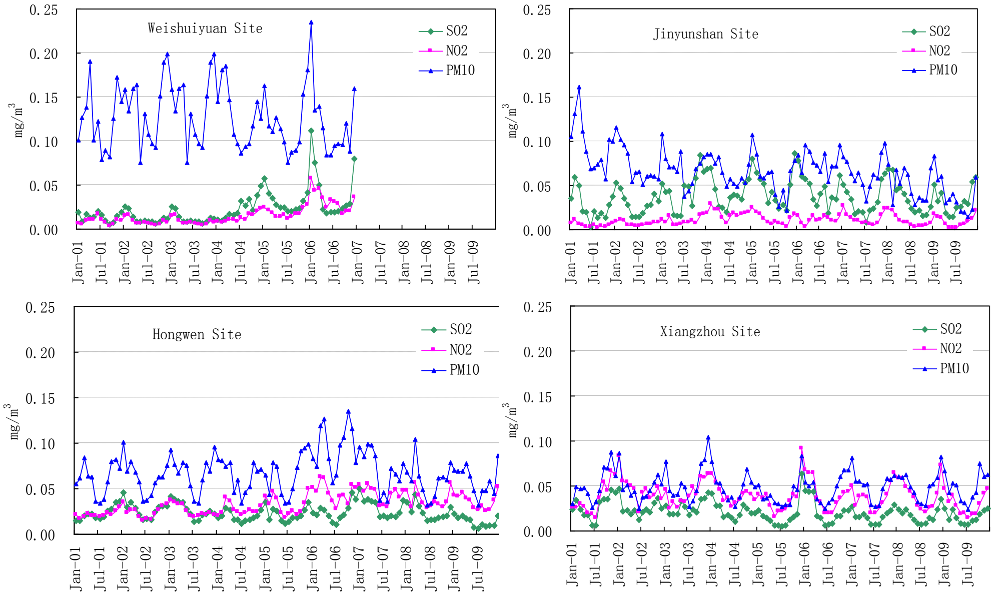

Figure 2.2.16. Monthly averaged concentration of SO_2, NO_2, PM_{10} at participating sites of China.

2.2.2 State of inland aquatic environment

From 2001~2009, the 4 network cities carried out monitoring on inland aquatic environment at Jiwozi, Jinyunshan, Zhuxiandong and Xiaoping sites respectively. Parameters with two kinds of sampling frequency had been measured at the 4 sites. Measured once a season: pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}. Measured annually: water color, transparency, COD, NO_2^- and PO_4^{3-}.

From 2001~2009, the annual averages of pH at the inland aquatic environment monitoring sites were between 5.42 ~ 7.93. As shown in Figure 2.2.17, the annual averages of pH at Jinyunshan site were lower than other sites, and showed downward trend from 2001 to 2008, then increased a little in 2009.

From 2001~2009, the annual averages of EC at inland aquatic environment monitoring sites were ranged from 4.50 to 12.35 $mS.m^{-1}$. As shown in Figure 2.2.18, the annual averages of EC in Jinyunshan site were higher than other sites. Annual averages of EC showed upward trend in Jinyunshan site from 2001 to 2007, then showed downward trend after 2007.

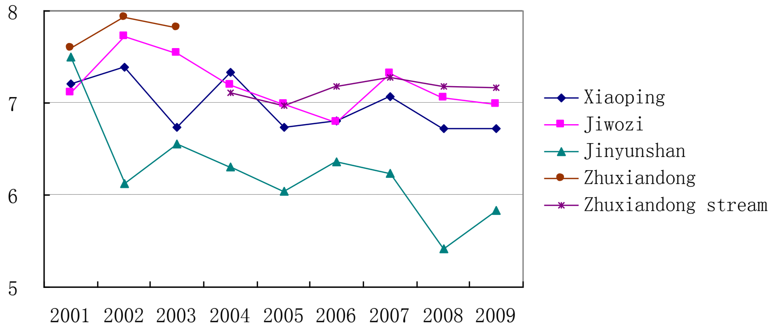

Figure 2.2.17. Trends of annual average of pH at the inland aquatic environment monitoring sites.

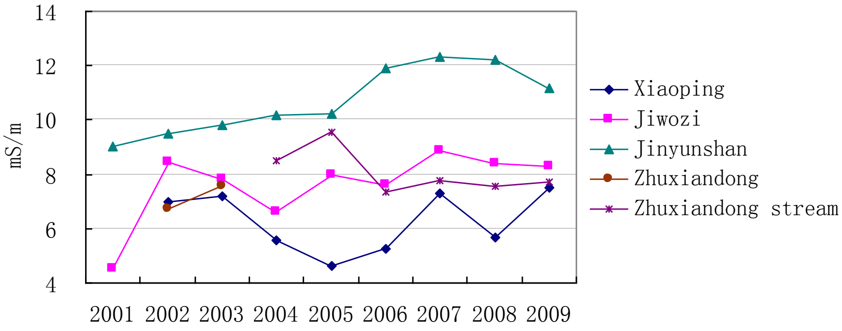

Figure 2.2.18. Trends of annual average of EC at the inland aquatic environment monitoring sites.

The annual average concentrations of SO_4^{2-} at the inland aquatic environment monitoring sites were ranged from 1.43 to 37.19 mg.l^{-1}. As shown in Figure 2.2.19, the annual average concentrations of SO_4^{2-} showed upward trend at Jinyunshan site from 2003 to 2007, then showed downward trend after 2007. The concentrations at Jiwozi site showed upward trend since 2001, on the whole. The concentrations at Xiaoping site remained stable since 2001.

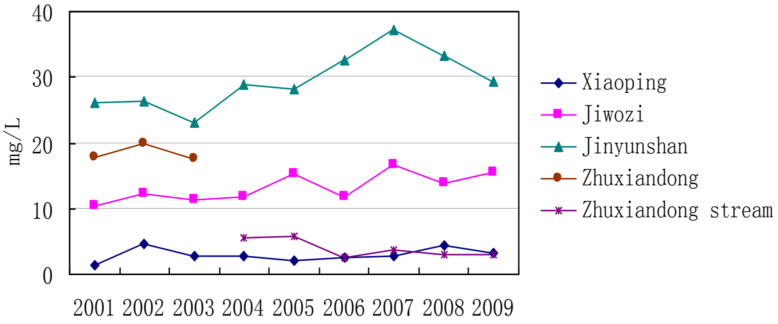

Figure 2.2.19. Trends of annual average of SO_4^{2-} concentration at the inland aquatic environment monitoring sites.

The annual average concentrations of NO_3^- at the inland aquatic environment monitoring sites were ranged from 0.29 to 12.78. As shown in Figure 2.2.20, annual average concentrations of NO_3^- showed upward trend at Jinyunshan site from 2001 to 2008, on the whole, and decreased in 2009. Higher values of NO_3^- were observed from 2002 to 2004 at Xiaoping site, and then remained almost unchanged from 2005 to 2009.

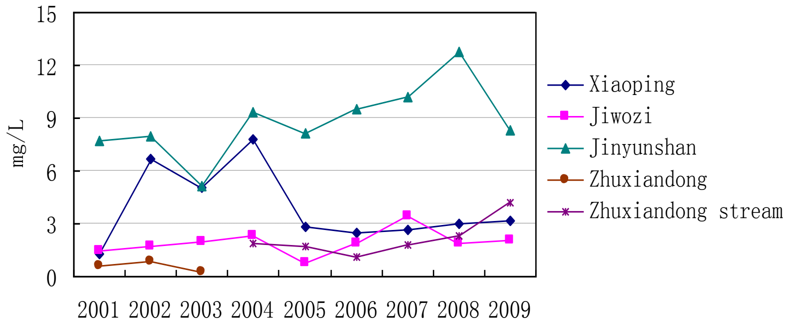

Figure 2.2.20. Trends of annual average of NO_3^- concentration at the inland aquatic environment monitoring sites.

2.2.3 Overall analysis

2.2.3.1 Wet deposition

From 2005 to 2009, the annual averages of pH at Shizhan, Xiangzhou and Zhuxiandong sites showed upward trends. At Hongwen, Xiaoping and Jinyunshan sites, the annual averages of pH showed downward trends. The percentages of precipitation with observed pH values lower than 4.5 were ranged from 0.8% to 40.0%.

2.2.3.2 Dry deposition

From 2006 to 2009, annual concentrations of SO_2, NO_2 and PM_{10} showed decreased trend at Hongwen, Jinyunshan and Xiangzhou sites on the whole.

2.2.3.3 Inland aquatic environment

From 2001 to 2009, annual averages of pH showed decreased trend at 4 cities. Annual averages of EC and annual concentrations of SO_4^{2-}, NO_3^- showed upward trends at Jinyunshan site.

2.2.3.4 Conclusions

EANET started monitoring activities on a regular basis since 2001, all the participating sites in China carried out QA/QC program according to Technical Manual of EANET. Annual averages of R1 and R2 showed upward trend year by year.

From 2005 to 2009, annual averages of pH at Shizhan, Xiangzhou and Zhuxiandong sites showed upward trend. Annual averages of pH at Hongwen, Xiaoping and Jinyunshan sites showed downward trend. Annual averages of pH were higher in the spring and lower in the autumn at inland sites, the results may be caused by coal-fired heating in winter.

During the Tenth and the Eleventh Five-year plan period, the investment for environmental protection in China increased significantly, series of policies were strengthened. Environment quality was improved. From 2006 to 2009, decreasing trends of SO_2, NO_2 and PM_{10} concentrations were observed at almost all of EANET dry deposition sites in China.

2.3. Review of National Measures Against Acid Deposition

2.3.1 Intensified industrial restructuring

In 2009, China formulated and implemented a plan for restructuring and invigorating ten key industries, encouraged enterprises to accelerate technological upgrading, and provided 20 billion yuan to support 4,441 technological upgrading projects. Further progress was made in mergers and reorganization in key industries. Great efforts had been made to restrict excess production capacity and redundant development in some industries, to close down 26.17 million kilowatts of small thermal power stations, and to eliminate backward facilities with total production tons in the steelmaking industry, 21.13 million tons in the iron-smelting, 74.16 million tons in the cement industry and 18.09 million tons in the coke industry.

2.3.2 Progress in conserving energy, reducing emissions and protecting the environment

China supported 2,983 key energy conservation and recycling projects through budgetary investment, implemented a project to promote energy-efficient products, putting into use more than 5 million energy-saving air-conditioners and 150 million energy-efficient light bulbs. China continued to develop key ecological projects in the forestry industry, and completed the afforestation of 5.88 million hectares, thereby raising the percentage of land covered by forest to 20.36%. Over the first four years of the Eleventh Five-Year Plan period, energy consumption per unit of GDP fell 14.38%，and chemical oxygen demand and sulfur dioxide emissions decreased 9.66% and 13.14% respectively.

SO_2 emission reduction in China had obtained substantial progress. China had promoted pollution reduction through industrial restructuring, implementation of relevant projects, improvement of management and released a series of industrial, fiscal, taxation and pricing policies. The ambient air quality had been improved continuously. In 2009, the annual average concentration of SO_2 for all urban sites was 0.035 mg.m^{-3}, a decrease of 17% lower than 2005. The annual average concentration of SO_2 of key environmental protection cities was 0.046 mg.m^{-3}, a decrease of 24.6% lower than 2005. The ratio of the cities which ambient air quality satisfied the Level II of National Ambient Air Quality Standard was 79.6%, and increased significantly higher than 2005.

During the Eleventh Five-Year Plan period, China had adopted a series of policy measures to further expand investment in environmental pollution control. In 2009, the national environmental pollution control investment was 452.5 billion yuan, an increase of 89.5% higher than 2005, which account for 1.33% of GDP of 2009.

China has made great efforts to improve acid deposition monitoring during the Eleventh Five-year period. China had equipped participating cities with automatic sampler, pH meter, conductivity instrument and ion chromatography in order to improved national acid rain monitoring network. 385 remote monitoring sites were established to monitor regional acid deposition, and 80 urban monitoring sites were established to monitor acid deposition in urban areas. 14 national background value monitoring stations had been built.

Table 2.3.1. Qualified rate of industrial gases emissions.

Indicators	Unit	2005	2006	2007	2008	2009
Industrial SO_2	%	79.4	81.9	86.3	88.8	91.0
Industrial smoke	%	82.9	87.0	88.2	89.6	90.3
Industrial dust	%	75.1	82.9	88.1	89.3	89.9

2.3.3 Strategy of the 12th five-year plan (2011-2015)

China will continue to keep a resource-conserving, environment-friendly society as accelerating transformation of the mode of economic development of the important points. Thorough implementation of resource conservation and environmental protection, energy saving, basic state policies reduce greenhouse gas emissions intensity, to promote social and economic growth with the population, resources and environment and the way of sustainable development.

Efforts will be made to promote energy production and utilization. Accelerate development of new energy and promote the traditional energy utilization, clean in ecological protection under the premise of positive development in the safety of hydropower.

During the 12th five-year plan period, Environmental protection will be intensified. Pollution which may damage human health such as air pollution, drinking water and soil pollution will be further

treated, management will be strengthened, and the environmental quality will be improved obviously. The pollutant emission reduction targets will be set, and the main pollutant total emission amount control will be implemented continuously.
During the 12th five-year plan (2011-2015), total SO_2 emission amount should be reduced by 8%, total nitrogen oxide emission amount should be reduced by 10%.

More policies will be implemented to improve ambient air quality, to promote the emission amount control of sulfur dioxide and nitrogen oxides of power plant, steel, nonferrous metals, chemical industry and building materials industries. Enhance the stable operation of desulfuration and denitration facilities. Management of particulate matter pollution and exhaust gases of motor vehicles will be strengthened. The ratio of the prefecture-level cities which ambient air quality satisfy the Level II of National Ambient Air Quality Standard should be reach to 80% at the end of 2015.

At the same time, MEP will strengthen the management of regional air quality during the Twelfth Five-year plan period, several regional air quality monitoring networks, such as Beijing-Tianjin-Hebei regional monitoring network, Yangzi river delta regional network, Zhujiang river delta regional network, will be established to provide useful inputs and information for the regional air quality management.

2.4 References

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National Assessment on Acid Deposition Indonesia

3.1. Basic Information on National Monitoring Activities

3.1.1. Outline of the activities on acid deposition and national monitoring plan

The monitoring of acid deposition in Indonesia is carried out by observing wet deposition, dry deposition, and attempted in assessing the impacts by observing soil, vegetation and inland aquatic water. These tasks are conducted by various related national institutions where Pusarpedal of the Ministry of Environment as the National Coordination Center. The participating institutions are Climatology Meteorological and Geophysical Agency (BMKG), National Institute of Aeronautics and Space (LAPAN) for wet and dry deposition monitoring. Research Center for Water Resources (RCWR) for inland aquatic, Soil Research Institute of the Ministry of Agriculture and Forest (SRI) for soil monitoring and Nature Conservation Research and Development Center for vegetation monitoring.

3.1.2. Monitoring program of acid deposition from 2005-2009

The progress on acid deposition monitoring program during year 2005–2009 is to continue the existing monitoring and to increase the site number of monitoring stations on wet deposition, dry deposition and inland aquatic. The monitoring sites located in the western part of Indonesia and not represent the national vast territory. Therefore in 2007, wet deposition monitoring was established at Maros, South Sulawesi in eastern Indonesia.

Ideally wet deposition station monitoring conducted in paralel with dry deposition. This condition has been applied in Serpong Stations. Therefore in the beginning of 2007, Jakarta and Kototabang stations have started to monitor dry deposition by means of passive sampler method for SO_2 and NO_2 as well as Bandung and Serpong in year 2008. The inland aquatic monitoring expanded when a new site conducted at Situ Gunung Sukabumi in year 2007.

To improve the laboratory competency, Pusarpedal conducted training for analysts in the field of sampling and analysis of wet and dry deposition, inland aquatic, soil and vegetation monitoring.

3.1.3. Monitoring stations

Table 3.1.1. Monitoring stations in Indonesia.

Station name	Laboratory/ Institution	Type of monitoring	Classification of site	Latitude/ Longitude	Altitude (m)	Height of sampling point (m)
Serpong	Pusarpedal - KLH	WD, DD	Rural	06°15‘ S, 106° 34‘E	46 m	3 m
Bandung	LAPAN	WD, DD	Urban	06° 54‘ S, 107° 35‘ E	743 m	13 m
Jakarta	BMKG	WD, DD	Urban	06° 11‘ S, 106° 50‘E	7 m	2.5 m
Kototabang	BMKG	WD, DD	Remote	00° 02‘ S, 100° 19‘E	864 m	12 m
Maros	BMKG	WD	Rural	04° 55‘ S, 119° 34‘E	11 m	1,2 m
Situ Patengang	BLK–Kem.PU	IA	Rural	06° 32’ S, 107° 35‘ E	1600-1700 m	-
Situ Gunung	BLK-Kem.PU	IA	Rural	06° 49‘ S, 106° 55‘ E	1600 m	-
Dramaga Research Forest	Kem. Hut	SV	Rural	06° 33‘ S, 106° 44‘ E	244 m	-

3.1.4. Sampling and measurement

a. Wet deposition monitoring

The sampling frequency of wet depositon was carried out in every precipitation event (Serpong station), daily (Bandung station), weekly (Jakarta, Kototabang and Maros stations). Parameters of pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+} were analyzed by glass electrode cell, conductivity cell, and ion chromatography methods.

b. Dry deposition monitoring

Sampling of SO_2, HNO_3, HCI, NH_3, SO_4^{2-}, Cl^-, NO_3^-, Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+ in gas and aerosol by filter pack method were conducted biweekly in Serpong. These parameters were analyzed by ion chromathography.

Monitoring of SO_2 and NO_2 by passive sampler were carried out biweekly in Serpong, Bandung, Jakarta and Kototabang stations. SO_2 was analyzed by ion chromatography and NO_2 by spectrophotometry method.

Meteorological parameters such as wind direction, wind speed, air temperature, humidity, and precipitation amount are measured as well using meteorological automatic instrument in Serpong and Jakarta stations.

c. Monitoring of inland aquatic

Quarterly monitoring was conducted for inland aquatic. Measurements were done on twelve parameters as follows: temperature, pH, EC, alkalinity (at pH 4.8 baseline), SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+}. And also for mandatory parameters such as transparency, water color, COD, NO_2^-, and PO_4^{3-} were analyzed by glass electrode cell, conductivity cell, titration, ion chromatography, spectrophotometry, seichi disk, and AAS methods.

d. Monitoring of soil and vegetation

The acid deposition observation for soil and vegetation has been made in Dramaga Forest Research. Soil samples were collected and analyzed for moisture content, pH (H_2O and KCI), and exchangeable cation. Exchangeable acidity and ECEC were calculated. This monitoring frequency is about every three until five years. Indonesia has three times monitoring of soil in year 2002, 2007, and 2009. Meanwhile, the first understory vegetation survey and the observation of tree decline were conducted in year 2008.

3.2. State of Acid Deposition

3.2.1. State of wet deposition

Wet deposition monitoring data in four locations in Indonesia in year 2005-2009 are analyzed to indicate rainwater chemistry characteristics. Rainwater cemistry compositions are mapped to assess precipitation location characteristic. Acid and base concentrations are analyzed to indicate their roles in determining rainwater acidity. Rain impact to ion concentrations are assessed by relation between rain numbers and major acid and base concentrations. Ratio between concentration of sulphates to nitrates in rainwater contents is analyzed to study gas emission characteristics. Monthly and annual averages values are analyzed to study acid deposition trend.

3.2.1.1. Distribution of precipitation pH

The averaged weighted pH of precipitation for the period from year 2005 to 2009 is show in Figure 3.2.1. Rainwater with low pH indicates that precipitation were acidic i.e. rainwater contains high H^+ ion concentration. Average pH values in Indonesia are between 4.5 - 5.6. In Jakarta average pH value was 4.6 ± 0.3. Because there is only little different between rainwater pH in Jakarta and

Serpong therefore, we also need to consider acid deposition contents dissolved in rainwater and months of precipitation. It is because of Jakarta is an urban area with relatively higher density of transportation compared with Serpong which is considered as a rural area. Rainwater pH values were less than 5.0 in Jakarta shows influence of other acids such as Cl^- except sulfuric and nitric acids that is originated from seasalts that reduce pH.

Bandung as an urban area has monthly average rainwater pH 5.6 ± 0.8. In the other hand, Kototabang as a remote area has average pH 5.0 ± 0.4. pH values in Bandung are higher compared with three other locations as a result of higher degree of neutralization as a present of high concentration of ammonium base compounds. Kototabang with pH values were less than 5.0 indicates lower base neutralization influence compared with acid compounds. As forest fires in North Sumatra and Riau that often occur during dry seasons and contribute CH_3Cl, aerosol nitrates to the atmosphere.

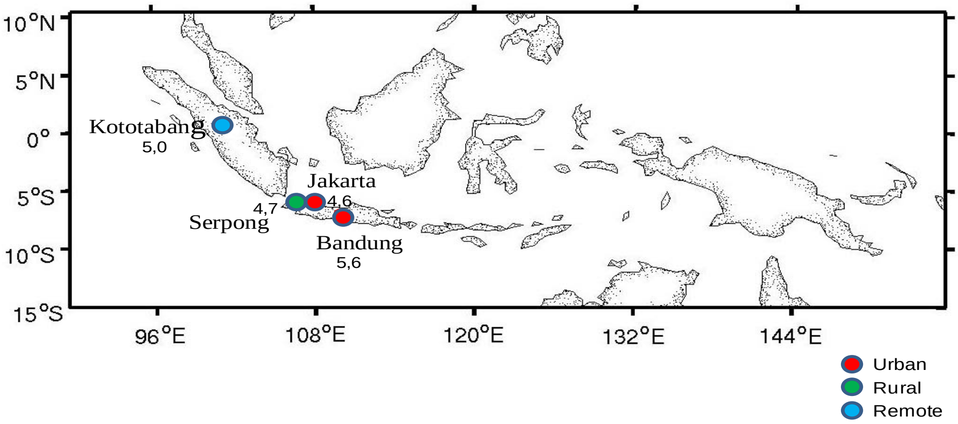


Figure 3.2.1. Distribution of pH level, 2005-2009.

Based on monthly average pH from year 2005-2009 precipitation events with pH less than 5.6 shows that Bandung has lowest rank compared with the other three locations. In the other hand Jakarta as an urban area shows highest precipitation events with rainwater pH less than 5.6. Therefore during year 2005-2009 those 4 cities have experienced acid rains as shown by event frequency.

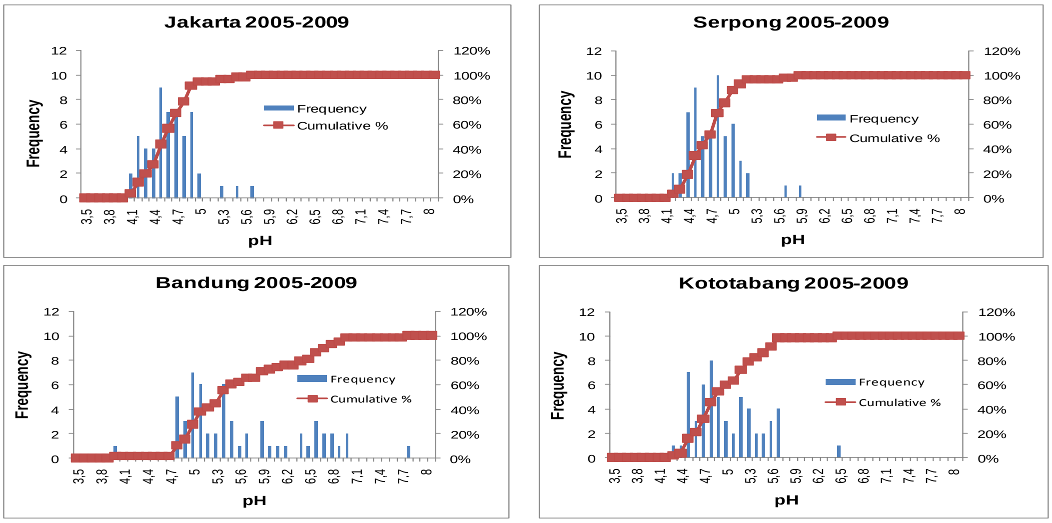


Figure 3.2.2. Rainwater pH distribution in Jakarta, Serpong, Bandung and Kototabang from year 2005-2009.

3.2.1.2. Chemical composition of rainwater

Rainwater is composed of dissolved anions and cations as a result of union between gases and aerosol in ambient air. Anions and cations are SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg_2^+, and H^+. Non sea-salts (nss) SO_4^{2-} and Ca^{2+} are also measured theoretically. Based on rainwater chemistry composition we can study characteristics of rainwater locations as shown in Figure 3.2.3.

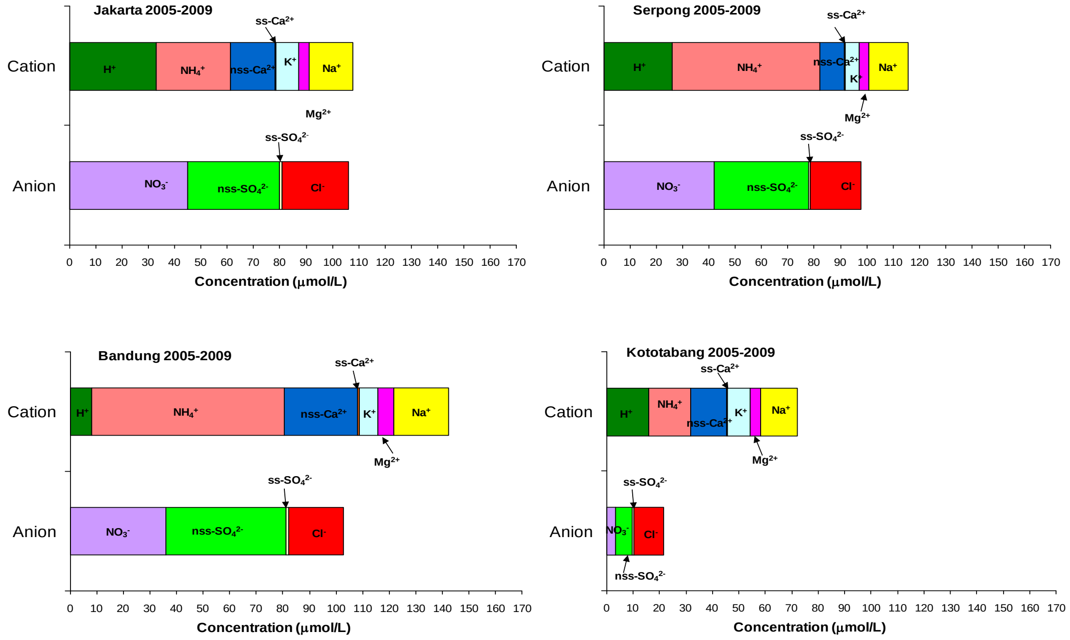


Figure 3.2.3. Anions and cations concentrations contents of rainwater at the EANET Indonesia's monitoring site in Jakarta, Serpong, Bandung and Kototabang from 2005 to 2009.

Figure 3.2.3 shows the characteristics of chemical rainwater in Jakarta, Serpong, Bandung and Kototabang from monthly averaged from year 2005-2009. The characteristics in Jakarta indicated major anions such as nitrates (NO_3^-) and nss-sulphates (nss-SO_4^{2-}). Sea-originated ions such as Cl^- and Na^+ are high, as an indications of coastal area. Different cases were found in Bandung, Serpong and Kototabang which is dominated by ammonium (NH_4^+). Bandung as an urban area and Serpong as a rural area has many vegetations that release ammonia (NH_3). In dry season $(NH_4)_2SO_4$ and NH_4NO_3 in soil dust will increase the concentration of NH_4^+ in rainwater. Major anions such as nitrates (NO_3^-) and nss-sulphates (nss-SO_4^{2-}) originated from fossil fuel combustion were relatively higher and dominant in Serpong.

Bandung has also high major anions such as nitrates (NO_3^-) and nss-sulphates (nss-SO_4^{2-}) as indication of strong anthropogenic source influence. Kototabang as a remote area has a higher concentration of ammonium (NH_4^+) in that indicates biomass burning. Land forest fires contributions to atmospheric NH_3 during dry seasons that are often occurred in another province, Riau.

Jakarta has the highest NO_3^- ion concentration as related to a huge transportation number and also high nss-SO_4^{2-} compared to other parameters. The concentration of Cl^- and Na^+ indicates a significant relationship as coastal areas (Figure 3.2.3).

Figure 3.2.4 shows a correlation between $[NH_4^+]/[2.\text{nss-}Ca^{2+}]$ in Jakarta indicating these parameter significantly affect the pH value. Meanwhile, the value of $[NH_4^+]/[2.\text{nss-}Ca^{2+}]$ in Serpong is higher than 1 in every season. The situation indicated NH_4^+ as a major ion with averaged value of pH below 5. It almost similar to the situation in Bandung, but in the dry season $[NH_4^+]/[2.\text{nss-}Ca^{2+}]$ has raised the pH value, caused by particulates containing NH_4NO_3 and $[NH_4]_2SO_4$ dissolved in precipitation. In Kototabang varied from 0 to 10, with a tendency to below 1 in the rainy season. This indicates that nss-Ca^{2+} as major cation is more important than NH_4^+. In the months SON from year 2005 to 2009, frequent forest fires and soil dust due to dry season is relatively a lot.

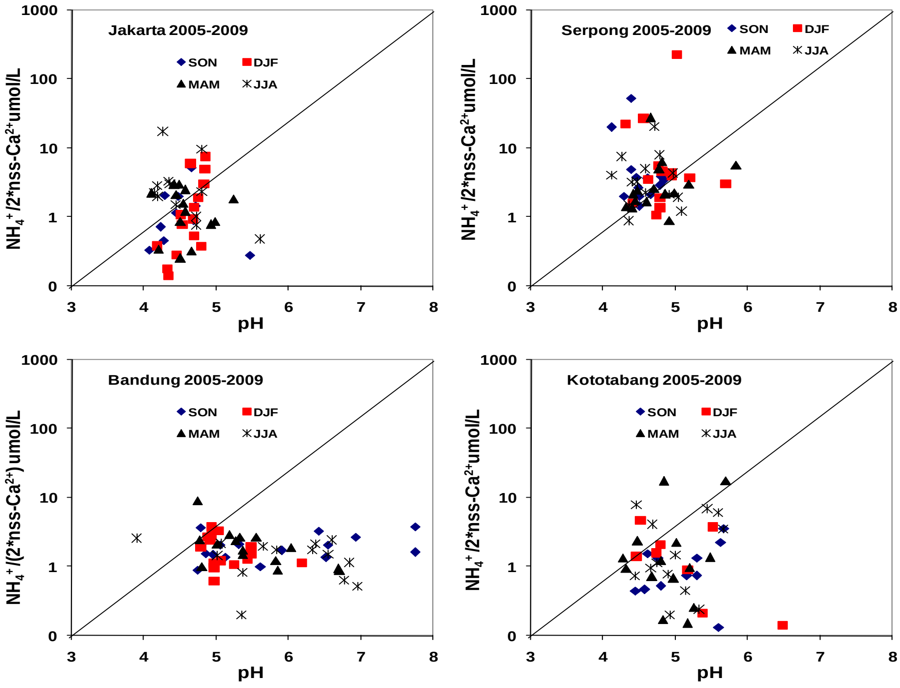


Figure 3.2.4. Measured $[NH_4^+]/[2.nss\text{-}Ca^{2+}]$ versus pH at Jakarta, Serpong, Bandung and Kototabang in Indonesia (2005 to 2009).

3.2.1.3. Rainfall variation

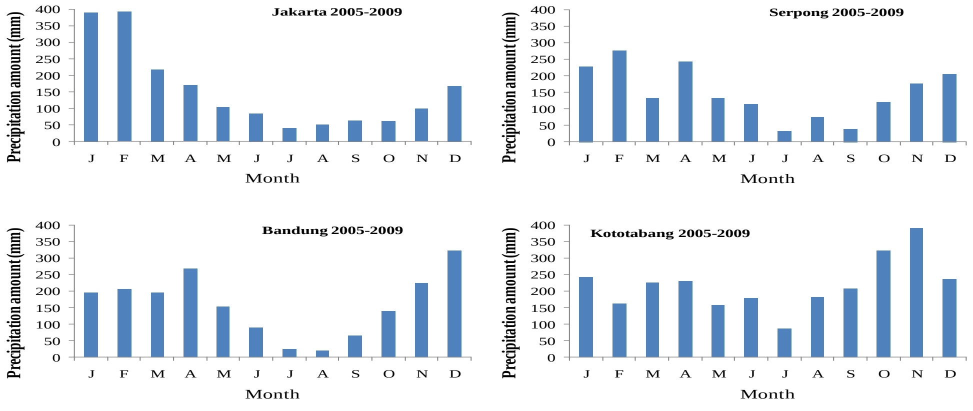


Figure 3.2.5. Monthly averaged precipitation amounts (mm) at Jakarta, Serpong, Bandung and Kototabang for 2005-2009.

The range of rainfall (30 – 390 mm) seems very large compared to other climate elements. Rainfall is one of the important elements of climate.

Wet deposition precipitation in Indonesia varied due to differences in the amount of annual rainfall. Table 3.2.1 below shows the mean of annual wet deposition of major ions ($meq.m^{-2}.yr^{-1}$) and precipitation ($mm.yr^{-1}$) in every monitoring site at year 2005-2009. The highest total annual average rainfall 2,420.1 $mm.yr^{-1}$ of Kotatabang has also average annual deposition of major ions nss-SO_4^{2-} compared to other ions in Jakarta, Serpong and Bandung.

Table 3.2.1. Annual mean wet deposition of major ions ($meq.m^{-2}.yr^{-1}$) and precipitation ($mm.yr^{-1}$) at Indonesia monitoring site for 2005-2009.

Indonesia	Precipitation mm yr^{-1} Mean	nss-SO_4^{2-} $meq.m^{-2}.yr^{-1}$ Mean	NO_3^- $meq.m^{-2}.yr^{-1}$ Mean	NH_4^+ $meq.m^{-2}.yr^{-1}$ Mean	nss-Ca^{2+} $meq.m^{-2}.yr^{-1}$ Mean	H^+ $meq.m^{-2}.yr^{-1}$ Mean	$NH_4^+ + NO_3^-$ $meq.m^{-2}.yr^{-1}$ Mean	$H^+ + 2NH_4^+$ $meq.m^{-2}.yr^{-1}$ Mean
Jakarta	1,801.3	99.4	53.2	35.7	48.9	59.9	88.9	131.3
Serpong	1,765.0	97.0	52.6	77.5	25.9	42.6	130.1	197.6
Bandung	1,761.0	114.2	43.2	90.4	52.5	15.5	133.5	196.3
Kototabang	2,420.1	25.8	7.4	32.1	59.4	38.4	39.5	102.7

3.2.2. State of dry deposition

Dry deposition consists of gas and particle, where the gas which is consisted of SO_2, HNO_3, HCl and NH_3 contribute to form acid deposition. On the other hand, the aerosol which is consisted of anion and cation also contribute to form acid deposition.

The dry deposition monitoring resulted during period 2005-2009 for gas and aerosols can be described in Figures 3.2.6 and 3.2.7.

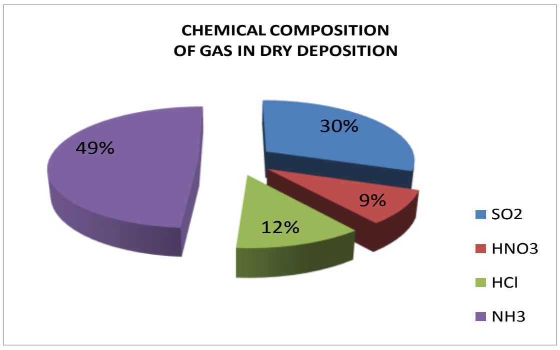


Figure 3.2.6. Average chemical composition of gas SO_2, HNO_3, HCl and NH_3 at Serpong station during year 2005-2009.

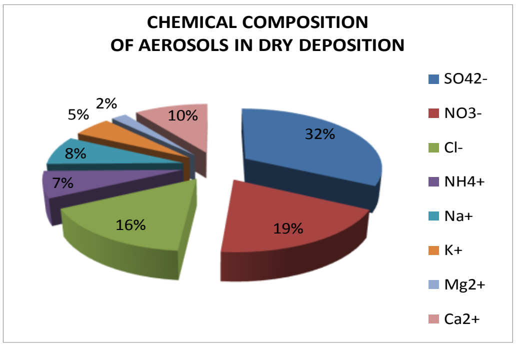


Figure 3.2.7. Average chemical composition of anion-cation in aerosol at Serpong station during year 2005-2009.

NH_3 concentration is the highest compare to other gases in dry deposition (Figure 3.2.6), where as SO_2 followed at the second order. Source of NH_3 gas could be generated from poultry, plantation, fertilizer, and domestic waste around Serpong station. While source of HCl could be generated from industrial activities around Serpong and Tangerang city; and SO_2 and HNO_3 could be generated from transportation.

The highest composition for anion and cation in aerosol were SO_4^{2-} followed by NO_3^- and Cl^- (Figure 3.2.7). Higher composition for SO_4^{2-} and NO_3^- could be generated from fossil fuel combustion around the area; as for Cl^-, the contribution would probably comes from sea salt at Northern part of Java Island as well as from industrial activity around Tangerang city.

Variability of gas and aerosols in dry deposition can be described in Figures 3.2.8 and 3.2.9 as follow:

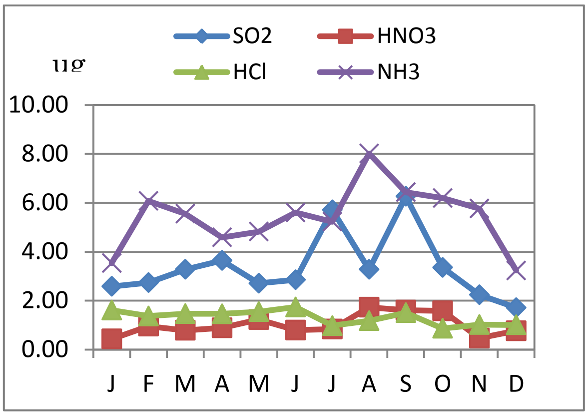


Figure 3.2.8. Monthly variation for gas in dry deposition at Serpong station during year 2005-2009.

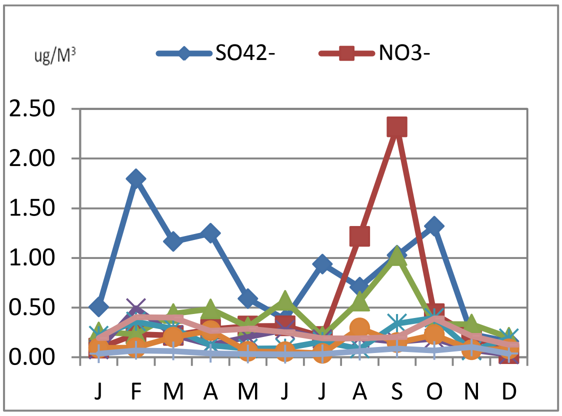


Figure 3.2.9. Monthly variation for aerosol in dry deposition at Serpong station during year 2005-2009.

Figure 3.2.10 describes the higher trend for NO_2 concentration in Jakarta station compare to Bandung and Kototabang station, although Bandung station shows increasing concentration at the last tri semester in year 2007 and 2008.

Figure 3.2.11 describes the higher trend for SO_2 concentration in Jakarta station compares to Bandung and Kototabang stations, although Bandung station shows the highest concentration during September to December year 2007 while Kototabang station shows the highest concentration during August to November year 2009.

The trend for NO_2 and SO_2 concentrations in Jakarta, Bandung and Kototabang stations describes as follow:

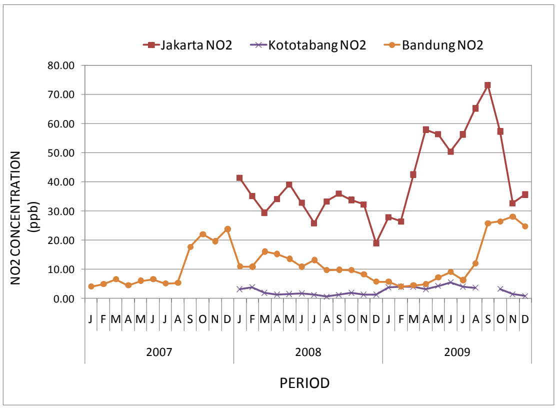


Figure 3.2.10. NO_2 in Jakarta, Bandung and Kototabang (year 2007-2009).

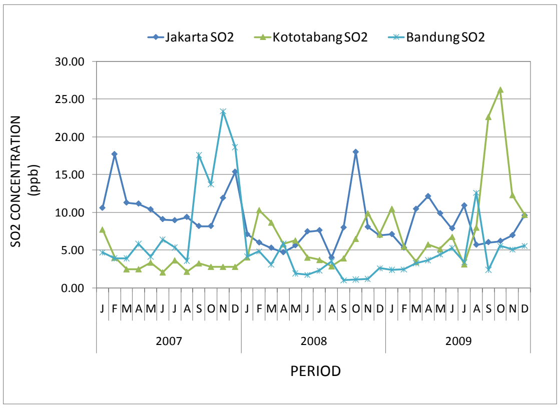


Figure 3.2.11. SO_2 in Jakarta, Bandung dan Kototabang (year 2007-2009).

3.2.3. State of inland aquatic environment

In year 2007, Situ Gunung was established as a new site of inland aquatic monitoring. Located 14 km Northwest of Sukabumi, at Kadudampit district, Sukabumi regency, West Java province, Indonesia. It is a nature conservation area, a nature tourism park based on the Decree of the Minister of Agriculture dated 27 November 1975 within area of 120 ha consisting of the territorial waters of a lake area 9.34 ha

Geographically situated between 06^0 50' 01" South latitude and 106^0 55' 24.4" East longitude, at an altitude of 1,600 – 1,700 m asl. The depth of the deepest lake is below 10 m. The elevation around 950 – 1,150 m asl. Rainfall ranges were from 3,500 – 4,000 $mm.yr^{-1}$ and the temperature was around 16^0C-28^0C.

Gunung Lake can follow two tracks: Jakarta - Bogor - Cisaat - Situ Gunung (123 km) and Bandung - Sukabumi - Cisaat (108 km). Mileage from Cisaat to Gunung Lake (7 km) is a road passable by wheeled vehicles 2 or 4 wheels and 6 wheels.

Dominant trees species around the Gunung Lake are amber, flower, and Saninten Rasamala. The source of lake water comes from the waterfall Cimanaracun Mountain, a distance of 1.5 km from there and can be reached by foot.

Figure 3.2.12. Situ Gunung, Sukabumi, West Java.

The pH range of Situ Patengang is 7.14–7.0, and in Situ Gunung is 6.69-6.73. The value of electrical conductivity in Situ Patenggang and Situ Gunung is seen that there is still showed a good value for acid deposition monitoring site selection in inland aquatic because its value is still below 10 $mS.m^{-1}$. The alkalinity value has exceeded the maximum limit (>0.2 $meq.l^{-1}$). The highest of alkalinity value is alleged the existence of the positive influence of anions and cations in the water. An increased in levels of nitrite caused by the decayed vegetable and animal matter, fertilizer use, domestic effluents sewage sludge disposal to land, and atmospheric washout all contribute to these ions in water sources. Fluctuations in sulfate levels allegedly associated with the composition of cations and anions to reach the ion balance.

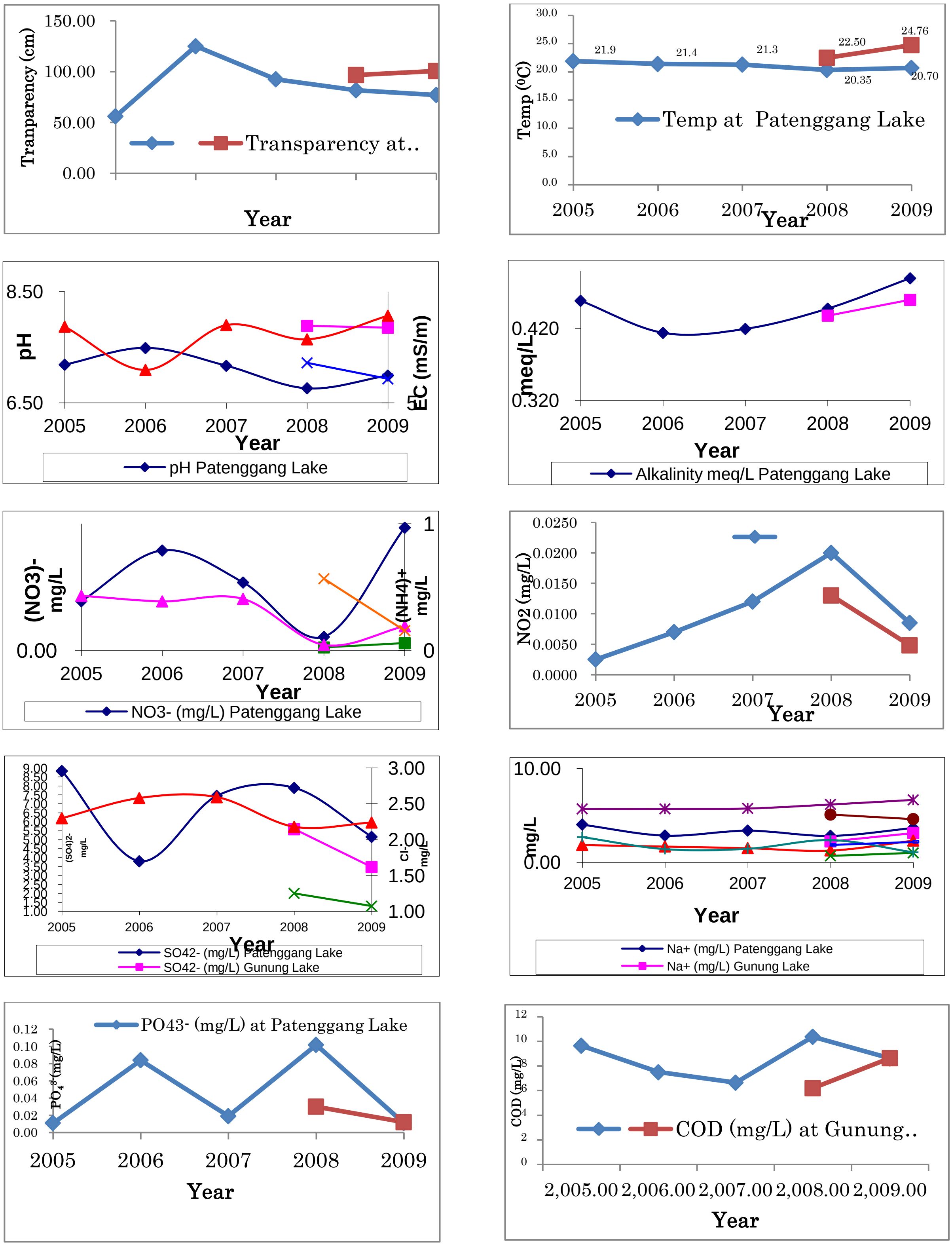


Figure 3.2.13. The values of transparancy, temperature, pH, alkalinity, NO_3^-, NH_4^+, NO_2, SO_4^{2-}, Cl^-, Na^+, K^+, Mg^{2+}, Ca^{2+}, PO_4^{3-} and COD in Situ Patenggang and Situ Gunung.

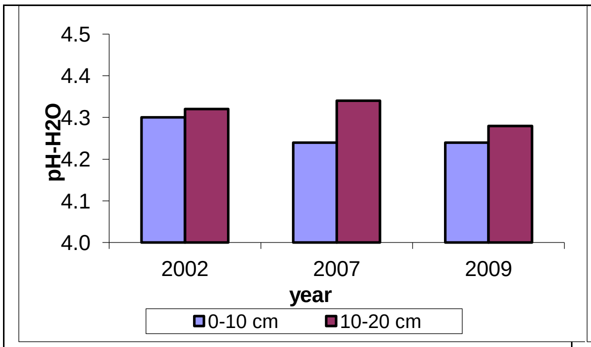
3.2.4. State of soil and vegetation

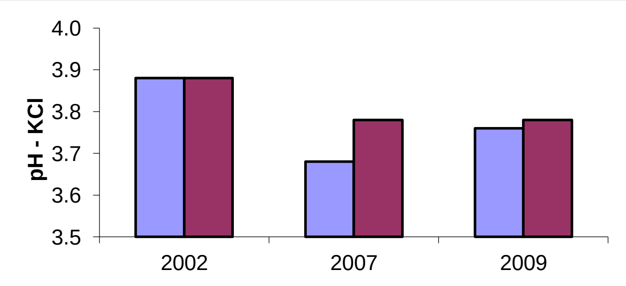
Soil and vegetation observations have been made in Dramaga Forest Research, Bogor. This forest is 40 years old man made type with *Hopea mengarawan* the major tree species and managed by

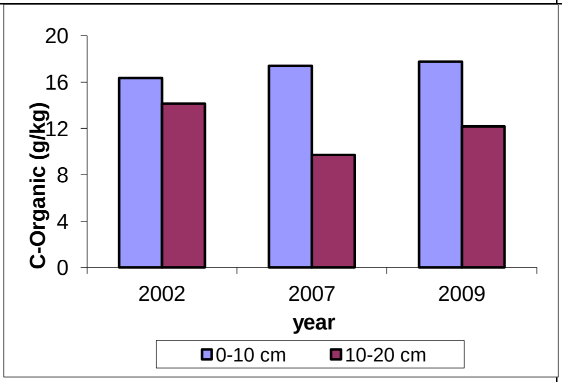
Forestry Research and Development Center, Ministry of Forestry of Republic Indonesia as experimental forest.

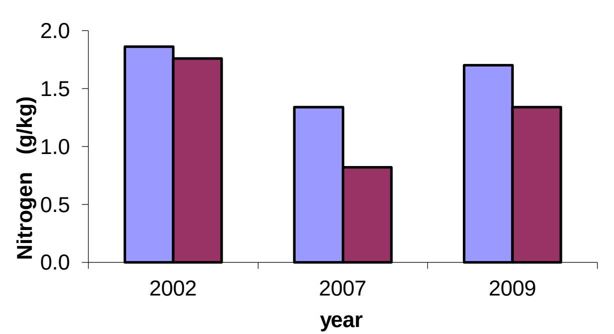
3.2.4.1. State of soil

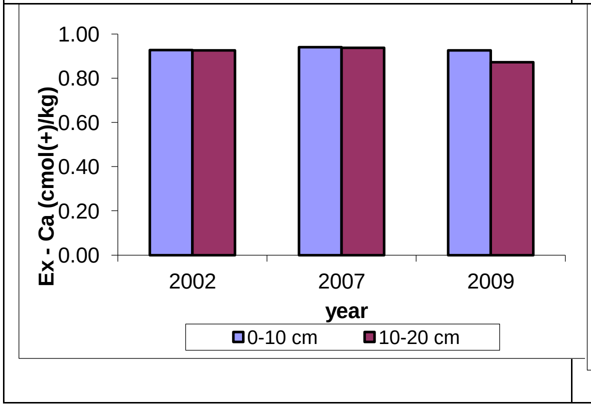
Soil chemistry monitoring in Dramaga Experimental Research, Bogor, Indonesia in the period of observation in 2002, 2007 and 2009 showed the acidity soil symptoms as decreasing soil pH, base saturation and higher acid saturation. The type of soil has a very acid pH, low organic matter, exchangeable-cation and cation exchange capacity (CEC), so it is considered as poor soil.

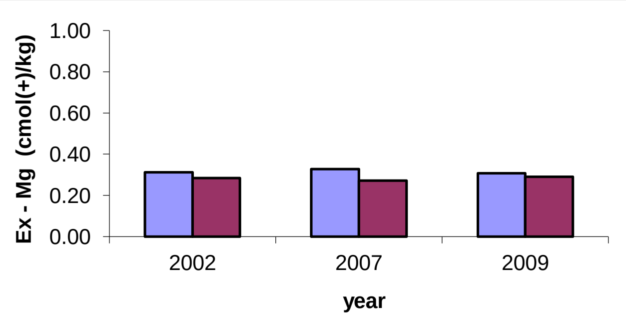












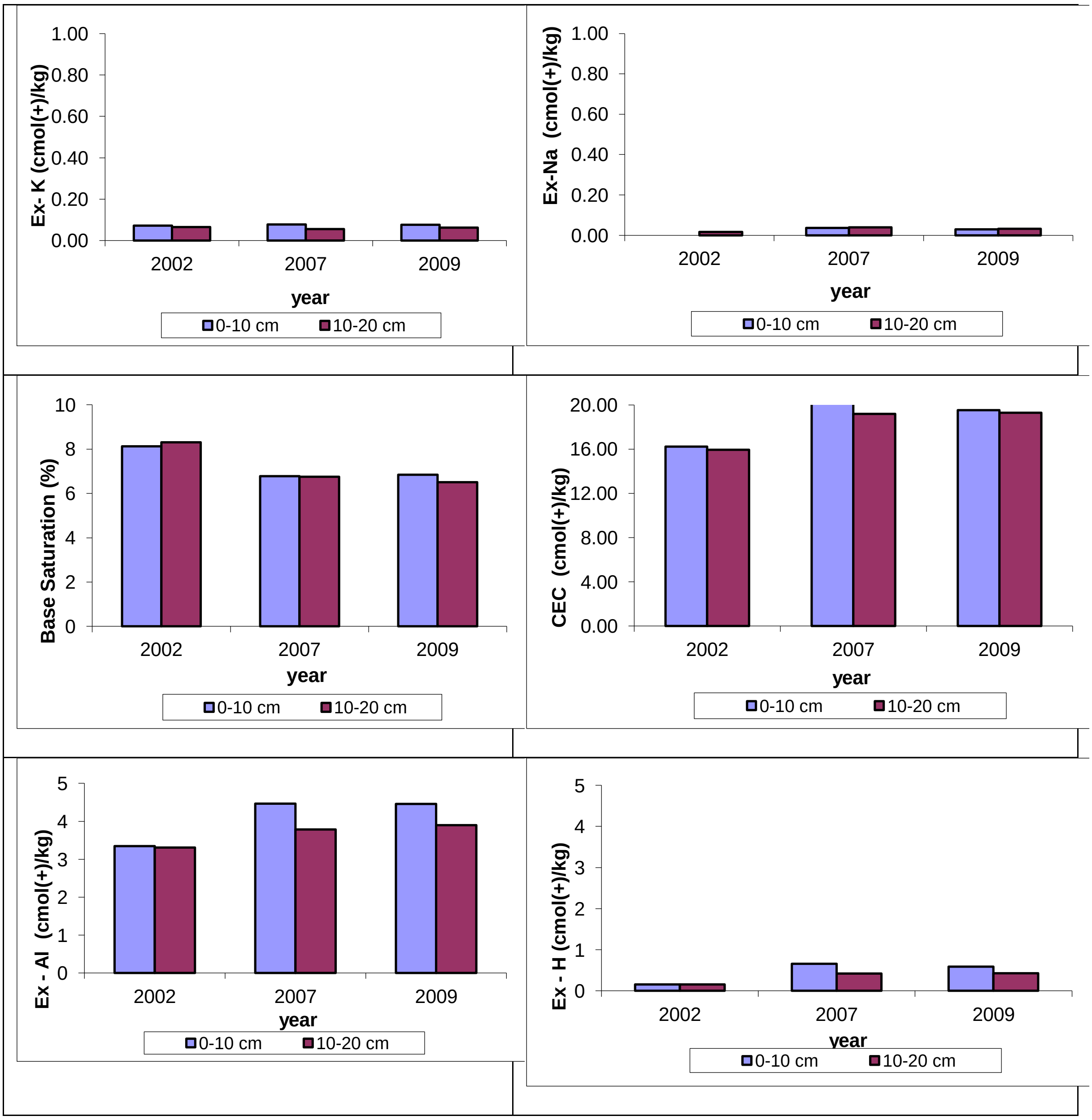


Figure 3.2.14. The values of pH (H_2O), pH (KCl), C - organic, N – Kjeldahl, Ex-cations, base saturation, CEC, Ex-Al, and Ex-H.

The soil pH in Dramaga station tends to be extremely acidic (<4.5). Figure above shows the gradual change of pH-H_2O at 10 cm upper part of soil layer (top soil) and 10 cm underneath for 3 times observation during year 2002, 2007 and 2009.

Both soil layers tend to decrease in pH even in small scale (< 0.1 pH unit). The topsoil has lower pH-H_2O and pH-KCl than the lower layer. It is also a similar pattern for gradual change in pH-KCl. The lower pH of soil at the top layer was caused by some sources of acid (H^+) above ground, that could be generated from organic decomposition or from rain water.

Level of organic matter in topsoil is higher than the layer underneath as it commonly found in natural soils. C-organic content in the topsoil tends to increase. The bottom layer shows a decreasing level from year 2002 to 2007. The same pattern was shown in Nitrogen level for the second soil layer. C/N ratio of soil organic material represents the level of decomposition of organic material.

Exchangeable cations in soil samples was dominated by exchangeable-Ca (Ex-Ca), followed by exchangeable – Mg (Ex-Mg), exchangeable-K (Ex-K) and exchangeable-Na (Ex-Na) is the smallest such as generally normal land. There has been no change during the observation in year 2002-2009.

Soil base saturation decreased over the time, especially at the lower soil layers as an indicator of soil acidity. The second soil layer shows elevated level of exchangeable-Al (Ex-Al) and exchangeable-H (Ex-H) during observation.

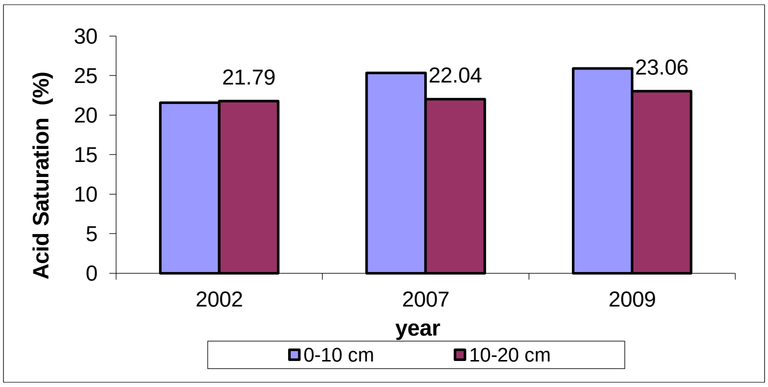


Figure 3.2.15. The values of acid saturation.

Acid saturation describes the amount of acid (exchangeable-Al and exchangeable-H) which occupies the negative charge on soil sorption complex. Increasing soil acidity was higher in upper layer than the bottom layer. Acid saturation is a good indicator to monitor soil acidity as well as base saturation.

3.2.4.2. State of vegetation

Vegetation monitoring has been done in 2008. As a whole, it has not indicated the impact of acid deposition on observed vegetation. Some existing vegetation experienced disturbances such as pests and diseases are more due to the high density stands (11,755 trees.ha^{-1}). High-density stands causing micro-climate in the observation plot are very conducive for pest and disease outbreaks. Meanwhile, the impact of acid deposition is not clear whether it is the color of the leaf and canopy structure. To see the impact of acid deposition in detail and valid, required an in-depth micro-analysis of physiological plant leaves, especially on the leaves tissue.

Figure 3.2.16. Dramaga Forest Research, Bogor.

1). Measurement of trees

Maximum height	45.0 m
Maximum diameter	133.5 cm
Mean height of dominant trees	6.7 m
Mean DBH of dominant trees	5.0 cm
Basal area	183.9 $m^2.ha^{-1}$
Total volume	5,013.9 $m^{-3}.ha^{-1}$
Density	11,755 $trees.ha^{-1}$

2). Understory vegetation survey

Date: December 16, 2008
Number of Species: 21

Species name	Dominance scale	Species name	Dominance scale
Hopea mengrawan Miq	4	*Khaya grandifolia* C.DC	+
Strombosia javanica Blume	2	*Maesopsis emenii* Engl	+
Calophyllum soulattri Burm F	1	*Zalaca edulis* Reinw	1
Eugenia cymosa Lamk	1	*Alpinia galanga* Sw	1
Lansium domesticum Jack	1	*Tetracera indica* L	+
Palaqium javense Burck	1	*Driopteris iregularis* Pr	1
Shorea selanica Blume	+	*Taenitis blanchoides* Sw	1
Melia excelsa Jack	1	*Pleocnemia leuzeana*	1
Hopea odorata Roxb	1	*Elalis guinensis* Jack Pr	1
Parinari corymbosum Blume	1	*Enterolobium cyclocarpum* Grisb	+
Evodia aromatica Blume	+		

3.3. Review of National Measures Againts Acid Deposition

Indonesia does not have the specific national measures against acid deposition. To control the emission of air pollutant there are some regulations of stationary emission standard, vehicle emission standard and ambient standard. The Ministry of Environment Republic of Indonesia has company's environmental performance rating program as an alternative compliance instrument. This program is not directly reduced the emission of sulfur dioxide and nitrogen oxide which is the main cause of acid deposition, but there is an assessment of compliance to the requirement of air pollution regulation.

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National Assessment on Acid Deposition in Japan

4.1 Basic Information on National Monitoring Activities

4.1.1 Outline of activities on acid deposition and national monitoring plan

The acid deposition is regarded as a global issue and has been highly concerning in many regions in the world. In 1983, the Environment Agency of Japan, which was reorganized as the Ministry of the Environment (MOEJ) in January 2001, raised the malignant influence of acid deposition upon the environment in Japan, and set up the Committee for Acid Deposition Measures consisting experts on air pollution, soil, vegetation and inland aquatic environments. Then the Acid Deposition Monitoring Survey Program was launched. The continuous monitoring of acid deposition has been implemented based on the long term monitoring plan for acid deposition by the MOEJ since 2003.

The activities on the internal quality control for the monitoring data has been also conducted to get the internationally comparable, high precision and high accuracy data by the implementation and evaluation of sites audit and inter–laboratory comparison survey.

4.1.2 Monitoring program in 2005 – 2009

4.1.2.1 Plan on the long–term monitoring of transboundary air pollution and acid deposition

(1) Background

The economic activities in East Asian region have been developing rapidly with the severe environmental issues such as air pollution and so on. The transboundary air pollution including acid deposition becomes more serious in the near future.

Ministry of the Environment, the government of Japan (MOEJ) launched the first survey for the measure against acid rain in 1983, and until terminating fourth survey, the acid deposition monitoring on the field of ambient air, soil and vegetation, and inland aquatic environment were conducted. As the result of these surveys, it was confirmed that the situation of the acid deposition in Japan was almost same as that in European countries and the tendency of increasing the acidic components in the Japan sea coastal area in winter season.

Based on these backgrounds, MOEJ is promoting *long term monitoring of acid deposition* and *study on the investigation of the measure against acid deposition in East Asia* under the Acid Deposition Monitoring Network in East Asia (EANET) and international corroboration.

This plan was prepared to indicate the middle and long-term direction of Japan for continuous implementation of wide-area and long-term monitoring of acid deposition.

And, based on the monitoring results from 2003 to 2007, with the addition of catchments survey and the reviewing of wet deposition monitoring sites, and on the view point of clarification of the monitoring for transboundary air pollution not only on acid deposition, but also ozone and aerosol, this plan was revised partly in 2009.

(2) Objectives

The objectives of the long-term monitoring of transboundary air pollution and acid deposition (long-term monitoring) are grasping the long-range transboundary transportation and long-term trend, etc. of air pollutants, such as acid rain causing substances, ozone and so on. The long-term air monitoring and ecological impact monitoring would be implemented with EANET activities.

(3) Structure for the implementation of long–term monitoring of transbounday air pollution and acid deposition

a) Components of the structure

The long-term monitoring consists *Ambient Air Monitoring* and *Ecological Impact Monitoring*. Ambient Air Monitoring includes *Wet Deposition Monitoring* by measuring the components in the precipitation and *Air Pollutants Monitoring* by measuring the components in the aerosol and gas. Dry deposition of acidic substances is included in the Air Pollutants Monitoring. The Ecological Impact Monitoring consists *Soil and Vegetation Monitoring* and *Inland Aquatic Environment Monitoring*. The schematic structure is shown in Figure 4.1.1.

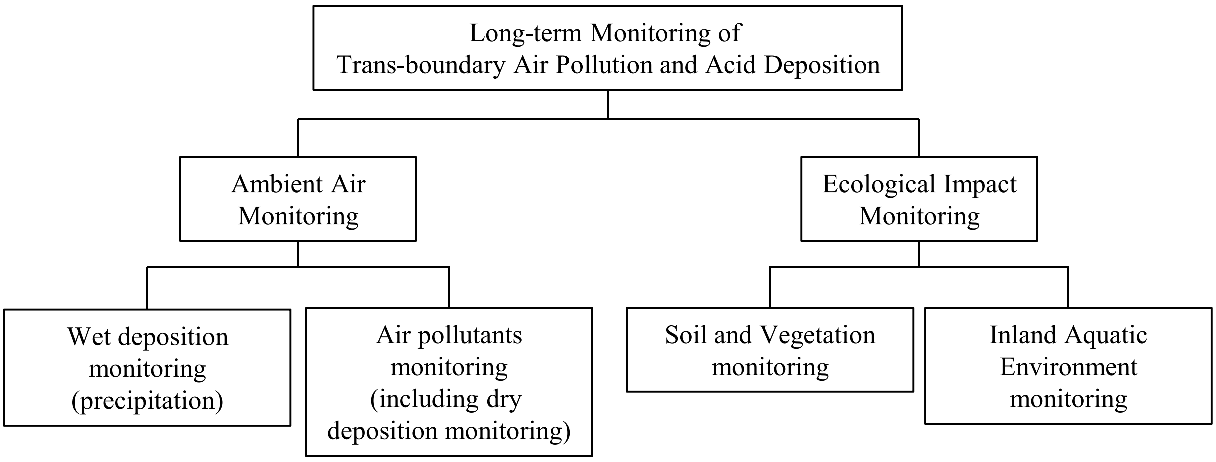


Figure 4.1.1. Schematic structure of long–term monitoring.

b) Implementing organisations

The task on the long–term monitoring is implemented by following organisations.

Tasks	Implementation organisations
Planning and arrangement	MOEJ Asia Center for Air Pollution Research (ACAP)*, Japan Environmental Sanitation Center (JESC)
Sample collection	Local governments and other organisations contracted with MOEJ
Analysis	Local governments, ACAP and other organisations contracted with MOEJ
Quality control and assurance	ACAP
Data compilation, analysis and evaluation	MOEJ ACAP

** ACAP is designated as the Network Center for EANET and the National Center of Japan.*

(4) Ambient air monitoring

a) Objectives of the ambient air monitoring

The objectives of the ambient air monitoring are implemented to assess the state of concentration and deposition of acidic substances and air pollutants such as ozone and so on. The targets of the assessment are whole ecosystem including, 1) coastal and plane region in the remote area, 2) mountain region in the remote area, 3) rural area, 4) suburban area, 5) urban area, 6) special emission sources like volcano, and 7) forest and inland aquatic environment.

b) Monitoring items, interval and method

i) Wet deposition (precipitation)

- Monitoring items: electrical conductivity, pH, sulfate ion (SO_4^{2-}), nitrate ion (NO_3^-), chloride ion (Cl^-), ammonium ion (NH_4^+), sodium ion (Na^+), potassium ion (K^+), calcium ion (Ca^{2+}) and magnesium ion (Mg^{2+})
- Sampling intervals: daily sampling for EANET sites and monitoring sites for transboundary air pollution every 7 days for ecological impact monitoring sites.
- Monitoring methods:

Item	Analytical instrument (principle of the analytical method)
Electrical conductivity	electrical conductivity meter
pH	pH meter (glass electrode method)
SO_4^{2-},NO_3^- and Cl^-	ion chromatograph
NH_4^+	ion chromatograph or spectrometer (Indophenol method)
Na^+, K^+, Ca^{2+} and Mg^{2+}	ion chromatograph or atomic adsorption

ii) Air pollutants (gas and aerosol) by automatic monitor

- Monitoring items: sulfur dioxide (SO_2), ozone (O_3), nitrogen oxides (NO/NO_2 or NOx*), particulate matter (<10 μm) (PM_{10}) and particulate matter (<2.5 μm) ($PM_{2.5}$)
- Sampling intervals: continuous monitoring and summarized as hourly data
- Monitoring methods:

Item	analytical method
SO_2	ultraviolet fluorometry (high sensitivity type)
O_3	ultraviolet adsorption method
NOx	chemical luminescence method (high sensitivity type)
PM_{10}, $PM_{2.5}$	TEOM method, β-ray adsorption method

iii) Air pollutants (gas and aerosol) by filter-pack method

- Monitoring items: gaseous components: SO_2, HNO_3, HCl and NH_3
  aerosol components: SO_4^{2-},NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+}
- Sampling intervals: sample is collected for two weeks. The sampling period at high concentration sites is designed as one week.
- Monitoring methods: filter-pack method

iv) Dry deposition

Dry deposition at EANET sites are estimated by inferential method.

c) Monitoring stations for ambient air monitoring

The ambient air monitoring is conducted at following sites as shown in Table 4.1.1

Table 4.1.1. The monitoring sites for the ambient air monitoring.

#	Site name	Prefecture	Classification of climate	Site classification	Wet deposition	Sampling interval	Dry deposition						Notes
							FP	SO$_2$	O$_3$	NOx	PM$_{10}$	PM$_{2.5}$	
1	Cape Ochiishi	Hokkaido	SE of Hokkaido	Remote	✓	daily	✓	✓	✓	✓	✓	✓	EANET*1
2	Rishiri	Hokkaido	NW of Hokkaido	Remote	✓	daily	✓	✓	✓	✓	✓	✓	EANET
3	Sapporo	Hokkaido	NW of Hokkaido	Urban	✓	weekly			✓				Long-term
4	Hachimantai	Iwate	E of Tohoku	Rural	✓	weekly			✓				
5	Nonodake	Miyagi	E of Tohoku	Rural	✓	weekly			✓				
6	Cape Tappi	Aomori	W of Tohoku	Remote	✓	daily	✓	✓	✓	✓	✓		EANET
7	Akagi	Gumma	Kanto	Rural	✓	weekly			✓				
8	Tokyo	Tokyo	Kanto	Urban	✓	daily	✓	✓	✓	✓	✓		EANET
9	Sado-Seki	Niigata	Hokuriku	Remote	✓	daily	✓	✓	✓	✓	✓		EANET
10	Niigata-Maki	Niigata	Hokuriku	Rural	✓	daily			✓				
11	Happo-one	Nagano	Hokuriku	Remote	✓	daily	✓	✓	✓	✓	✓		EANET
12	Cape Echizen	Fukui	Hokuriku	Remote	✓	daily		✓	✓				
13	Lake Ijira	Gifu	Tosan	Rural	✓	weekly	✓	✓	✓	✓	✓		EANET
14	Kyoto-Yawata	Kyoto	Kinki	Urban	✓	weekly			✓				
15	Amagasaki	Hyogo	Seto-uchi	Urban	✓	weekly			✓				
16	Oita-Kuju	Oita	Seto-uchi	Rural	✓	weekly			✓				
17	Shionomisaki	Wakayama	Nankai	Remote	✓	weekly		✓	✓				
18	Yusuhara	Kochi	Nankai	Remote	✓	daily	✓	✓	✓	✓	✓		EANET
19	Oki	Shimane	San'in	Remote	✓	daily	✓	✓	✓	✓	✓	✓	EANET
20	Lake Banryu	Shimane	San'in	Urban	✓	weekly	✓	✓	✓	✓	✓		EANET
21	Tsushima	Nagasaki	W of San'in NW of Kyushu	Remote	✓	daily		✓	✓				TBP*3
22	Chikugo-Ogori	Fukuoka	W of San'in NW of Kyushu	Rural	✓	weekly			✓				
23	Goto	Nagasaki	W of San'in NW of Kyushu	Remote	✓	weekly		✓	✓				TBP
24	Ebino	Miyazaki	S of Kyushu	Remote*2	✓	daily		✓	✓				Volcano
25	Yakushima	Kagoshima	S of Kyushu	Remote	✓			✓	✓				WH*4
26	Cape Hedo	Okinawa	East China Sea	Remote	✓	daily	✓	✓	✓	✓	✓		EANET
27	Ogasawara	Tokyo	W Pacific Ocean	Remote	✓	daily	✓	✓	✓	✓	✓		EANET

**1: Designated as EANET site, *2: Belonging to Remote with the influence of volcano, *3: possibilities of the effect by transboundary pollution, *4: World Heritage.*

(5) Ecological impact monitoring (soil and vegetation and inland aquatic environment)

a) Objectives of ecological impact monitoring

The soil and vegetation monitoring is conducted for the establishment of the baseline data of soil and forest in representative forests in Japan and for detecting effects of acid deposition/air pollution in early stage. The inland aquatic environment monitoring is conducted for detecting effects of acid deposition on inland aquatic environments in early stage.

b) Monitoring items, interval and method

i) Soil and vegetation monitoring

<u>Forest vegetation monitoring:</u>

- Monitoring items: Mandatory: General description of forest (description of trees (species name, diameter at breast height (DBH) and height of tree), understory vegetation survey), observation of tree decline.
  Optional: photographic records of tree decline and estimation of decline cause.
- Sampling frequency: Every five years for general description of forest, once a year for survey of tree decline.
- Monitoring methods: Observation plots are established in the selected forest areas:
  - Area focusing on impacts on trees (national parks): one plot.
  - Area focusing on impacts on soil: one plot respectively for two soil types (two plots in total).
  - EANET sites: one plot respectively for two soil types (two plots in total).

<u>Soil monitoring:</u>

- Monitoring items: Mandatory: Moisture content, pH (H_2O), pH (KCl), exchangeable base cations (Ca, Mg, K, and Na), exchangeable acidity, exchangeable Al, exchangeable H, effective cation exchange capacity (ECEC), carbonate content (calcareous soils only).
  Optional: total N, total C, available P, Sulphate, soil physical properties (fine earth bulk density, penetration resistance).
- Sampling frequency: Every five years.
- Monitoring methods: Sampling plots are established in the selected forest areas:
  - Area focusing on impacts on trees (national parks): two plot.
  - Area focusing on impacts on soil: two plots respectively for two soil types (four plots in total).
  - EANET sites: two plots respectively for two soil types (four plots in total).
- Analytical methods:

Item	Analytical instrument or method (principle)
Moisture amount	electrical conductivity meter
pH (H_2O), pH (KCl)	pH meter (glass electrode method)
Exchangeable base (Ca, Mg, K, Na)	After extracting with ammonium acetate, atomic absorption spectrometer (AAS), ICP/AES, ICP/MS
Exchange acidity	After extracting with KCl aq., titrimetry
Exchangeable Al and H	After extracting with KCl aq., titrimetry
SO_4^{2-},NO_3^- and Cl^-	ion chromatograph
NH_4^+	ion chromatograph or spectrometer (Indophenol method)
Na^+, K^+, Ca^{2+} and Mg^{2+}	ion chromatograph or AAS

ii) Inland aquatic environment monitoring

- ➢ Monitoring items:
  - ✓ Water sample:
    - ● Mandatory: water temperature, pH, EC, alkalinity (pH 4.8), NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, SO_4^{2-}, NO_3^-, Cl^-, Chlorophyll a, Dissolved oxygen (DO)
      Optional: Plankton
    - ● Mandatory: transparency, water color, DOC, NO_2^-, PO_4^{3-}
      Optional: total dissolved Al, COD
  - ✓ Sediment sample:
    - ● Mandatory: NO_3^-, NH_4^+, and SO_4^{2-} of pore water
      Optional: organisms other than plankton, sediment (Pb, Pb–210, and stable isotope of S)
- ➢ Sampling frequency:
  - ✓ Water sample: 4 times (for four seasons) a year for the items (a) above, and once (in spring) to 4 times a year for the items (b) above
  - ✓ Sediment sample: every five years
- ➢ Monitoring methods:

Water sample:

Parameters	Analytical instruments or methods
Electric conductivity (EC)	Conductivity meter (conductivity cell)
pH	pH meter (glass electrode)
Alkalinity	Titration by Burette or Digital burette with pH meter
NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}	Ion chromatography (preferably with suppressor) or Spectrophotometry
NH_4^+	Ion chromatography or Spectrophotometry (Indophenol blue)*
Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography or Atomic absorption/Emission spectrometry
Cl^-	Ion chromatography or Titration
Chlorophyll a	SCOR/UNESCO 法
DO	DO Meter method or Winkler–modified sodium azide method
DOC	Combustion–Infrared method or Wet–oxidation method
Transparency	Secci disk method
Water color	Observation
Total dissolved Al	Atomic absorption spectrometry with graphite furnace, ICP Emission spectrometry or ICP/MS
COD	Acidic potassium permanganate method
Plankton	Water column sampling method (for phytoplankton), Plankton net sampling (for zoo plankton)

Lake sediment and their pore water:

Parameter	Analytical methods
NO_3^-, NH_4^+	Ion chromatography or Spectrophotometry
SO_4^{2-}	Ion chromatography or Turbidimetry
Pb	Atomic absorption spectrophotometry with graphite furnace after acid extraction, ICP emission spectrophotometry or ICP/MS
Sedimentation dating	Pb–210 method (Pb–210 : γ–radiation spectrometry)
S (stable isotopes ratio)	Isotope mass spectrometry by ionization

c) Monitoring sites

Table 4.1.2. Soil and vegetation monitoring sites.

Classification	Name of forest area	Targeted tree species or soil types	Remarks
			Nearest sites for ambient air monitoring
Area focusing on impacts on trees (focusing on natural forests)	Shiretoko National Park (Hokkaido Pref.)	*Abies sachalinensis*	Cape Ochiishi
	Shikotsu–Toya National Park (Hokkaido Pref.)	*Betula ermanii*	Sapporo
	Towada–Hachimantai National Park (Iwate Pref.)	*Abies mariesii*	Hachimantai
	Bandai–Asahi National Park (Niigata Pref.)	*Fagus crenata*	Niigata–Maki
	Nikko National Park (Tochigi Pref.)	*Fagus crenata*	Akagi
	Chubu–Sangaku National Park (Toyama Pref.)	*Fagus crenata*	Happo–one
	Hakusan National Park (Ishikawa Pref.)	*Fagus crenata*	Cape Echizen
	Yoshino–Kumano National Park (Nara Pref.)	*Fagus crenata*	Shionomisaki
	Daisen–Oki National Park (Tottori Pref.)	*Fagus crenata*	Oki
	Ishizuchi Quasi–National Park (Kochi Pref.)	*Fagus crenata*	Yusuhara
	Aso–Kuju National Park (Oita Pref.)	*Fagus crenata*	Oita–Kuju
	Kirishima–Yaku National Park (Yakushima Island, Kagoshima Pref.)	*Criptomeria japonica,* glossy–leaved forest	Yakushima
Area focusing on impacts on soil	Sekidozan and Horyuzan (Ishikawa Pref.)	red soil, brown forest soil	Cape Echizen
	Hodoji and Amanosan (Osaka Pref.)	yellow soil, yellowish brown forest soil	Amagasaki
	Shimofuritake and Tokusagamine (Yamaguchi Pref.)	yellow soil, black soil	Lake Banryu
	Kashiigu and Koshosan (Fukuoka Pref.)	reddish brown forest soil, brown forest soil	Chikugo–Ogouri
EANET sites (focusing on relationship with inland water)	Lake Ijira area (Ijira and Yamato) (Gifu Pref.)		Lake Ijira
	Lake Banryu area (Banryu and Iwami–rinku factory park) (Shimane Pref.)		Lake Banryu

Table 4.1.3. Monitoring sites for inland aquatic environment.

	Lake or ponds	Location	Remarks
1	Imagamioike	Yamagata Pref.	
2	Karikomiko	Tochigi Pref.	
3	Futagoike	Nagano Pref.	
4	Sankyonoike	Niigata Pref.	
5	Ohataike	Ishikawa Pref.	
6	Yashagaike	Fukui Pref.	
7	Ijirako	Gifu Pref.	EANET site
8	Sawanoike	Kyoto Pref.	
9	Yamanokuchi Dam	Yamaguchi Pref.	
10	Banryuko	Shimane Pref.	EANET site
11	Nagatomiike	Kagawa Pref.	

d) Other ecological surveys

i) Catchment monitoring

Input–output budget of acid substances is estimated based on the strengthened surveys on inflowing rivers to Lake Ijira (Kamagatani River and Kobora River) to monitor effects of acid deposition impacts in the acidified catchment. Intensive surveys during heavy rain events or additional surveys on soil chemistry are also planned.

- Outline of the catchment monitoring

Items		Methods
Estimate of input (total deposition)	Precipitation distribution	Rain gauges at three different slope positions: upper, middle (Ijira Station), and lower.
	NO_2	Passive sampling
	Wet deposition	EANET data, taking account of the precipitation distribution above
	Dry deposition	EANET data, taking account of NO_2 data above
	Total deposition	Sum of wet and dry deposition above
Estimate of output (material discharge)	Discharge	H–Q curve method based on the water level data
	Water chemistry	Biweekly sampling Parameters: water temperature, pH, EC, alkalinity (pH4.8 endpoint and Gran's Plot titration methods), NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, SO_4^{2-}, NO_3^-, Cl^-, TOC, total dissolved Al, SiO_2
	Material discharge	Based on the amount of flow and the water quality of the river described above, the periodic outflow amount in every two weeks is estimated.

ii) Effects of ozone on vegetation

To monitor effects of ozone on vegetation, additional surveys, such as observation of visible injury, and passive sampling of ozone in forest area, are planned.

iii) Identification of hotspots

The areas, whose soil or geology have low acid neutralizing capacity and in which acid deposition is large, may have large risk of acidification and should be monitored as "hotspots". Integrated assessment is conducted by collaborative monitoring of atmospheric environments and ecological impacts to identify such "hotspots".

4.2. State of Acid Deposition in Japan

4.2.1. Overview

The Ministry of the Environment, Government of Japan, has been conducting the surveillance for countermeasure against the acid deposition from FY1983 to grasp the state of acid deposition and its effect to the environment in Japan. The wet and dry deposition monitoring at 31 sites, inland aquatic environment monitoring at 11 sites for lakes and marshes, and soil and vegetation monitoring at 25 sites have been conducted based on the long-term acid deposition monitoring plan (prepared in March 2002).

This National Assessment of Japan summarized the long-term monitoring results from FY2003 to FY2007 and intensive surveillance at Ijira catchment where the acidification of the surrounding soils has been observed.

4.2.2. State of acid deposition and transboundary air pollution

4.2.2.1. Results of the acid deposition monitoring

- The five-year average for pH of precipitation in each site ranged from 4.51 (Lake Ijira) to 4.95 (Ogasawara), and average of whole pH data was 4.64, and the acid deposition was still observed. The precipitation with less than pH 3.0 which concerned for the acute damage to the plants was not observed, however, the pH data of the precipitation which were less 4.0 were observed at 4.5% of the daily wet deposition monitoring sites out of 14 monitoring sites.
- The pH data of the precipitation were varied year by year, there were some sites where the pHs were slightly low, and the pH values were generally moving sideways. And the deposition of the non–sea salt sulfate ion was varying within the monitoring period, and the tendency also flattened out. The deposition amount of nitrate ion also flattened from the middles of 1990's.
- The annual deposition amount of acidic components in Japan was calculated, and the non-sea salt sulfur species with 16–54 mmol m^{-2} yr^{-1} and nitrogen species with 22–130 mmol m^{-2} yr^{-1} were observed.
- The deposition amount of the acidic components related to the precipitation increased from late autumn to Spring at coastal area of Japan sea in the middle North part of Honshu Island and San'in regions, and it was recognized that the remarkable increasing tendency of the sulfur dioxide concentration in the ambient air at coastal area of Japan sea and Western Japan region.
- Since the precipitation amounts in Japan is more than those in Europe and North-America, the depositions of non-sea salt sulfate ion and nitrate ion by rain fall were twice or triple times higher than those observed in Europe and North-America. The deposition of H^+ ion in Japan was also several times higher than those in Europe and North-America. And the H^+ ion deposition was highest in East Asian region, since there was much precipitation and the percentage of acidic components which were neutralized with basic components in the ambient air and the precipitation was low.
- The wet deposition amount of non-sea salt calcium ion, PM_{10} concentration and calcium ion concentration in the aerosol were highest in Spring anywhere in Japan, and the effect to these phenomena by Yellow-sand was suggested.
- The concentration of ozone increased in Spring anywhere in Japan, and it was suggested that this phenomena caused by the effect of transboundary air pollution.

4.2.2.2. Reviews of studies on the transboundary air pollution

- The annual contribution of the transboundary pollution to the amount of acid deposition in Japan was estimated as ca. 30 – 65 % for non-sea salt sulfate ion and ca. 35 – 60 % for nitrate ion by the estimation using recent simulation model numerical calculation.
- The effect of transboundary pollution to the concentration of ozone in Japan is varied in each region, each season and day by day. Based on the results of the numerical model estimation, it was suggested that the origin of the ca. 10-25 % of monthly average concentration of ozone in Spring was East Asian region and several ppm of ozone was also came from Europe in Spring.

4.2.3. Ecological impact

4.2.3.1. The monitoring results of soil and vegetation

- The symptom of the tree deterioration was found in 17 sites out of 25 monitoring sites in FY2007. However, no tree deterioration which was exactly caused by the acid deposition and/or soil acidification as primary factors was observed.
- The decreasing tendency of pH (H_2O) in the surface layer and second layer of soil at Lake Ijira sites was observed from FY1990 to FY2004, and the significance of the continuous monitoring was suggested, since the pH of the surface layer of soil was 3.9 in FY2004 and it would be an acidity, which affected to the growth of the plants, to soak aluminum ion out of soil.
- There was no apparent acidification tendency was observed throughout the overall evaluation of each surveillance item.

4.2.3.2. The monitoring results of inland aquatic environment

- The pH and alkalinity data for the surface water of lakes and marshes were ranged from 5.36 to 7.34 and from 0.017 to 0.512 $mmol_c\ l^{-1}$, respectively. The pH and alkalinities of Lake Futago-ike Meike (Nagano), Lake Yashagaike (Fukui) and Lake Sawanoike (Kyoto) were less than and equal to 5.8 and 0.030 $mmol_c\ l^{-1}$, respectively, and these lakes could be highly acid sensitive, however, no apparent effect from acid deposition to whole lakes and marshes were not observed.
- In the catchment area around Lake Ijira, the pH of River Kamagaya which flew into Lake Ijira tend to decrease from FY1996 to FY2003, and those of pH from FY2004 has been keeping around 7. The significant increase of sulfate ion concentration in the surface water of Lake Ijira and two rivers which flew into Lake Ijira were observed

4.2.3.3. The results of catchment study in Lake Ijira

- Since the change which supposed to be caused by the acid deposition, such as pH decrease and so on, in the rivers which flew into the lake and surrounding soil around Lake Ijira was observed based on the survey from FY1988 to FY2002, the surveillance of the amount of inflow and outflow, and intensive monitoring of freshet rivers were conducted from FY2005 to FY2007 to clarify the symptom of acidification and its process quantitatively.
- Based on the following information, the acidification in the catchment area has been suggested to be kept with the elution of sulfur (S) and nitrogen (N) which were accumulated in the soil caused by the acid deposition from ambient air, such as acid precipitation.

i) The total deposition of N at the catchment around Lake Ijira was estimated as 18.2 – 28.7 $kg_{-N}\ ha^{-1}\ yr^{-1}$ which was the index of nitrate ion outflow to the mountain stream in Europe and North America. And high concentration outflow of nitrate ion has been kept even after the middle of 1990's. contribution of this much amount of the nitrogen deposition involving outflow of nitrate ion to the acidification of rivers has been suggested.

ii) As the results of the material balance in the catchment around Lake Ijira, outflow of S was twice of inflow of S in this catchment. This phenomena indicated that the S which was accumulated in the soil in past contributed to the acidification of rivers.

iii) According to the increasing tendency of sulfate and nitrate ions on freshet state, the outflow of S and N accumulated in the surface of ground in the catchment was suggested.

- Since the mechanism of the acidification around the catchment of Lake Ijira was complicated and there was a room for solving scientifically, revealing the quantitative progress of acidification in the catchment around Lake Ijira is difficult at present.
- Present state is not affect something to the human health and ecosystem immediately, and the incidence of the effect in the future and the acidification in the other region which conditions are as well as the catchment around Lake Ijira were concerned, the survey at the hot spot with high acidification risk is quite significant.

4.3. Review of National Measures Against Acid Deposition

4.3.1. Result of acid deposition monitoring

4.3.1.1. Results of wet deposition monitoring

(1) Tendency of the annual average of wet deposition

The annual average values were compared with each other which satisfied the data completeness as below.

a) Precipitation

The annual precipitation values were ranged from 626 mm.yr^{-1} in Cape Ochiishi (2004) to 5,233 mm.yr^{-1} in Yakushima. Comparing 5-year average values, relatively high precipitation were observed at Yakushima (3,831 mm yr^{-1}), Ebino (3,117 mm.yr^{-1}) and Yusuhara (2,949 mm.yr^{-1}), and the precipitation at Cape Ochiishi (830 mm.yr^{-1}), Rishiri (961 mm.yr^{-1}) and Sapporo (1,018 mm.yr^{-1}) are relatively low. The precipitation values tended to high at the Pacific Ocean side of Shikoku and Kyushu islands., and to low in Hokkaido island. No remarkable variation was observed in every monitoring site (refer to the detailed data in Appendices).

b) pH

The annual average values in recent five years and five-year average values were shown in Figure 4.3.1. The range of the annual average pH in each site was from 4.40 in lake Ijira (2003) to 5.04 in Ogasawara (2003). And the pH in Rishiri, Sapporo and Goto were relatively low in these years. Whole average of pH was 4.68, and it was recognized that the precipitation was still acidified.

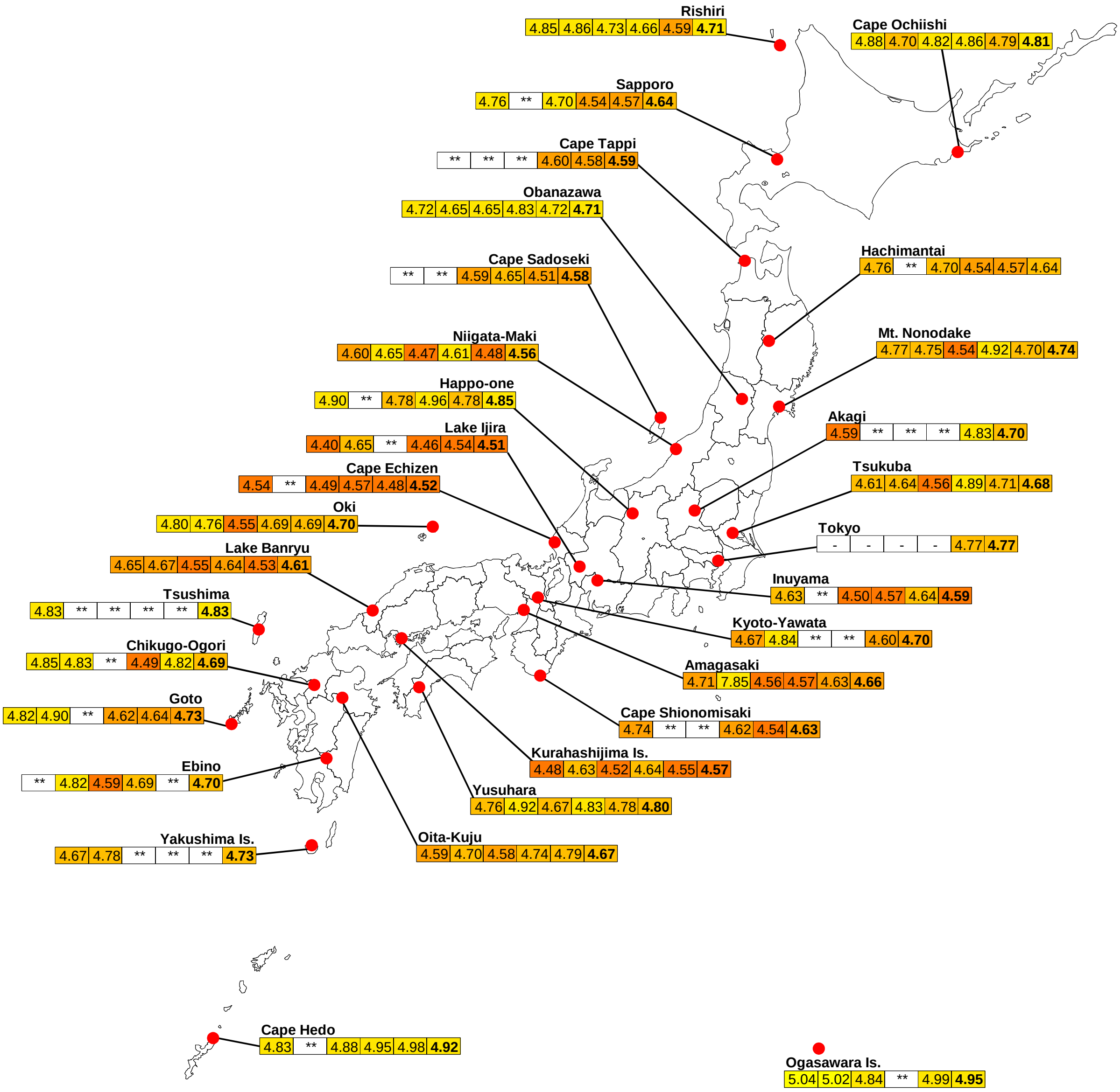


Figure 4.3.1. Geographical distribution of precipitation pH over Japan.

-: no monitoring data

***: Data did not satisfy the completeness criteria*

Notes: 1) Weighted means for precipitation amounts were calculated

2) Data that did not satisfy the completeness criteria were not used for the calculation

c) Concentrations and deposition amounts of primary ion components

The pH values are generally determined by the balance of acidic and basic components. Since sulfuric acid and nitric acid are considered as the primary acidic components and ammonium and basic calcium compounds are considered as the primary basic components in the wet deposition, non-sea salt sulfate ion and nitrate ion in the precipitation are regarded as the index contributing to the acidification of wet deposition, and ammonium ion and non-sea salt calcium ion are regarded as the index of counter-acidification. The information on the wet deposition amount is available for grasping the long-term effect to the eco-system. The overview of the concentrations and deposition amounts of these four ion components were shown in Table 4.3.1.

Table 4.3.1. Concentrations and deposition amounts of primary ion components in the precipitation samples.

Ion components	Concentration	Deposition amount
nss-SO_4^{2-}	Range: 4.1 μmol.l^{-1} at Ogasawara in 2002 to 26.6 μmol.l^{-1} at Chikushi-Ogori in 2006 and Goto in 2007 Whole average: 13.8 μmol.l^{-1} Tendency: high concentration in Chikugo-Ogori and Cape Echizen, low concentration in Ogasawara, Yusuhara and Cape Hedo	Range: 5.0 mmol m^{-2} yr^{-1} at Ogasawara in 2004 to 67.5 mmol m^{-2} yr^{-1} at Chikushi-Ogori in 2006 Tendency: high concentration in Yakushima, Lake Ijira and Ebino, low concentration in Cape Ochiishi and Ogasawara
NO_3^-	Range: 3.2 μmol.l^{-1} at Ogasawara in 2005 to 28.8 μmol.l^{-1} at Lake Banryu in 2007 Whole average: 14.2 μmol.l^{-1} Tendency: high concentration in Cape Tappi, Cape Sado-Seki and Cape Echizen, low concentration in Ogasawara, Yusuhara and Ebino	Range: 4.8 mmol m^{-2} yr^{-1} at Ogasawara in 2004 to 68.0 mmol m^{-2} yr^{-1} at Lake Ijira in 2006 Tendency: high concentration in Lake Ijira, Yakushima and Cape Echizen, low concentration in Ogasawara and Cape Ochiishi
NH_4^+	Range: 3.6 μmol.l^{-1} at Ogasawara in 2002 to 37.2 μmol.l^{-1} at Chikushi-Ogori in 2006 Whole average: 15.1 μmol.l^{-1} Tendency: high concentration in Tokyo, Chikugo-Ogori and Sapporo, low concentration in Ogasawara, Yusuhara and Cape Hedo	Range: 5.7 mmol m^{-2} yr^{-1} at Ogasawara in 2003 to 94.2 mmol m^{-2} yr^{-1} at Chikushi-Ogori in 2006 Tendency: high concentration in Chikugo-Ogori and Lake Ijira, low concentration in Ogasawara and Cape Ochiishi
nss-Ca^{2+}	Range: 0.8 μmol.l^{-1} at Ogasawara in 2005 to 11.0 μmol.l^{-1} at Chikushi-Ogori in 2007 Whole average: 3.3 μmol.l^{-1} Tendency: high concentration in Cape Tappi, Chikugo-Ogori and Cape Sado-Seki, low concentration in Ebino, Ogasawara and Yusuhara	Range: 1.7 mmol m^{-2} yr^{-1} at Ogasawara in 2004 to 17.9 mmol m^{-2} yr^{-1} at Chikushi-Ogori in 2007 Tendency: high concentration in Chikugo-Ogori and Happo-one, low concentration in Cape Ochiishi, Ogasawara and Rishiri
H^+	Range: 9.1 μmol.l^{-1} at Ogasawara in 2003 to 39.7 μmol.l^{-1} at Lake Ijira in 2003 Whole average: 20.8 μmol.l^{-1} Tendency: high concentration in Lake Ijira and Cape Echizen, low concentration in Ogasawara, and Cape Hedo	Range: 10.8 mmol m^{-2} yr^{-1} at Cape Ochiishi in 2003 to 115 mmol m^{-2} yr^{-1} at Lake Ijira in 2003 Tendency: high concentration in lake Ijira and Yakushima, low concentration in Cape Ochiishi, Ogasawara and Rishiri

(2) Seasonal trend of wet deposition

Thirty one monitoring sites were categorized to 7 regions, Hokkaido (R-1), Japan sea coastal area of middle and Northern region of Honshu island. (R-2), coastal area of the Pacific Ocean (R-3), coastal area of Seto-naikai (R-4), San'in region (R-5), coastal area of East China sea (R-6) and South-Eastern Islands (R-7), for grasping the seasonal trend of wet deposition in each region.

Seasonal variation on the deposition amount of nss-SO_4^{2-} and NO_3^- which were the index of contribution to the acidification of the precipitation were shown in Figure 4.3.2 and Figure 4.3.3.

Maximum precipitation amount was observed in July in R-2, R-3, R-4, R-5 and R-6, and in June in R-7. This observation would be caused by the effect of the rainy season. And maximum precipitation amount in September in R-1 would be caused by the effect of typhoon.

High concentration tendency during winter to spring for nss-SO_4^{2-} except in R-1 and for NO_3^- except in R-7 were observed. The tendency of high deposition amount was observed during late autumn to spring in R-2 and R-5. The supply of the acidic compounds into the ambient air was considered in these regions, and this observation would be caused by the trans-boundary transportation from the continent.

Maximum concentrations of nss-SO_4^{2-} and NO_3^- in R-3 and R-4 were observed in July whose precipitation were much more than the other seasons, and minimum concentrations of those were observed during winter season. And, these concentrations in R-1 were less than any other regions throughout the year. The tendency of the NH_4^+ concentration and deposition amount was similar to those of NO_3^-, and it was suggested that the environmental behavior of these two species were similar.

Concentration and deposition amount of nss-SO_4^{2-} indicated maximum values in spring season except in R-7, and even in R-7, these values were relatively high also in R-7, and it was suggested that the effect of yellow sand was observed in whole regions.
The concentration of H^+ in R-2, R-5, R-6 and R-7 indicated maximum value in winter and apparent seasonal variation was not observed in R-1, R-3 and R-4. The deposition amount of H^+ in R-2 and R-5 were high in winter and maximum values in R-3, R-4 and R-7 were observed in July.

(3) Quality assurance and quality control (QA/QC) of the monitoring data

Data quality for wet deposition monitoring has been secured by unifying any procedures from sample collection to the measurement and data evaluation in accordance with the Technical Manual for Wet Deposition Monitoring in East Asia. And monitoring sites and laboratories in charge of measurements have been inspected by the implementation of the site observation and Inter-laboratory comparison (ILC) Project. Some laboratories also participated in the other ILC programme which has been operated by foreign monitoring network such as WMO and EMEP to secure their monitoring quality to keep the international comparability.

a) Inter–laboratory comparison project for wet deposition monitoring

ILC project is conducted every year to improve the data quality by clarifying the problems which were realized by the evaluation of analytical methods, operating conditions of the analytical instruments, experience of the analysis and so on. Two artificial precipitation samples which were designed and prepared by National Network Center were analyzed by the participating laboratories and the analytical results were evaluated by comparing with the Data Quality Objectives (DQOs: 15% of designed values). The deviations of submitted data from designed values were expected to be within the range of DQOs. In this period, ca. 99% of submitted data for high concentration samples and ca. 90% of those for low concentration samples satisfied above criteria.

b) On–site observation of acid deposition monitoring station

On-site observation has been conducted at EANET monitoring station in every 2 years and at the

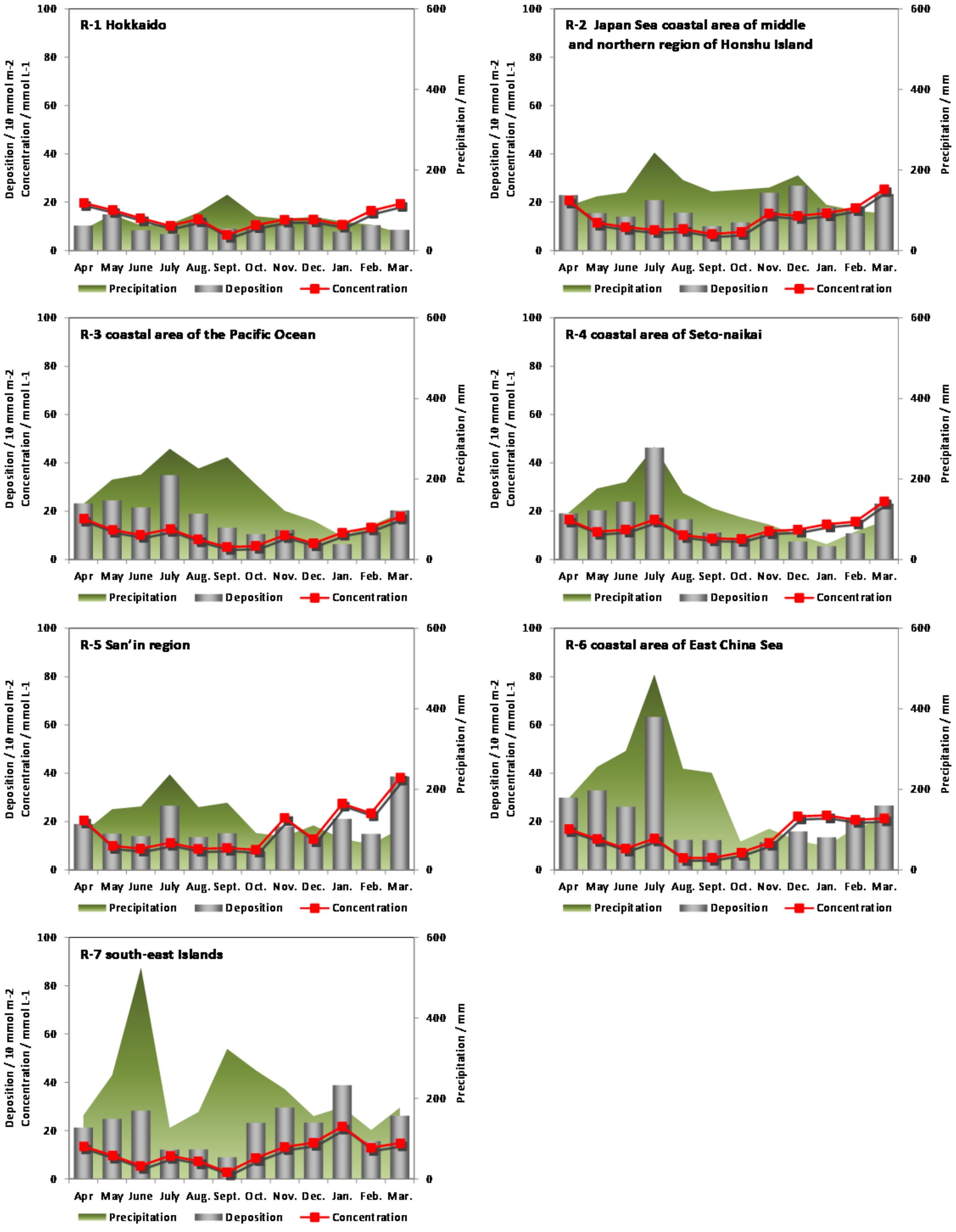


Figure 4.3.2. Seasonal trend of concentration, deposition amount and precipitation for nss–SO_4^{2-} from FY2003 to FY2007

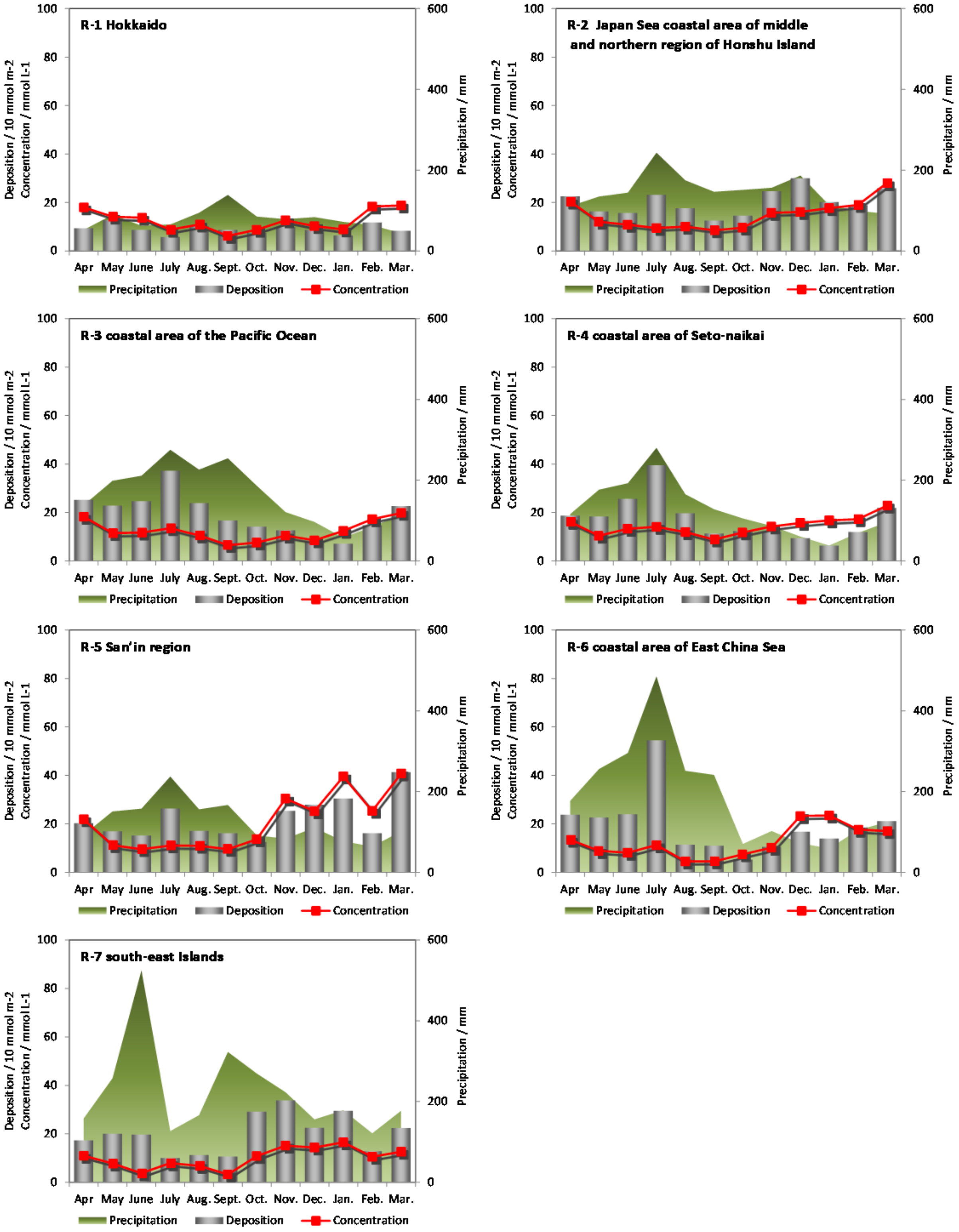


Figure 4.3.3. Seasonal trend of concentration, deposition amount and precipitation for NO_3^- from FY2003 to FY2007.

other monitoring sites in every 3 years. The on-site observation was conducted at the monitoring stations and their circumstances and analytical laboratories. This observation has been conducted by Acid Deposition and Oxidant Research Center (ADORC) (renamed Asia Center for Air Pollution Research (ACAP) from June 2010) has implemented this observation and installation conditions of sampler which effects to the collection efficiency for precipitations, existence of the interferences around the station and emission source, procedures for sample collection and analytical procedures have been investigated.

4.3.1.2. Dry deposition monitoring

(1) Trend of annual mean and seasonal variation in dry deposition

The outline of dry deposition monitoring for major monitoring parameter in 2003 to 2007, was shown in Table 4.3.2. Moreover, temporal variations of monthly mean for SO_2, O_3 and PM_{10} and $PM_{2.5}$ based on the five year estimates were shown in Figures 4.3.4, 4.3.5, and 4.3.6, respectively. The other parameters were referring to the reference data. The annual value and monthly value which were used for analysis were based on the datasets with data completeness of over 70% (An automatic monitor method: one hour value, a Filter-Pack method: two weeks value).

Major measurement parameters

a) Automatic monitor method

SO_2 (12 sites)、NOx* (11 sites)、O_3 (21 sites)、PM_{10} (11 sites)、$PM_{2.5}$ (3 sites).

b) Filter-pack method

Concentration of particulate component (SO_4^{2-}、NO_3^-、NH_4^+、Ca^{2+}) (11 sites).
Concentration of gaseous component (HNO_3、NH_3) (11 sites).
About SO_4^{2-} in the particulate component, non–sea salt SO_4^{2-} computed from Na^+ concentration as an index of a sea salt like wet deposition was used for consideration.

Table 4.3.2. Results of main monitoring items.

Monitoring items	Tendency of annual means and variations of monthly concentrations
SO_2 Automatic Monitor	Range：<0.1 ppb (2003, 2004, and 2007: Ogasawara)～1.2 ppb (2005: Yusuhara、 2007: Banryu and Ebino). Yusuhara, Ebino, and Banryu were high, and Ogasawara was low level. Whole average: (2003–2007): 0.6 ppb Tendency: There were many sites where SO_2 concentrations became high from the late autumn to spring, and those concentrations rose greatly on the Western Japan. In Ogasawara, low concentration continued through every year. The high concentrations from the late autumn to spring were considered to be the effect of transboundary air pollution like the seasonal variation of the nss–SO_4^{2-} deposition described by 4.3.1.1 (2).
NOx* Automatic Monitor	Range：0.4 ppb (2003, 2004, and 2007: Ogasawara)～4.2 ppb (2003: Banryu). Banryu, Ijira and Banryu were high, and Ogasawara was low level. Whole average (2003–2007)：1.7 ppb Tendency: The high concentrations in the Western Japan or along the coast of Japan sea from the late autumn to spring were considered to be the effect of transboundary air pollution like the seasonal variation of the NO_3^- deposition described by 4.3.1.1 (2). The concentration at Ijira was low in winter, and fluctuation of concentration at Rishiri, Ochiishi, Happo, and Hedo were small through every year.
O_3 Automatic Monitor	Range：19 ppb (2005: Ijira)～60 ppb (2004: Akagi、 and Happo) Happo and Akagi were high, and Ijira and Kyoto–yawata were low level Whole average (2003–2007): 39 ppb Tendency: O_3 concentration at all sites were high in spring and low in summer, moreover in Western Japan, high concentrations of O_3 were appeared in autumn. O_3 concentrations were high at Happo and Akagi where these heights were higher than the other sites through every year. The high concentration in spring was considered to be the effect of transboundary air pollution.
PM_{10} Automatic Monitor	Range：11 μg m^{-3} (2003: Ogasawara)～37 μg.m^{-3} (2005: Hedo) Hedo was high, and Ogasawara and Happo were low level Whole average (2003–2007)：22 μg.m^{-3} Tendency: PM_{10} concentration was high in spring at all sites and there were some sites where the concentration in autumn becomes a little higher. The high concentrations of Ca^{2+} were considered to be effected by yellow sand, because the Ca^{2+} concentration in aerosol were higher in spring than other seasons.
$PM_{2.5}$ Automatic Monitor	Range：7 μg.m^{-3} (2004: Ochiishi)～16 μg m^{-3} (2005: Oki) It is high in order of Oki, Ochiishi, and Rishiri. Whole average (2003–2007)：11 μg.m^{-3} Tendency: $PM_{2.5}$ Concentration at Oki is slightly high in spring, and Rishiri and Ochiishi had small fluctuation through every year.
nss–SO_4^{2-} Filter-Pack Method	Range：0.52 μg m^{-3} (2004: Ogasawara)～6.60 μg m^{-3} (2005: Banryu) Banryu and Yusuhara were high, and Ogasawara was low level Whole average (2003–2007)：3.56 μg.m^{-3} Tendency: nss–SO_4^{2-} Concentrations at almost sites were high in summer.

NO_3^- Filter-Pack Method	Range：0.11 $\mu g.m^{-3}$ (2004: Ogasawara)～4.08 $\mu g.m^{-3}$ (2007: Tokyo) Hedo and Banryu were high, and Ogasawara and Happo were low level. Tokyo was maximum value, but this data was only for one year. Whole average (2003–2007)：0.87 $\mu g.m^{-3}$ The variations of monthly mean; There were high concentrations in spring at almost sites.
HNO_3 Filter-Pack Method	Range ：0.03 ppb (2003 and 2004 : Ogasawara)～0.93 ppb (2007: Tokyo) Yusuhara and Ijira were high, and Ogasawara and Rishiri were low level. Tokyo was maximum value, but this data was only for one year. Whole average (2003–2007)：0.24 ppb Tendency: The little high concentrations were seen in a summer. HNO_3 concentration at Ogasawara and Hedo were low and had little fluctuation.
NH_4^+ Filter-Pack Method	Range：0.08 $\mu g.m^{-3}$ (2004: Ogasawara)～1.90 $\mu g\ m^{-3}$ (2007: Tokyo). Ijira, Banryu, and Yusuhara were high, and Ogasawara and Rishiri were low level. Tokyo was maximum value, but this data was only for one year. Whole average (2003–2007)：0.83 $\mu g.m^{-3}$ Tendency: There were high concentrations in summer at almost sites.
NH_3 Filter-Pack Method	Range：0.18 ppb (2003: Ogasawara)～5.64 ppb(2007: Tokyo). Ijira and Banryu were high, and Rishiri, Tappi, and Happo were low level. Tokyo was maximum value, but this data was only for one year. Whole average (2003–2007)：0.78 ppb Tendency: The high concentrations from spring to summer were appeared at many sites. Although Tokyo had only one year data, high concentration was continued.
Ca^{2+} Filter-Pack Method	Range ：0.02 $\mu g.m^{-3}$ (2004: Ogasawara)～0.57 $\mu g.m^{-3}$ (2007: Tokyo) Hedo was high, and Ogasawara was low level. Tokyo was maximum value, but this data was only for one year. Whole average (2003–2007)：0.24 $\mu g.m^{-3}$ Tendency: The high concentrations were appeared at almost sites in spring, and the effect of yellow sand was suggested.

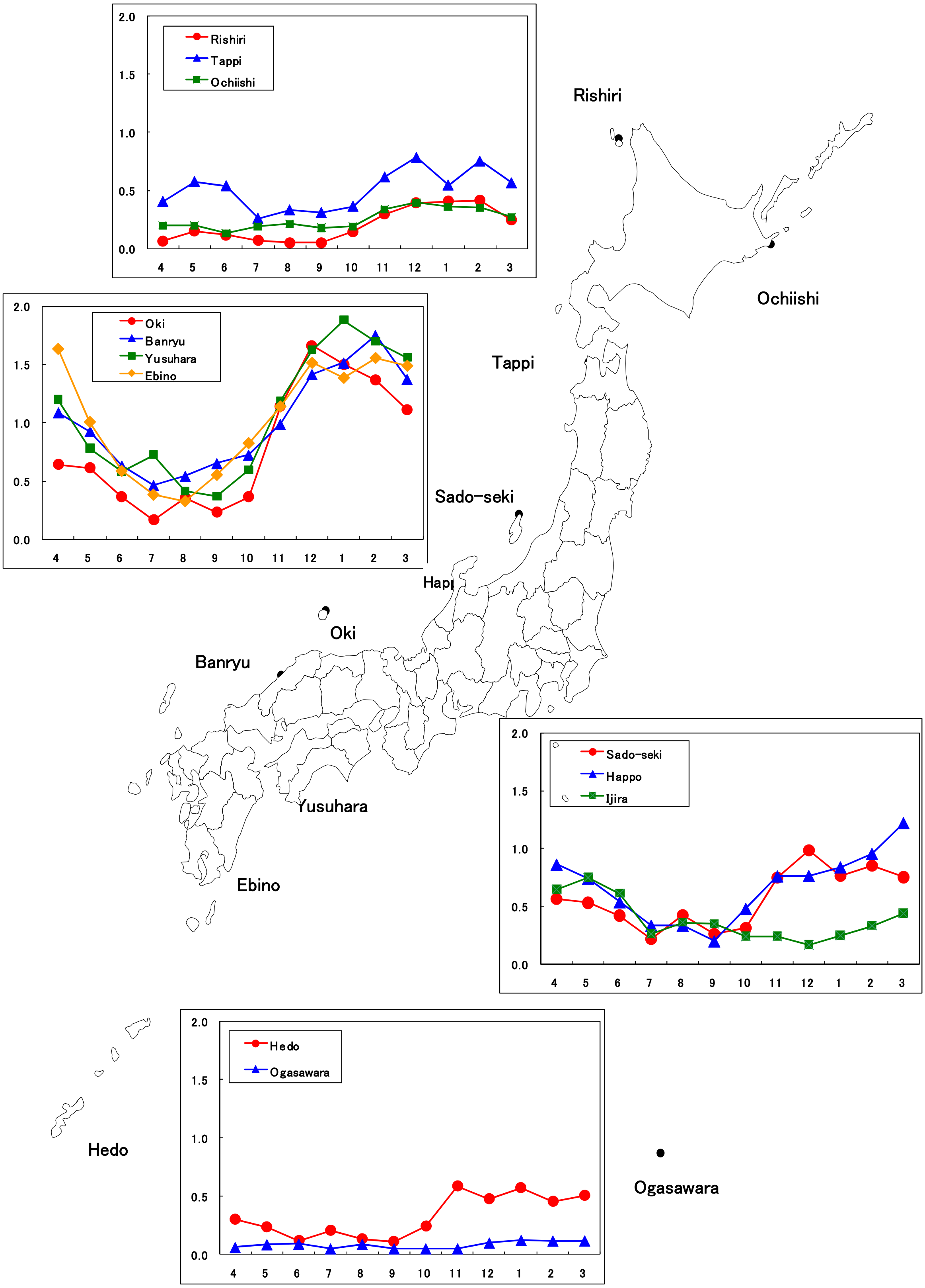


Figure 4.3.4. Temporal variation of monthly mean concentration of SO_2 in 2003–2007. *(Unit :ppb)*

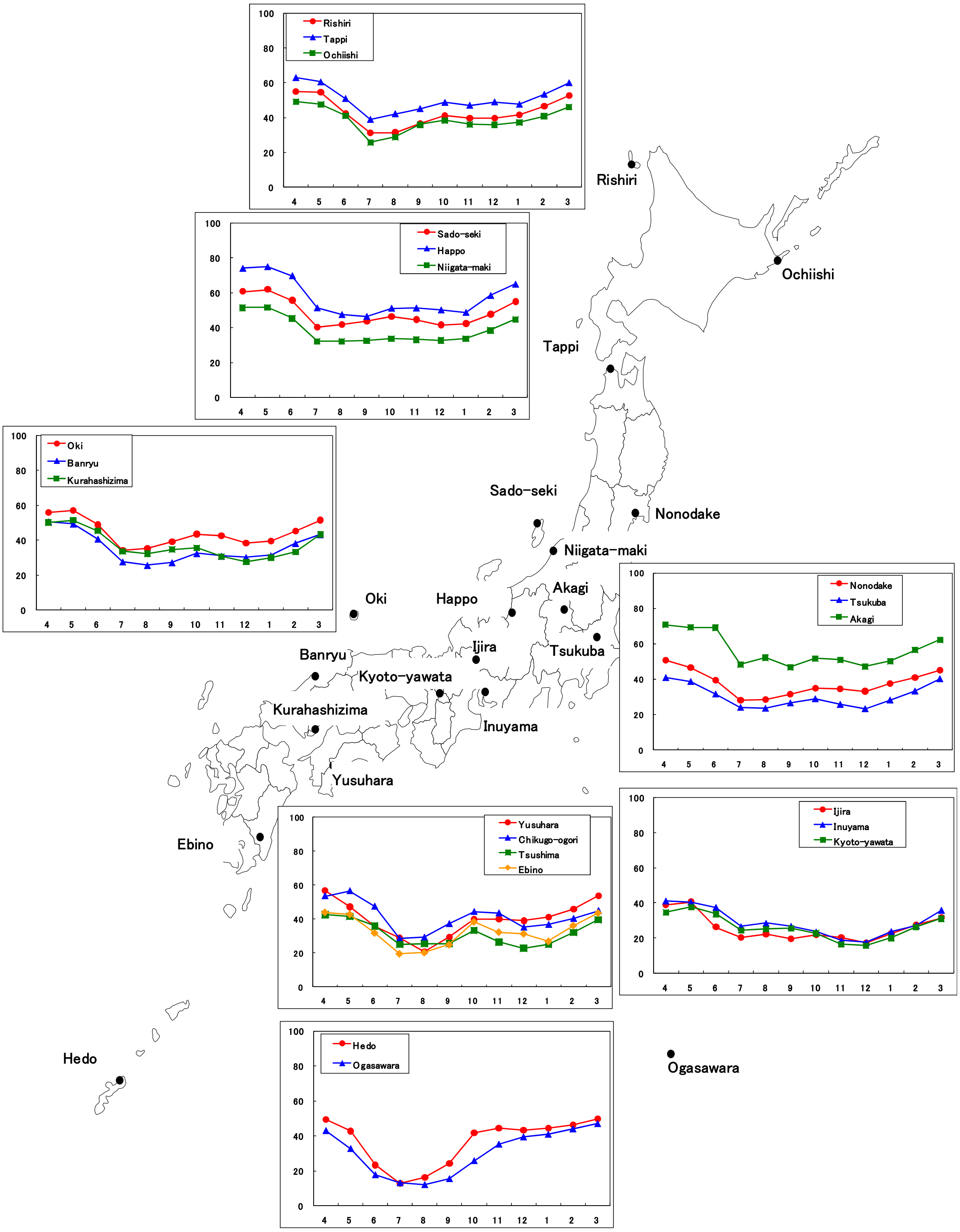


Figure 4.3.5. Temporal variation of monthly mean concentration of O_3 in2003–2007 (Unit: ppb).

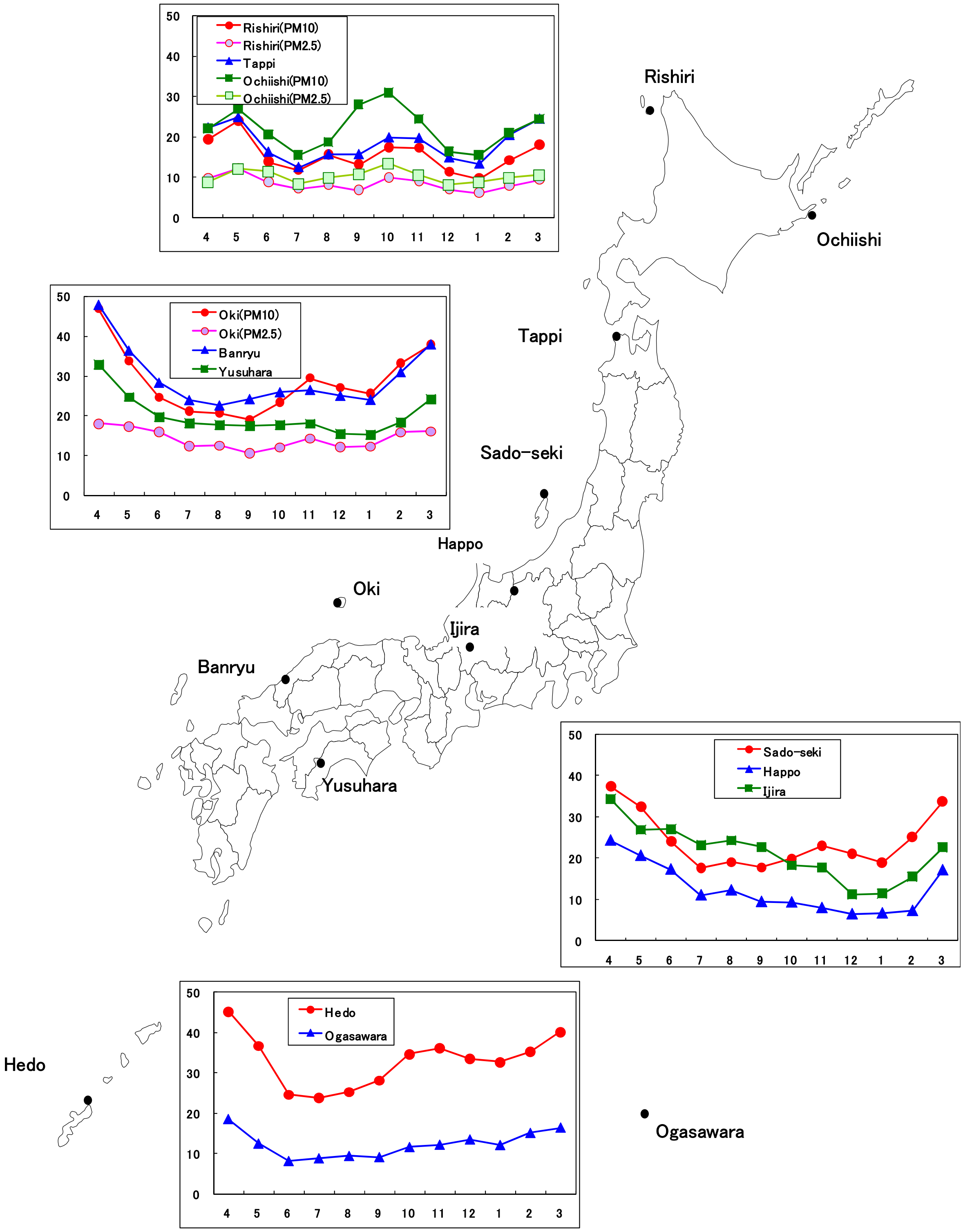


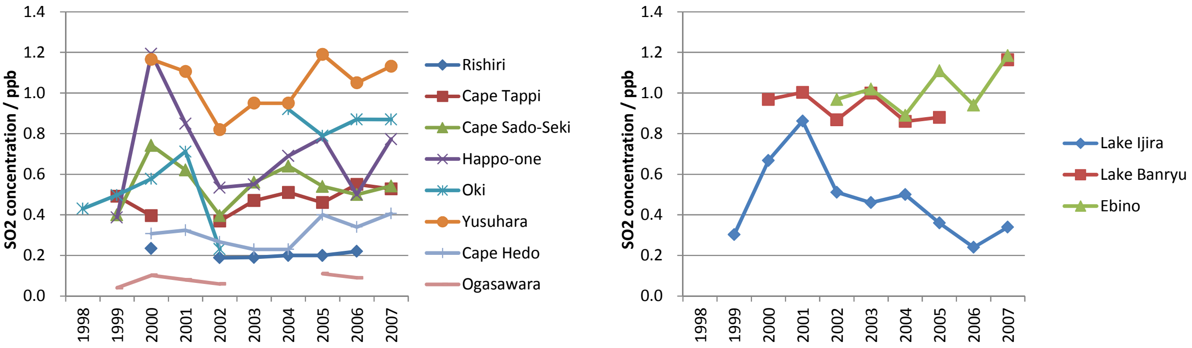
Figure 4.3.6. Temporal variation of monthly mean concentration of PM_{10} and $PM_{2.5}$ in2003–2007. *(Unit: $\mu g\ m^{-3}$)*

(2) Long–term trends of dry deposition

a) SO_2

During the period from 1998 to 2007, temporal variations of SO_2 concentration were illustrated for sites with valid data for more than six years in Figure 4.3.7.

SO_2 concentrations in remote sites were 1.0 ppb or less in concentration in general. In it, the concentration in Yusuhara was high and these in Ogasawara and Rishiri located far from the continent were low in this period. In remote sites along the coast of Japan sea, SO_2 concentrations were likely to decreased from the West side in order of Oki, Sado–Seki, Tappi, and Rishiri, and it was suggested that continental source contribution was larger as the site position was nearer to the continent. On the other hand, in non–remote sites including Ebino near Sakurajima an active volcano, the concentration in Ebino and Banryu were same level that were higher than in Ijira in this period.



［a］：Remote sites ［b］：Non–remote sites

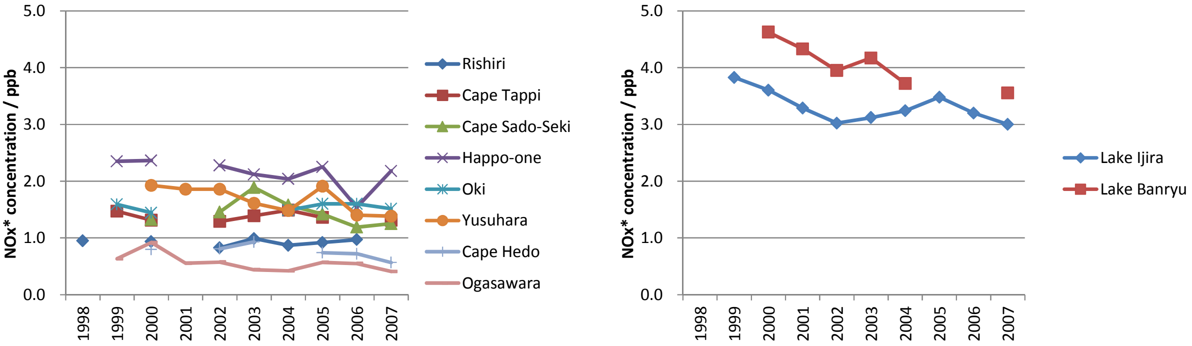
Figure 4.3.7. Trends in annual SO_2 concentration.

In Sado–seki, Happo, Ijira, and Yusuhara, SO_2 concentrations were higher in 2000 and 2001, which would be attributable to the volcanic SO_2 originating the eruption of Mount Oyama on Miyake island in August, 2000. In consideration of this effect, in recent years, some increasing trends on the concentration with fluctuations were noted in Tappi, Oki, Yusuhara, and Hedo, and the decreasing trend was suggested in Ijira.

b) NOx*

During the period from 1998 to 2007, temporal variations of NO_X* concentration were illustrated for sites with valid data for more than six years in Figure 4.3.8.

NO_X* concentration in Ijira and Banryu in non–remote site were higher than other remote sites. In remote site, the concentration in Ogasawara and Hedo were low and that in Happo was high. About long–term trend, decreasing trends on the concentration were noted in Yusuhara, Ijira, and Banryu, and the stable trends were suggested in other sites.



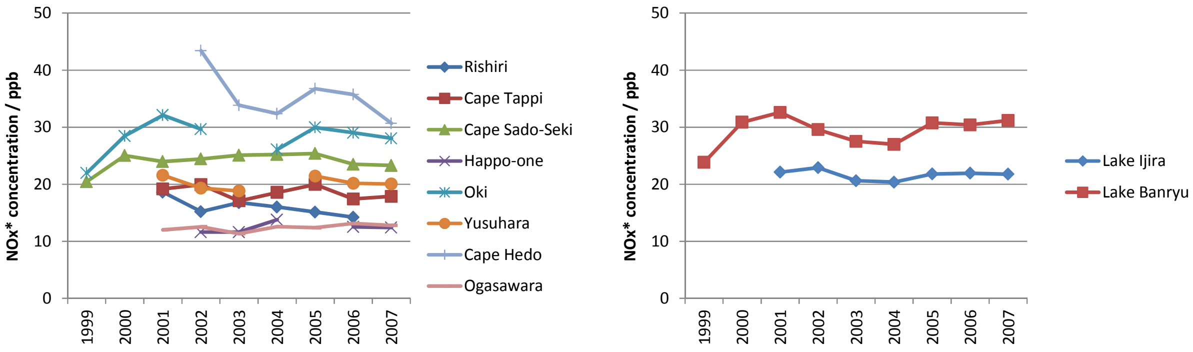
［a］：Remote sites ［b］：Non–remote sites

Figure 4.3.8. Trends in annual NO_X * concentration.

c) PM$_{10}$

During the period from 1999 to 2007, temporal variations of PM$_{10}$ concentration were illustrated for sites with valid data for more than five years in Figure 4.3.9.

In remote site, the concentration in Ogasawara and Happo were low and that in Hedo near from the continent was high. Moreover, in remote sites along the coast of the Japan sea, In remote sites in the sea of Japan side, PM$_{10}$ concentrations were likely to decreased from the West side in order of Oki, Sado–Seki, Tappi, and Rishiri, and it was suggested that continental source contribution was larger as the site position was nearer to the continent like SO$_2$ concentration. In non–remote sites, PM$_{10}$ concentration in Banryu was higher than in Ijira in this period. The long–term trends were stable in almost sites except Hedo.



［a］: Remote sites ［b］: Non–remote sites

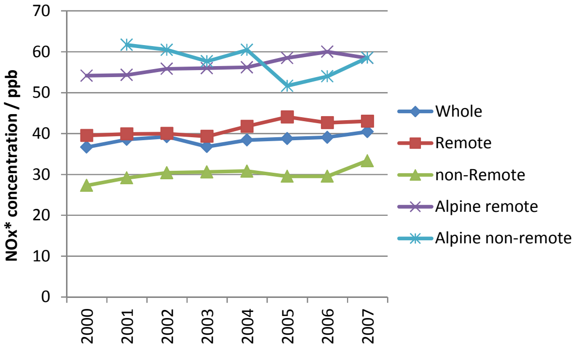
Figure 4.3.9. Trends in annual PM$_{10}$ concentration.

d) O$_3$

Monitoring sites where the valid data was obtained from 1998 in 2007 for seven years or more were classified into the remote (Rishiri, Tappi, Ogasawara, Sado–seki, Oki, Yusuhara, Tsushima, and Hedo), the non–remote (Ijira, Kyoto–yawata, Banryu, Kurahashijima, Chikugo–ogori), the alpine remote (Happo-one), and alpine non–remote (Akagi). Trends of annual mean concentration of O$_3$ in 2000 to 2007 when the valid data was obtained at 12 or more sites were shown in Figures 4.3.10 and 4.3.11.

Since annual mean concentrations for every classified area were high in order of the alpine, the remote, and the effect from the stratosphere in the alpine were larger than those from the ground level and the disappearance reaction of O$_3$ by NO in non-remote had arisen rather than the remote.

Moreover, O$_3$ annual mean concentration in remote, non–remote, alpine remote, and all sites were tended to increase. At the remote sites, O$_3$ concentrations were likely to decrease in order of the mountainous sites, the sea of Japan side, and the Pacific Ocean side.



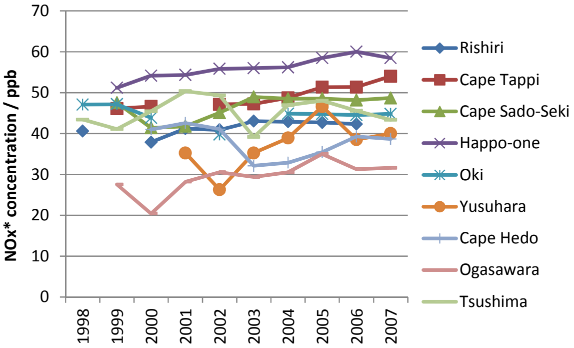


Figure 4.3.10. Trends in annual PM_{10} concentration every regions

Figure 4.3.11. Trends in annual O_3 concentration

(3) Estimation of Dry Deposition

In 10 sites (EANET sites except Tokyo and Ochiishi) which monitored the atmosphere using the Filter-Pack method in the 2003 to 2007, the dry deposition (gaseous substance: SO_2, HNO_3, NH_3, ion components in particulate matters: nss–SO_4^{2-}, NO_3^-, NH_4^+) at each site was estimated, and the results were shown in Table 4.3.3. The estimation method was made into the presuming method (the Inferential method) which searched from the product of the ingredient for the concentration in the atmosphere and the deposition rate of the each component. The deposition rate of each component was setting deposition surface to the forest and the grass field using the data of meteorological elements based on the Matsuda's method.

Dry deposition amounts to the forest were much than those to grass field for either the gaseous and particle matter. About the deposition of gaseous substances to the forest, SO_2 depositions at Banryu, Hedo, Cape Sado–Seki, and Tappi were larger, and those at Ijira and Rishiri were smaller. HNO_3 depositions at Yusuhara, Happo-one, Cape Sado–Seki, Banryu, and Tappi were larger, and that at Ogasawara was small. Moreover, NH_3 deposition showed large amount at Banryu. About the deposition of the particulate matter to the forest, every deposition at Tappi and Hedo were large, and those at Ogasawara and Ijira were small. The concentration of gaseous and particulate matter at Tappi and Cape Sado–Seki were not higher than other sites. But, there was a tendency for a deposition rate to become large depending on an ingredient, so that wind velocity was large. As the results, the large deposition amounts were estimated at both sites where had large wind velocity compared with the other sites. There is a tendency for a deposition rate to become large depending on an ingredient, so that wind velocity is large.

Table 4.3.3. Dry deposition.

Site	Year	Gaseous substance (mmol m^{-2} $year^{-1}$)						Particulate matter (mmol m^{-2} $year^{-1}$)					
		Forest			Grass field			Forest			Grass field		
		SO_2	HNO_3	NH_3	SO_2	HNO_3	NH_3	nss-SO_4^{2-}	NO_3^-	NH_4^+	nss-SO_4^{2-}	NO_3^-	NH_4^+
Rishiri	2003	4.0	7.2	4.7	2.2	2.0	2.7	7.7	4.5	8.6	0.8	0.4	0.9
	2004	4.1	5.1	5.2	2.1	1.4	3.0	7.1	4.6	6.5	0.6	0.4	0.6
	2005	3.9	7.0	4.6	2.1	1.9	2.7	8.9	4.5	9.1	0.8	0.3	0.9
	2006	4.3	4.9	4.5	2.3	1.3	2.3	7.2	3.9	7.3	0.7	0.3	0.7
	2007	**	**	**	**	**	**	**	**	**	**	**	**
Tappi	2003	15.9	19.4	5.2	7.3	5.4	3.9	13.5	11.6	19.2	1.0	0.7	1.4
	2004	16.9	21.2	5.2	7.2	5.9	3.5	17.9	14.0	19.3	1.1	0.7	1.3
	2005	14.1	22.0	2.3	6.2	6.1	1.7	21.8	16.7	25.3	1.6	0.9	1.8
	2006	16.6	16.7	2.8	8.0	4.7	2.1	19.1	16.2	22.7	1.4	0.9	1.7
	2007	15.2	20.7	4.1	7.8	5.8	3.2	22.9	18.3	23.5	1.5	1.0	1.7
Ogasawara	2003	7.6	2.0	2.3	2.7	0.5	1.2	1.5	1.1	1.0	0.4	0.2	0.3
	2004	7.6	2.3	3.4	3.3	0.6	2.0	0.5	0.3	0.4	0.1	0.1	0.1
	2005	9.9	2.5	7.1	3.7	0.7	4.0	1.6	0.7	1.0	0.4	0.1	0.2
	2006	**	**	**	**	**	**	**	**	**	**	**	**
	2007	1.9	2.6	5.1	0.7	0.7	2.8	4.3	1.9	3.0	0.7	0.3	0.5
Sade-seki	2003	12.5	18.3	3.3	5.4	5.0	2.4	10.1	6.5	8.3	0.7	0.4	0.7
	2004	**	**	**	**	**	**	**	**	**	**	**	**
	2005	16.1	28.8	4.2	7.0	7.9	3.2	15.4	7.7	14.3	1.3	0.5	1.3
	2006	20.7	23.2	4.4	8.1	6.4	3.2	12.7	7.8	12.0	1.0	0.5	1.1
	2007	22.5	20.3	4.5	9.6	5.6	3.5	18.9	13.3	17.4	1.3	0.8	1.3
Happo	2003	11.8	21.8	6.8	5.5	6.1	3.1	8.7	3.2	10.9	0.8	0.2	1.2
	2004	15.9	23.4	5.3	6.8	6.6	2.9	11.0	4.0	13.0	1.0	0.3	1.4
	2005	16.5	14.9	6.9	7.4	4.2	3.7	12.3	3.5	14.2	1.2	0.2	1.6
	2006	10.9	23.6	5.1	5.5	6.5	2.8	9.5	1.6	10.8	1.0	0.1	1.2
	2007	10.6	24.5	4.2	5.1	6.8	2.3	9.7	1.8	12.0	1.0	0.2	1.3
Ijira	2003	3.9	4.5	8.9	1.4	1.2	3.3	1.7	0.4	3.1	0.5	0.1	1.0
	2004	4.2	7.0	8.5	1.6	1.9	3.5	2.5	0.6	3.7	0.9	0.2	1.3
	2005	3.4	7.5	7.9	1.4	2.0	3.3	2.6	0.5	3.9	0.9	0.2	1.4
	2006	3.0	6.6	7.6	1.3	1.8	3.2	2.3	0.5	3.4	0.9	0.1	1.4
	2007	2.3	5.1	5.9	1.0	1.4	2.7	2.0	0.5	3.0	0.8	0.2	1.3
Oki	2003	12.0	7.2	5.0	5.4	2.0	3.2	11.5	5.7	8.6	1.1	0.4	0.9
	2004	12.7	8.4	5.8	5.6	2.3	4.0	10.7	6.9	12.8	1.1	0.6	1.4
	2005	15.8	16.4	5.5	6.7	4.5	3.9	17.5	8.9	19.8	2.0	0.7	2.4
	2006	15.5	15.9	4.1	7.2	4.3	3.2	16.8	9.0	20.1	1.9	0.7	2.3
	2007	**	**	**	**	**	**	**	**	**	**	**	**
Banryu	2003	18.5	12.7	10.3	8.2	3.5	6.1	8.3	4.3	8.1	1.0	0.4	0.9
	2004	21.6	19.8	13.1	9.0	5.4	7.8	11.7	6.8	15.3	1.5	0.6	2.0
	2005	16.9	23.0	8.3	8.1	6.3	5.3	14.4	8.0	19.4	2.1	0.7	2.7
	2006	21.4	20.9	9.9	9.5	5.7	6.1	15.6	8.5	20.8	2.3	0.8	3.0
	2007	21.2	21.2	8.8	9.5	5.8	5.5	15.6	8.2	20.1	2.0	0.8	2.7
Yusuhara	2003	11.7	16.7	5.4	5.8	4.6	3.0	8.3	2.8	10.3	1.4	0.4	1.7
	2004	11.7	19.0	5.3	5.2	5.2	2.7	11.6	2.3	13.4	1.8	0.3	2.2
	2005	12.3	25.5	3.6	6.4	7.2	2.2	11.9	2.7	15.0	2.5	0.4	3.1
	2006	17.8	23.7	4.8	8.2	6.7	2.4	11.1	2.4	14.8	2.2	0.3	2.8
	2007	17.5	25.3	7.3	8.5	7.1	3.5	12.5	2.5	15.5	2.3	0.4	3.0
Hedo	2003	21.1	8.9	5.0	9.0	2.4	3.9	16.3	17.4	16.7	1.4	1.2	1.4
	2004	28.9	14.2	6.7	12.6	3.9	5.2	9.6	6.6	7.9	0.9	0.5	0.7
	2005	17.1	11.4	5.9	7.5	3.2	4.8	26.0	14.9	22.0	2.4	1.0	2.0
	2006	13.8	8.6	5.4	6.4	2.4	4.3	24.4	14.9	19.4	2.3	1.1	1.9
	2007	12.4	12.0	7.9	5.6	3.3	6.2	26.2	14.3	24.2	2.2	1.0	2.3

** Data was rejected because of less than 70% of valid data in the period

(4) Quality assurance / quality control

Based on the 3rd Scientific Advisory Committee, inter–laboratory comparison for dry deposition started since 2005. Impregnated filters which contain three ions, SO_4^{2-}, Cl^-, and NH_4^+, were prepared and distributed to the participating laboratories by the Network Center (NC). Most of the laboratories participating in EANET activities joined this activity and submitted their analytical results to NC. Obtained results for the amount of SO_4^{2-}, Cl^-, and NH_4^+ on the distributed filters were compared with the prepared values and statistically treated.

Submitted analytical data quality for low concentration sample were keep these quality, 83.3% of DQOs at 1st project, 85.7% of DQOs at 2nd project, and 66.7% of DQOs at 3rd project.

In high concentration samples were keep these quality, 91.7% of DQOs at 1st project, 100% of DQOs at 2nd project, and 95.2% of DQOs at 3rd project.

4.3.2. Results of ecological impact monitoring

4.3.2.1. Results of soil and vegetation monitoring

(1) Results of soil and vegetation monitoring from 2003 to 2007

The objectives of this survey were to obtain baseline data on soil and vegetation and to make early detection of acid deposition impacts on forest ecosystems. Twenty-five sites (50 soil plots) of 19 areas were established in conservation areas such as national parks (NPs) or natural heritages focusing on impacts on trees or in the areas with red-yellow soils focusing on impacts on soil. Soil surveys and forest vegetation surveys were carried out there.

a) **Acid buffering capacity of soil and effective factors to the variability**

Forest soils in Japan are generally acidic. Chemical properties of soil depend on its formation process and effective factors to the formation. Acidic soil can be produced even under natural conditions without anthropogenic effects. Therefore, chronological changes of chemical properties and their degrees will be evaluation criteria for assessment of impacts on soil. In this section, acid buffering capacity of soil was evaluated taking soil types in the respective sites into consideration. The pH (H_2O) and exchangeable (Ca+Mg+K)/Al (equivalent ratio) of the surface soil of each site were shown in Figure 4.3.12.

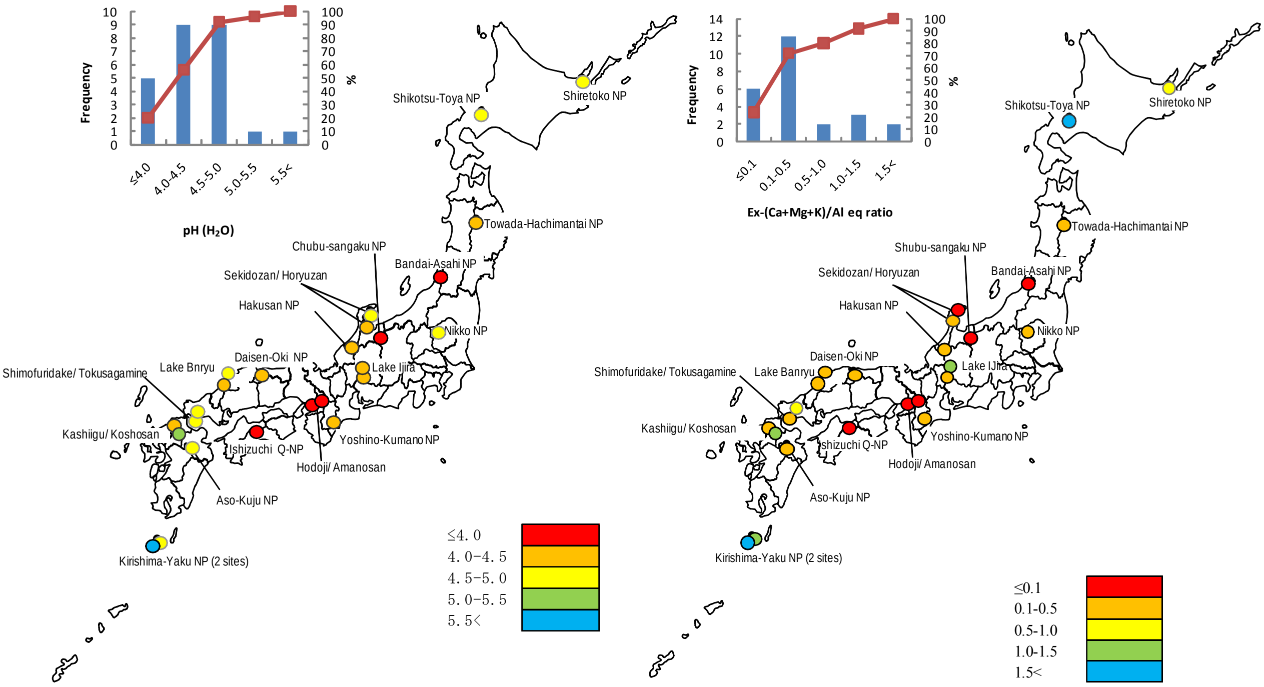


Figure 4.3.12. The pH (H_2O) (left) and exchangeable (Ca+Mg+K)/Al (equivalent ratio) (right) of surface soil in each site.

The soil pH (H_2O) was lower than or equal to 5.0 in all the sites except for a laurel forest of Yakushima island or Mt. Koshosan. The pH (H_2O) was lower than or equal to 4.0 especially in Bandai-Asahi National Park (brown forest soil), Chubu-Sangaku NP (podzolic soil), Ishizuchi Quasi-NP (brown forest soil), Houdouji Temple (red-yellow soil), and Mt. Amanosan (brown forest soil). The pH (KCl) was lower than 4.0 in all the sites except for the laurel forest of Yakushima Island (4.8), Mt. Koshosan (4.5), Nikko NP (4.1), and Yoshino-Kumano NP (4.1). Especially in Ishizuchi Quasi-NP, Houdouji Temple, and Bandai-Asahi NP, significantly lower pH was recorded: pH (H_2O) was 3.8, 3.8, and 3.9, and pH (KCl) was 3.1, 3.2, and 3.4, respectively.

The equivalent ratio of exchangeable (Ca+Mg+K) to exchangeable Al (Ex-BC/Al ratio), which can be considered as an indicator of acid buffering capacity, showed a similar tendency to pHs: the values in the sites with significantly lower pH (<4.0), such as Mt. Amanosan, Ishizuchi Quasi-NP, Bandai-Asahi NP, and Houdouji Temple, were 0.06, 0.07, 0.09, and 0.09, respectively. Moreover, the Ex-BC/Al ratio showed a relatively high positive correlation with pH (H_2O) and pH (KCl) (r: 0.611 and 0.574, respectively).

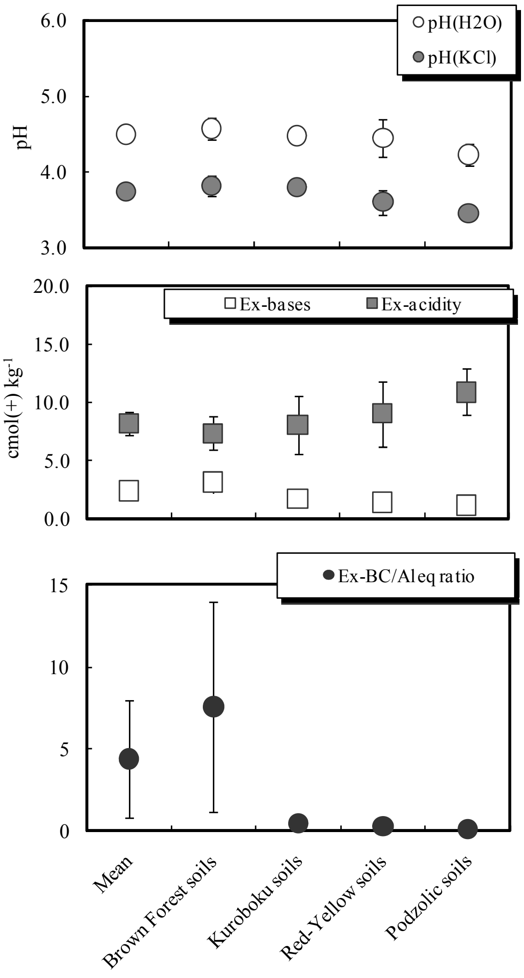


Figure 4.3.13. Chemical properties of each Great Group soil.

Based on an acidification experiment of various soil types, the Synthesis Report on Japan Acid Deposition Surveys (2004) pointed out that the Ex-BC/Al ratio can be changed by a pH 4.0 acid precipitation in case of the soil whose Ex-BC/Al ratio was lower than 0.1. Therefore, in the sites with lower pH and Ex-BC/Al ratio, changes in soil chemical properties should be monitored continuously.

According to the Unified Soil Classification System of Japan-2nd Approximation- (Japanese Society of Pedology, 2002), soils in the survey sites can be classified into four Great Groups, namely, Brown Forest soils (14 sites), Kuroboku soils (4 sites), Red-Yellow soils (4 sites), and Podozolic soils (3 sites). The mean values and standard errors of representative parameters among each soil Great Group were shown in Figure 4.3.13. In pH (H_2O), Podozolic soils < Red-Yellow soils ≈ Kuroboku soils ≈ Brown Forest soils, and in pH (KCl), Podozolic soils < Red-Yellow soils < Kuroboku soils ≈ Brown Forest soils. Exchangeable acidity was from 3 to 10 times larger than sum of exchangeable base cations (Ca, Mg, K, and Na) in all the soil Great Groups, reflecting low pH of the soils. Especially in Podozolic soils and Red-Yellow soils, the difference between the sum of base cations and the acidity was significantly larger, suggesting less base cations and more acidity.

In Ex-BC/Al ratio, Podozolic soils (0.1) < Red-Yellow soils (0.3) ≈ Kuroboku soils (0.5) << Brown Forest soils (7.6). The larger mean value of Brown Forest soils can be attributed to a base-rich soil in the laurel forest of Yakushima Island. When this significantly larger value is removed, the mean value will be 1.2. Variation among Brown Forest soils was quite large. As mentioned above, the survey sites showing relatively high acidity, represented by Ishizuchi Quasi-NP, Bandai-Asahi NP, Mt. Amanosan, could also be found.

Soil monitoring was carried out taking effective factors to variability of the obtained data into account. As the effective factors in the field sampling, several sampling levels, such as “area”, “soil type (site)”, “plot”, and “subplot”, were considered. Cumulative contributions of these sampling levels to the data variability were shown in Figure 4.3.14.

Area	18
Soil type	1 or 2
Plot	2
Subplot	5
Repeat analysis	2 times

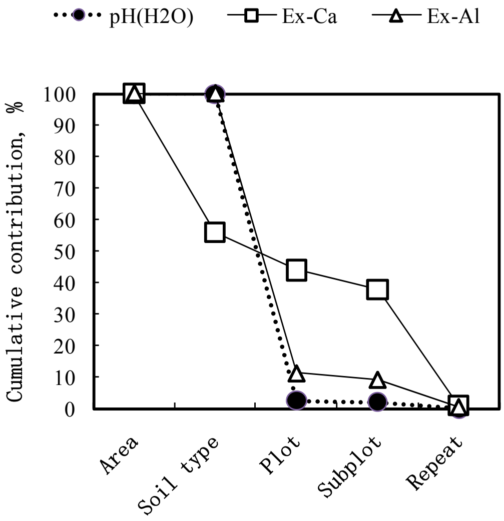


Figure 4.3.14. Soil sampling system (left) and cumulative contributions to variance in chemical properties of surface soils (right).

The data in Mt. Koshosan, which showed significantly larger variations among plots and subplots, were not included in the analysis.

In soil pH and Ex-Al, indicators of acidity, “soil types” had much effect on the total variability, reflecting difference of soil acidity in the respective soil types. In Ex-Ca, “subplots” and “area” had much effect on the total variability; the former one might reflect spatial heterogeneity of soil, such as thickness of organic layer, and the latter one might reflect geology or climate than soil type.

1) Evaluation of soil acidification trends

Most survey sites focusing on soil acidification were established in 2001 and Red-Yellow soils or similar types of soil were selected with their reference types of soil in each area. According to the long-term monitoring program, the second surveys were carried out for all the sites until 2007, while the sampling intervals were varied from 2 to 6 years. The mean values among the respective plots (mean of five subplots) in these sites were shown in Table 4.3.4.

Table 4.3.4. Changed of chemical propertied of surface soils (0-10 cm) in red-yellow soils.

Area	Site	Soil type	Plot	Survey year	pH		ECEC cmol(+) kg^{-1}	BS %	Ex–(Ca+Mg+K)/Al eq ratio
					H_2O	KCl			
Ishikawa Pref.	Sekidozan	Brown forest soils	1	2001	4.4	3.7	15.29	8.02	0.08
				2005	4.3	3.5**	14.82	10.83	0.12
			2	2001	4.5	3.8	13.16	11.19	0.13
				2005	4.4	3.5**	13.50	12.38	0.15
	Horyuzan	Red soils	1	2001	4.6	3.8	17.17	9.87	0.10
				2005	4.6	3.6	17.20	8.50	0.09
			2	2001	4.6	3.8	19.67	12.38	0.13
				2005	4.6	3.6**	19.18	10.51	0.11
Osaka Pref.	Amanosan	Reddish brown forest soils	1	2001	4.2	3.4	9.16	9.07	0.11
				2007	4.1	3.4	9.03	5.22*	0.06*
			2	2001	3.8	3.1	11.10	6.55	0.08
				2007	4.0	3.3	10.47	4.72	0.05
	Houdouji	Yellow soils	1	2001	3.9	3.2	11.29	5.24	0.06
				2007	3.8	3.1	10.51	9.12*	0.10*
			2	2001	4.0	3.3	8.31	7.40	0.09
				2007	3.9	3.2	9.13	8.14	0.09
Shimane Pref.	Lake Banryu	Brown forest soils	1	2001	4.8	3.9	4.30	17.07	0.21
				2006	4.9	3.8	5.13	30.39*	0.53
			2	2001	4.7	3.7	4.86	27.10	0.44
				2006	4.8	3.9*	4.83	21.97	0.33
	Iwami-Rinku FP	Red soils	1	2001	4.3	3.5	8.56	16.51	0.22
				2006	4.5	3.7	7.58	15.65	0.21
			2	2001	4.2	3.3	10.61	10.72	0.12
				2006	4.4	3.6	10.53	12.60	0.16
Yamaguchi Pref.	Tokusagamine	Kurobuku soils	1	2001	4.6	3.8	11.87	10.08	0.12
				2003	4.5	3.9*	11.43	13.03	0.20
			2	2001	4.6	3.8	12.22	13.09	0.20
				2003	4.6	3.9	11.39	10.01	0.13
	Shimofuridake	Yellow soils	1	2001	4.9	3.9	5.18	31.14	0.77
				2003	4.9	3.9	4.87	36.01	0.84
			2	2001	4.8	3.9	4.45	25.95	0.47
				2003	5.0	4.0	4.05	36.11	0.97
Fukuoka Pref.	Kasiigu	Reddish brown forest soils	1	2001	4.2	3.4	19.00	13.04	0.17
				2007	4.1	3.3	18.71	8.57	0.09
			2	2001	4.5	3.5	27.90	25.03	0.42
				2007	4.4	3.4	23.62	15.13	0.18
	Koshosan	Brown forest soils	1	2001	4.8	3.9	14.23	51.29	>1.0
				2007	4.5	3.6	8.35	40.22	0.84
			2	2001	6.5	5.6	30.54	90.49	>1.5
				2007	6.1	5.4	25.50	78.40	>1.5

*Note. Superscripts, * and **, indicate significant difference at 5 % level and 1 % level, respectively, by the t-test for the mean values of subplots.*

Most plots showed no clear acidification trend but two sites in Ishikawa Pref. showed significant decrease of pH (KCl). Soil acidity in these sites may increase, since pH (KCl) indicates potential acidity of soil. In Plot 1 of Mt. Amanosan (Osaka Pref.), pH (H_2O) and pH (KCl) showed mostly same levels but base saturation and Ex-BC/Al ratio showed significant decrease. In these sites, Ex-BC/Al ratio was low, approx. 0.1, and therefore, the soils may be sensitive to acid deposition, as mentioned above. The continuous surveys are necessary in these sites. On the other hand, the opposite tendency, increase of parameters, was also found; base saturation and pH (KCl) at Lake Banryu (Shimane Pref.), pH (KCl) at Mt. Tokusagamine (Yamaguchi Pref.), and base saturation and Ex-BC/Al ratio at Houdouji Temple (Osaka Pref.). Especially around Lake Banryu, changes in conditions of the catchment area may be related to the data, since forest managements for pine wilting decease have been carried out for the last decade.

The changes in pH (H_2O) and Ex-Al of the surface soil horizon (3 - 5 cm depths) and the subsequent soil horizon (10 – 15 cm depths) were shown for the long-term monitoring plots in the Lake Ijira Catchment site. The pH (H_2O) decreased continuously in the surface horizon and subsequent horizon at all five plots for 14 year from 1990 to 2004, while some fluctuations could be found. The mean pH (H_2O) of the surface layer (collected by the fixed depth, 0 - 10 cm) among two plots for the EANET monitoring were 4.3 (3.9 - 4.4) in 2006, and it can be clarified that these plots were also acidified similarly to the long-term plots. The Ex-Al, an indicator of acidity, showed increasing trends in most plots especially for the surface horizon, and in a few plots for the subsequent horizon.

In the Lake Ijira catchment, as described in the section 4.3.3, a wet deposition amount of H^+ is the highest level in Japan, and the river water chemistry showed several acidification phenomena, such as, temporary SO_4^{2-} leaching, decrease of the water pH, and continuous increase of the NO_3^- concentration. Therefore, changes in the soil chemical properties can be considered as a part of the acidification process in the whole catchment area.

Since soil pH may decrease due to a rapid uptake of nutrient bases during plant growth periods, it may be necessary to evaluate the respective contributions of H^+ production in the ecosystem and H^+ input from the atmosphere to the soil acidification in detail. However, as shown in the section 4.3.3, the tree growth rates in the Lake Ijira catchment showed decreasing trends during the sampling period of soil. The rapid decrease of soil pH observed here cannot be explained only by plant uptake. In the catchment, since forest managements such as thinning had not been carried out, the management conditions should also be considered. However, taking the highest level of wet deposition amounts in Japan, the high acid loading seems to be a main cause of soil acidification. The soil pH (H_2O) decreased to the significantly lower level, 3.9 in average in the surface soil. In the buffering process of soil, buffering reactions by Al-(hydro)-oxide may occur mainly in the pH range, and Al^{3+} toxic to plant growth can be leached into the soil water. Therefore, it may be necessary to monitor effects of the soil acidification on plant physiology in future.

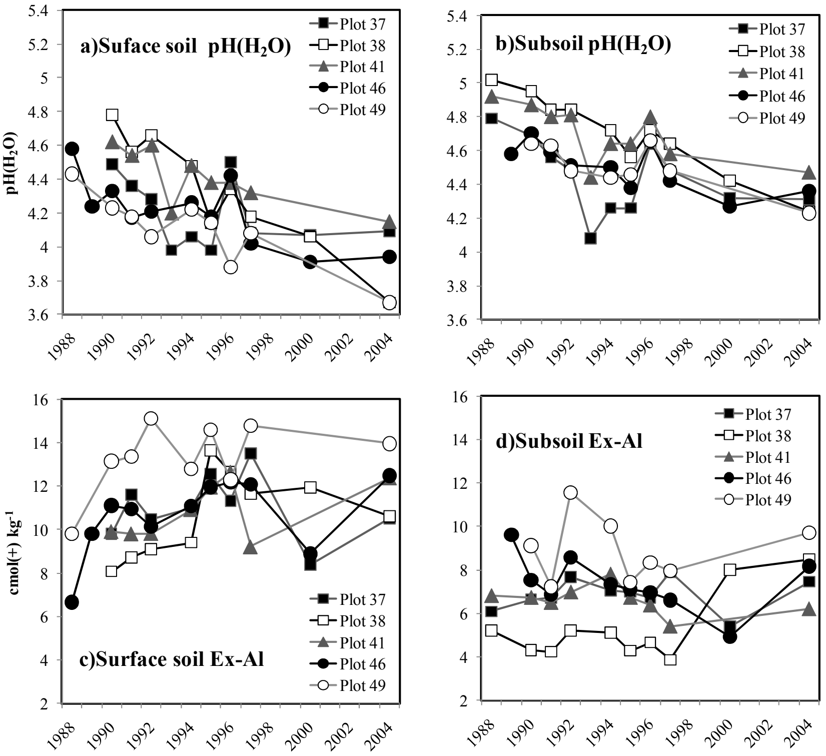


Figure 4.3.15. Chronological changes in pH (H_2O) and exchangeable Al of soils at long-term monitoring plots in the Lake Ijira Catchment site.

Surface layer, until 3 – 5 cm depths; subsequent layer, until 10 – 15 cm depths. The measurement of pH(H_2O) was done by the following soil:solution ratio: 1:5 until 1992, and 1:2.5 from 1993.

2) Assessment of tree decline conditions

Figure 4.3.16 showed the mean values of “dieback of stem” and “density of foliage”, which were observed as indices of tree decline symptoms. The indices were recorded according to 5- or 4-class decline scales, from 0 (healthy) to 5 (dead) in case of “Dieback of stem” or 4 (dead) in case of “Density of foliage”. The larger values showed clearer decline symptoms.

Some decline symptoms were observed in 17 sites among 25 sites, while small changes of tree forms in Mt. Sekidozan and Mt. Amanosan were not included in the figure. The cumulative values of two parameters were the largest in Chubu-Sangaku NP and then in Yoshino-Kumano NP, where more than half of trees showed some symptoms. In Yoshino-Kumano NP, typhoons may be a main cause of the symptoms, which were observed in *Fagus crenata* and *Abies homolepis*. In Chubu-sangaku NP, the cause has not been identified but small precipitation amounts during the growing period in 2007 were pointed out. In other sites also, the declining trees, which were mainly caused by acid deposition or soil acidification, were not identified.

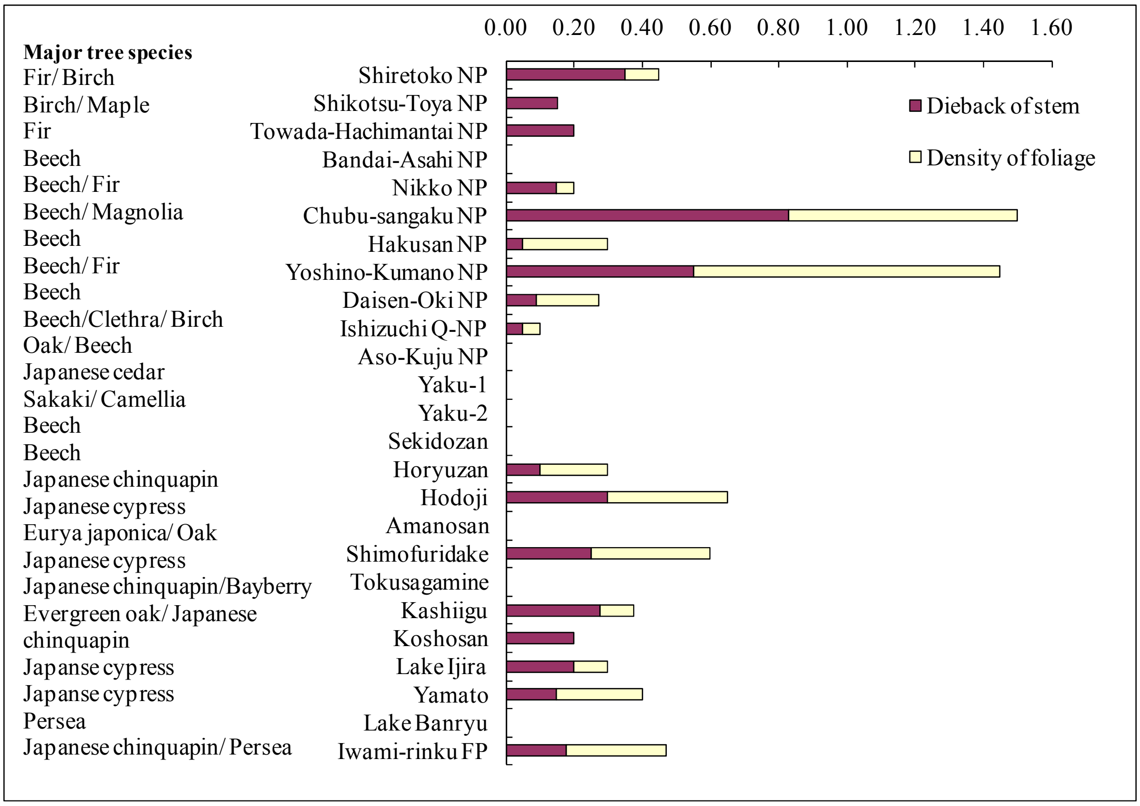


Figure 4.3.16. Major tree species and conditions on “dieback of stem” and “density of foliage” in 2007.

The column graph shows cumulative values of the means of two parameters in the respective plots (the larger values shows clearer decline symptoms).

Chronological changes in “vitality of trees” recorded as the total index of tree decline were shown in Figure 4.3.17. The tree decline symptoms that were processed from 2004 to 2005 seemed to be recovered in the later years in Shikotsu-Toya NP, Nikko NP, Daisen-Oki NP, and Ishizuchi Quasi-NP. It was suggested that damages by typhoons in 2003 were recovered after a few years. It is difficult by the observation to clearly distinguish changes by acid deposition or air pollution from changes by meteorological events/conditions, such as typhoons, cold summer, and draught stress, especially in the previous surveys until 2002, because the observation was done only once 3 – 5 years. However, the observation has been done at least once a year since 2003 according to the long-term monitoring plan, and therefore, it may be possible to distinguish effects of meteorological events/conditions. In the Lake Ijira catchment, a thinning of the dense forest as a forest management was done just after the observation of 2006, and the recovery has already been observed in 2007.

On the other hand, it seemed that the tree decline symptoms were gradually processed in Shiretoko NP, Chubu-Sangaku NP, Yoshino-Kumano NP, Hakusan NP, and Houdouji Temple. In these sites, suppression by other surrounding trees or damages by strong winds were suggested as possible main causes. However, the soil pH (H_2O) was significantly low in Houdouji Temple as described above. It can be suggested that continuous observations should be done carefully in these sites.

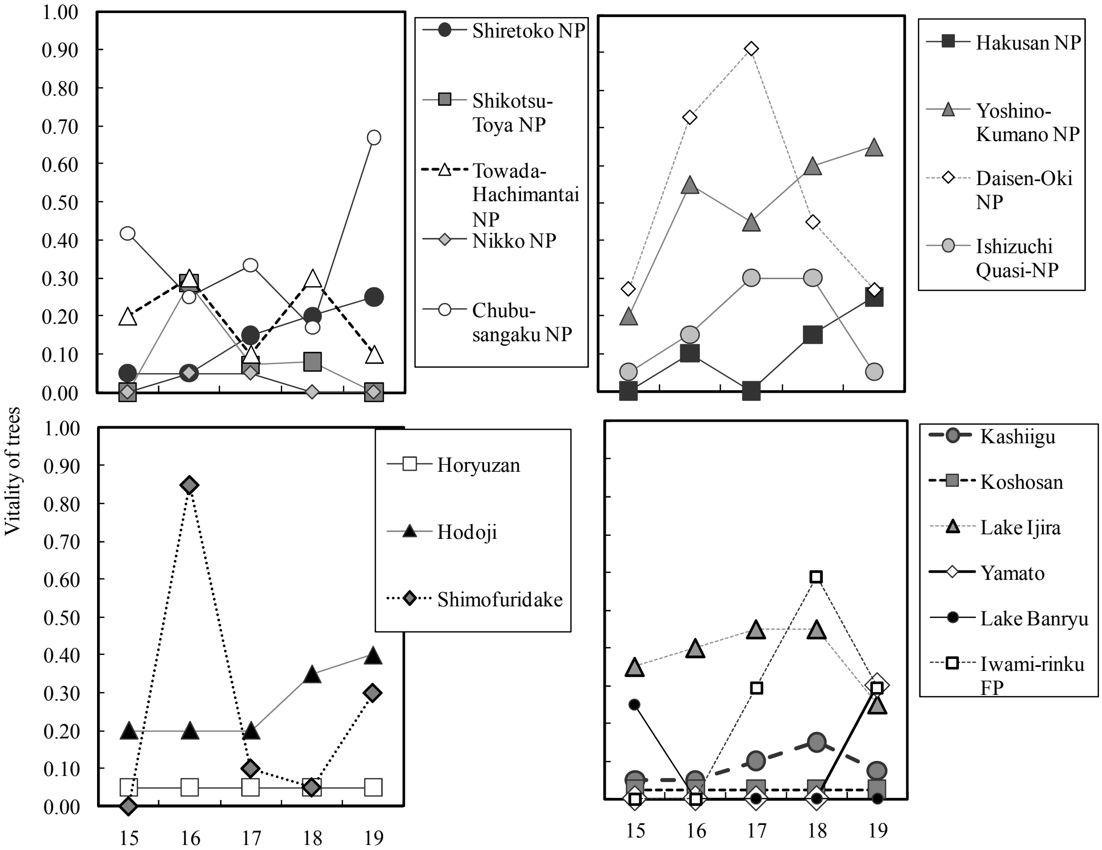


Figure 4.3.17. Chronological changes in "Vitality of trees" (the larger value shows severer decline.)

As a part of forest vegetation monitoring, description of trees (measurement of tree size or growth) and surveys on species composition in understory vegetation have also been done and the data has been accumulated. At the present, the first surveys have just finished in the last five years, and it is be expected that growth rates of trees in the respective sites will be evaluated in future.

(2) Quality assurance/quality control (QA/QC) of the data

The data quality is assured through the audit of the national center of Japan, ADORC, and in this occasion, design of the monitoring plots and sampling procedures in the sites and conditions of the laboratories are confirmed. As for analytical precisions of soil, variations in the repeatability condition, within-laboratory reproducibility condition, and reproducibility condition were significantly small and their precisions might be enough high according to the results of the inter-laboratory comparison projects on soil. The reliable data may be obtained in the surveys.

4.3.2.2. Results of monitoring on inland aquatic environment

(1) Results of monitoring on inland aquatic environment from 2003 to 2007

In this survey, 11 lakes and their inflow/outflow rivers with low EC and low alkalinity, which may be susceptible to acidification, were selected as the monitoring sites. The mean values of the representative parameters from 2003 to 2007 in the respective monitoring sites were shown in Table 4.3.5. The alkalinity in most sites was lower than 0.200 mmol$_c$ l^{-1}. Lake Futagoike (Oike), Lake Yashagaike, and Lake Sawanoike may be the most sensitive to acid deposition, showing the lowest level of alkalinity and pH; lower than 0.030 mmol$_c$ l^{-1} and lower than pH 5.8, respectively. In all the lakes including these sensitive ones, obvious effects of acid deposition were not identified. On the other hand, alkalinity and pH in Lake Nagatomiike were significantly higher than other lakes. Lake Sankyoike and Lake Banryu had large effects of sea salts and the water was dominated by Cl$^-$ and Na$^+$. The NO3- concentration was the highest in the surface water of Lake Ijira and inflow rivers among the monitoring sites. The features of the catchment areas were shown in Table 4.3.5 (b).

Table 4.3.5(a). Mean values of representative parameters in the monitoring lakes from 2003 to 2007.

Location Prefecture	Name of Lake or River	Point	pH	EC mS m^{-1}	Alkalinity mmol$_c$ l^{-1}	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}
						μmol$_c$ l^{-1}							
Yamagata.	Imagamioike	Surface	6.37	3.90	0.071	80.7	*1	175.3	*1	226.1	11.1	26.0	43.3
Tochigi	Karikomiko	Surface	6.91	3.25	0.156	115.2	5.3	20.0	1.4	131.0	14.0	117.8	14.3
Nagano	Futafoike(Oike)	Surface	7.02	1.86	0.112	33.4	15.9	11.3	0.7	46.1	6.4	107.4	15.8
	Futagoike(Meike)	Surface	5.73	0.73	0.020	29.3	4.1	10.0	0.7	13.7	4.1	22.1	7.5
Niigata	Sankyoike	Surface	6.87	8.49	0.109	92.8	2.1	542.6	1.1	510.9	30.9	81.8	113.8
Ishikawa	Ohataike	Surface	6.53	4.29	0.134	33.5	8.6	186.5	2.5	197.1	25.8	65.0	70.1
Fukui	Yashagaike	Surface	5.36	1.64	0.017	42.7	7.5	61.3	4.9	59.7	8.5	20.3	18.2
Gifu	Ijira	Surface	7.03	4.24	0.163	108.8	31.0	64.7	3.5	91.9	7.9	153.3	110.7
	Kamgatani river	Inflow	6.96	4.43	0.140	136.2	39.6	63.2	*1	93.8	7.3	150.4	122.8
	Kobora river	Inflow	6.72	3.86	0.125	101.6	33.3	68.9	*1	102.5	6.5	100.5	116.5
Kyoto	Sawanoike	Surface	5.70	1.73	0.021	32.2	*1	83.4	*1	65.7	6.4	30.1	30.6
Shimane	Banryu	Surface	7.06	10.65	0.166	88.1	1.7	634.3	1.8	605.5	47.6	66.1	141.0
	Banryu No.3	Surface	7.05	10.60	0.173	89.9	2.1	624.5	1.4	604.4	47.9	72.2	142.5
Yamaguchi	Yamanokuchi dam	Surface	6.64	6.02	0.107	97.8	9.7	285.8	*1	332.4	25.1	65.6	72.2
Kagawa	Nagatomike	Surface	7.34	9.53	0.512	169.5	25.4	155.2	5.2	339.3	25.4	416.4	104.8

*1:Less than detection limit

Table 4.3.5(b). Features of the respective catchment areas.

Location	Lake name	Surface stratum	Soil type	Vegetation
Yamagata pref	Imagamioike	Partially consolidated sediment	Drained podsol	*Fagus crenata, Sasa kurilensis*
Tochigi	Karikomiko	Rhyolite, Andesite	Aquic and Drained podsol	*Abies mariesii, Abies veitchii*
Nagano	Futafoike	Lava	Aquic humic podsol	*Smilacina viridiflora, Betula ermanii*
Niigata	Sankyoike	Neogene period sediment	Brown forest soil	*Quercus crispula, Quercus serrata*
Ishikawa	Ohataike	Rhyolite, Andesite	Drained brown forest soil	*Castanea, Quercus crispula*
Fukui	Yashagaike	Sandstone, Shale, Chert	Brown forest soil	Fagus crenata, Lindera umbellata var. membranacea
Gifu	Ijirako	Chert	Brown forest soil	*Pinus densiflora*、*Chamaecyparis obtusa*
Kyoto	Sawanoike	Chert	Drained brown forest soil	*Pinus densiflora, Quercus serrata*
Shimane	Banryuko	Quaternary period sediment	Residual regosol	*Pinus densiflora, Pinus thunbergii*
Yamaguchi	Yamanokuchi dam	Rhyolite	Brown forest soil	*Rhododendron reticulatum*、 *Pinus densiflora*
Kagawa	Nagatomike	Diorite	Drained brown forest soil	*Quercus acutissima, Quercus serrata,*

The principal component analysis (PCA) was applied to the mean values of the monitoring sites, and loadings of two major factors (a) and principal component scores (b) were shown in Figure 4.3.18. The first factor loading (X axis) was 45.0% and the second factor loading (Y axis) was 33.9%, and more than 75% was explained by two axes. The data of Lake Nagatomiike with significant high alkalinity and Ca^{2+} was omitted in this analysis. The PCA was applied only to the acid sensitive lakes with low alkalinity (<0.200 mmolc l^{-1}), and therefore, characteristics of the respective lakes/catchments were confirmed in detail.

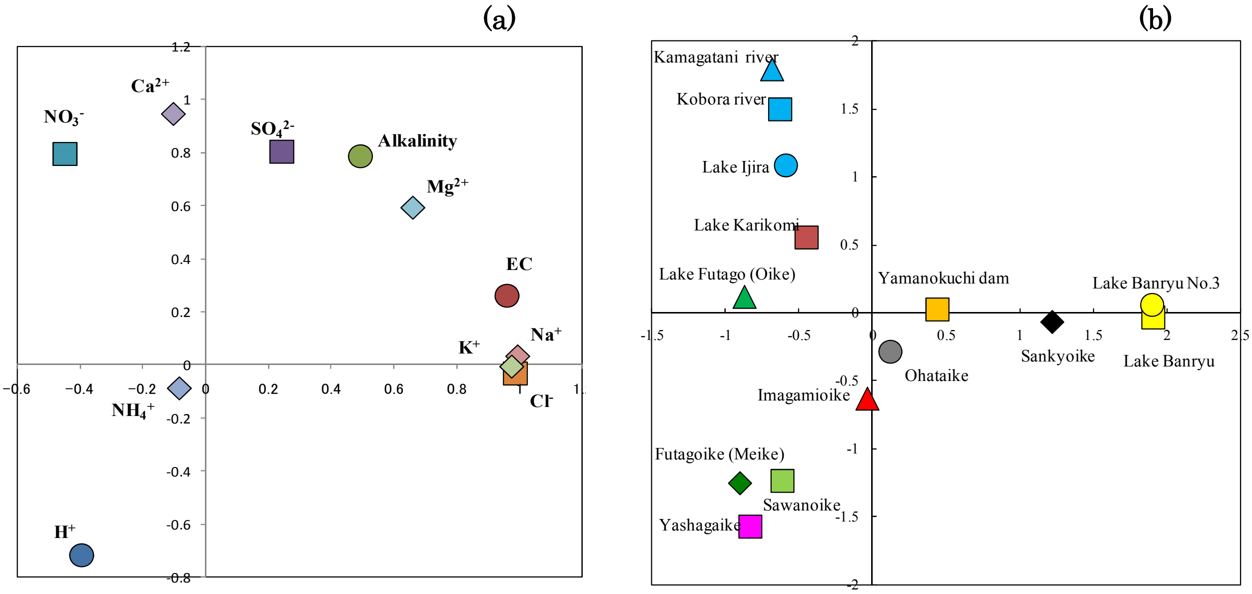


Figure 4..3.18. Factor loadings (a) in the principal component analysis and principal component scores (b) of the respective monitoring lakes.

As for the loadings of two major factors (Figure 4.3.18 (a)), the first factor loadings (X axis) of EC and many ions such as sea-salt-origin ions, Mg^{2+} and K^+ showed positive high values, indicating amounts of dissolved ions in the water. The second factor loadings (Y axis) of Ca^{2+} and alkalinity showed high positive values, while the loading of H^+ showed negative value, indicating acidity of the water. Moreover, the loadings of SO_4^{2-} and NO_3^- showed positive high values, suggesting effects of these ions.

As for the scores of each monitoring site (Figure 4.3.18 (b)), Lake Sankyoike and Lake Banryu showed high values on X axis because of their high EC, Na^+, and Cl^- suggesting effects of sea salts. The third quadrant may show the category of acid-sensitive lakes, whose acidity is high and ion concentration is low. The waters at Lake Yashagaike, Lake Futagoike (Meike), and Lake Sawanoike, which were located in the third quadrant, were high acid sensitive and therefore, acidification of these lakes should be carefully monitored. Lake Imagamioike was also located in the third quadrant and might be relatively acid sensitive. On the other hand, Lake Ijira, which has been acidified, was located in the second quadrant, showing less acidity compared with the lakes such as Lake Yashagaike. However, concentrations of SO_4^{2-} and NO_3^- at Lake Ijira were very high, suggesting effects of NO_3^- leaching by N saturation and high SO_4^{2-} leaching, as discussed later in the section 4.3.3. Lake Ijira should also be carefully monitored, since the acidification status may be different from those at the third quadrant. Lake Karikomi may have effects of high concentrations of SO_4^{2-} and Ca^{2+}.

(2) Long-term acidification trends of inland waters

A long-term trend analysis was done for major parameters by using the seasonal Mann-Kendall tests (Hirsch *et al,* 1982) as shown in Table 4.3.6. The analysis was applied only for several long-term monitoring sites.

Table 4.3.6. Long-term trend analysis of major parameters in the surface water or inflow rivers of the monitoring lakes.

Lake or River name	Duration	N	Z-score										
			pH	EC	Alkalinity	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}
Hutagoike(Oike)	1998-2007	30	1.56	1.83	1.35	4.94***	0.52	-0.31	-0.29	2.35**	-1.74	2.18*	1.26
Hutagoike(Meike)	1998-2007	30	-0.98	-1.77	0.73	3.53***	-1.66	-0.73	-1.83	2.94**	-1.84	0.05	-0.64
Sankyoike	2001-2007	27	-1.52	0.95	0.96	0.00	0.24	0.87	-0.78	0.16	-0.48	0.39	0.00
Yasyagaike	2000-2007	41	-1.81	-1.10	-2.27*	-1.23	1.55	-2.58**	-0.66	-2.00*	0.97	-1.17	-0.91
Ijirako	1988-2007	76	-0.74	5.68***	5.45***	0.87	5.43***	2.3*	1.89	0.89	-0.56	3.60***	2.55*
Kamagatani river	1988-2007	77	-2.07*	3.28**	1.19	1.03	6.00***	2.49*	-0.11	0.96	-0.05	1.49	1.68
Kobara river	1988-2007	57	-1.00	5.43***	1.66	2.20*	5.36***	2.28*	-0.41	2.87**	1.82	2.20*	3.16**
Banryuko	1989-2007	76	2.49*	5.14***	5.63***	-0.47	0.84	4.96***	-1.98*	6.00***	1.16	-0.97	3.61***
Banryuko No3.	1989-2007	76	2.40*	5.71***	4.60***	0.00	-0.11	4.28***	-1.61	5.61***	0.83	0.13	3.11**

*Notice: Asterisks, *, **, and ***, shows significant levels, $P < 0.05$, 0.01, and 0.001, respectively, by long-term trend analysis of seasonal Mann-Kendall tests using 3 or 4 times yearly seasonal data.*

Kamagatani river (an inflow river to Lake Ijira) showed a significant declining trend of pH ($p< 0.05$). As suggested in the Synthesis Report on Japan Acid Deposition Surveys (2004), a remarkable pH decline was seen since 1996 at Kamagatani river, but the trend became mostly flat since 2004 (Figure 4.3.19 (a)). On the other hand, a significant increasing trend of pH was found in Lake Banryu (Figure 4.3.19 (d)). A significant declining trend of alkalinity was seen in Lake Yashagaike, while the increasing trend was seen in Lake Ijira and Lake Banryu (Figure 4.3.19 (e)).

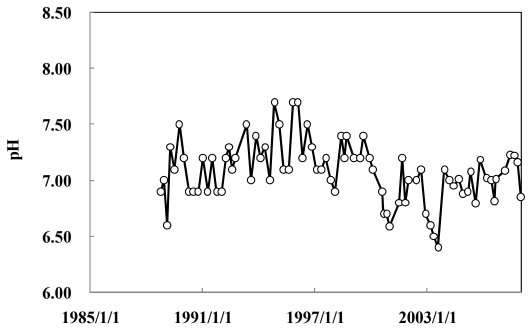


Figure 4.3.19 (a) pH changes at Kamagatani river

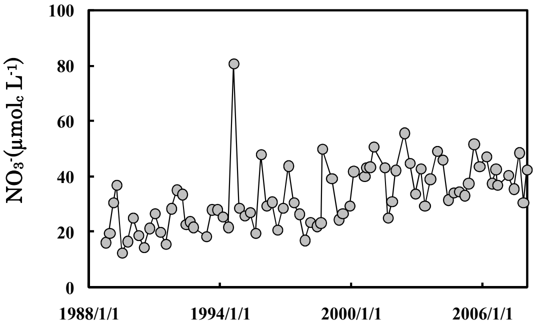


Figure 4.3.19 (b) NO$_3^-$ changes at Kamagatani

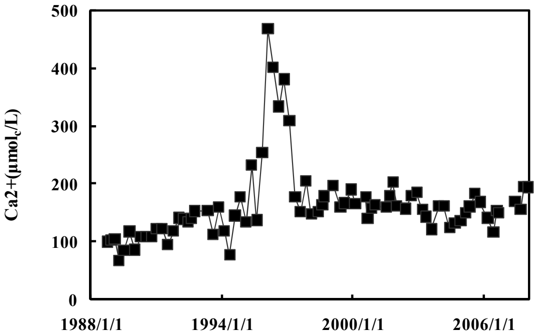


Figure 4.3.19 (c) Ca^{2+}changes at Lake Ijira

The peak as 1997 is unknown.

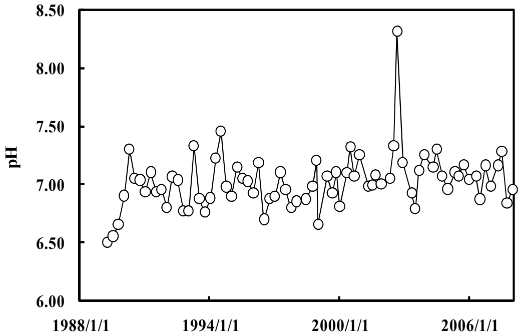


Figure 4.3.19 (d) pH changes at Lake Banryu

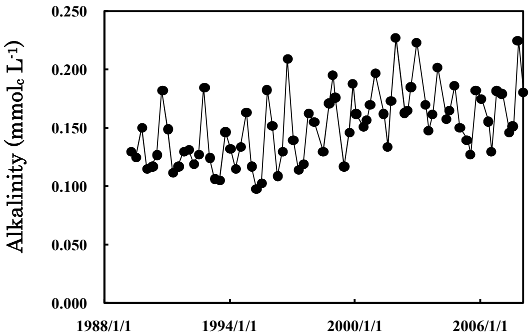


Figure 4.3.19 (e) Alkalinity changes at Lake Banryu.

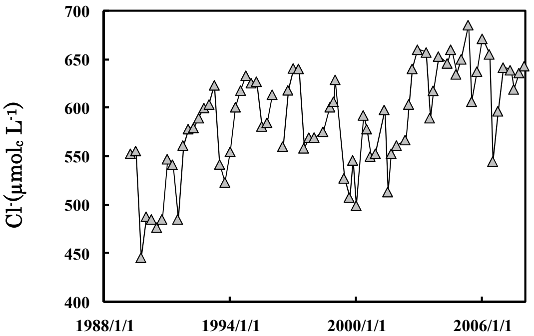


Figure 4.3.19 (f) Cl- changes at Lake Banryu.

At the Lake Ijira catchment, a significant increasing trend of NO$_3^-$ concentration was seen in the surface water of the lake and two inflow rivers (Figure 4.3.19 (b)). As mentioned above, the pH of Kamagatani River showed the declining trend, while the alkalinity of the lake surface water showed the increasing trend. Moreover, concentrations of base cations such as Ca^{2+} and Mg^{2+} also showed increasing trends in the lake surface water and Kobora River, another inflow river (Figure 4.3.19 (c)).

Significant increasing trends of SO$_4^{2-}$ concentration was seen in Lakes Futagoike (twin lakes, Oike and Meike). At the Lake Oike, concentrations of Na^+ and Ca^{2+} showed a significant increasing trend. At the Lake Banryu, where the alkalinity shows the increasing trend, Na^+, Cl^-, Mg^{2+} showed the increasing trend (Figure 4.3.19 (f)). Sea-salt-origin ions or ions derived from anthropogenic activities seemed to be increasing there, while Ca^{2+} concentration showed no clear trend. Concentrations of Na^+ and Cl^- showed a significant declining trend at the Lake Yashagaike, which was classified into the most acid-sensitive lakes (Figure 4.3.19).

(3) Quality assurance/quality control (QA/QC) of the data

The data quality is assured through the audit of the national center of Japan, ADORC, and in this occasion, sampling procedures at the sites and conditions of the laboratories are confirmed. Results of the inter-laboratory comparison projects for the last five years were shown in Figure 4.3.20. Through all the projects, the data more than 90% satisfied the data quality objectives. The laboratories seemed to keep relatively high data quality for the period. It was clarified that cations (low concentration or divalent ions) showed flagged data more frequently than pH, EC, and anions and larger variations among the laboratories. Efforts should be made for the data quality of cations.

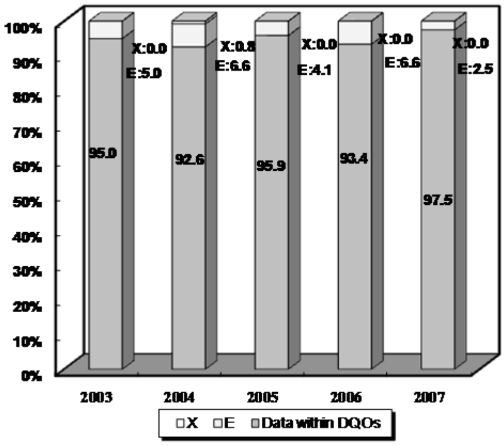


Figure 4.3.20. Changes of number of flagged data in the inter-laboratory comparison projects for the last five years.

4.3.3. Results of Lake Ijira intensive surveys

4.3.3.1. Acidification phenomenon in Lake Ijira catchment

The Synthesis Report of Japan Acid Deposition Surveys (2004) reported that simultaneous changes in chemical properties of inflow rivers and soil were recorded in Lake Ijira catchment in Yamagata city, Gifu prefecture, where wet deposition amounts of acid substances were the highest level in Japan. In this sub-section, acidification phenomena and discussions on the mechanism, which were reported in the Synthesis Report, will be summarized, and the discussion point of the intensive survey will be clarified.

(1) The highest level of wet deposition in Japan

It was pointed out that wet depositions at the Lake Ijira catchment were the highest level among the monitoring sites in Japan. Especially for nss-SO_4^{2-} and H^+, wet deposition amounts at Lake Ijira catchment were the highest among the sites. Annual total deposition of N was estimated to be approximately 19 kg-N ha^{-1} yr^{-1}, which exceeded 10 kg-N ha^{-1} yr^{-1}, a threshold value of the dissolved inorganic N (DIN) input at which NO_3^- output increase in river water in Europe and the U.S.

(2) Low acid neutralizing capacities in terms of geology/soil conditions and river water chemistry

Bedrock geology of the Lake Ijira catchment is dominated by chert, which is a silicate-rich rock. It can be considered that the acid neutralizing capacity (ANC) of the catchment is relatively low geologically. In fact, as described in the section 4.3.2, soils in the Lake Ijira catchment have been acidified continuously since the survey started. Although an internal acid production by plant uptake or the forest management condition should also be considered, the large wet deposition may affect soil chemistry.

Geology and soil conditions may closely related to acidification on the catchment-scale. It is pointed out that acid rocks, such as granite and ryholite, and chert, which are rich in silicate and poor in base cations, and soils derived from these rocks may have low ANC.

River water chemistry can be considered as a result of chemical reactions under the geology and soil conditions in the catchment and material cycles in the soil-plant ecosystems. The inland water, whose alkalinity as an indicator of ANC is lower than 200 μmol_c l^{-1}, may be susceptible to acid deposition. It was reported that alkalinity was relatively high in most rivers of Japan, 550 μmol_c l^{-1} in average of 225 rivers, and the acid-sensitive rivers with the alkalinity <200 μmol_c l^{-1} was limited (Kobayashi, 1960). However, the alkalinity of Kamagatani River, one of the inflow rivers of Lake Ijira, was very low, approximately 120 μmol_c l^{-1}, which can be considered as acid-sensitive also in terms of the river water chemistry.

(3) Specific ion leaching triggered by meteorological events, such as cold summer, and drought/torrid heat of summer

At Kamagatani river flowing into Lake Ijira, the high-concentration leaching of NO_3^-, SO_4^{2-} and Al and the decline of pH was observed from 1994 to 1996, as shown in Figure 4.3.21. The NO_3^- concentrations have been increased, and an effect of high N deposition was suggested.

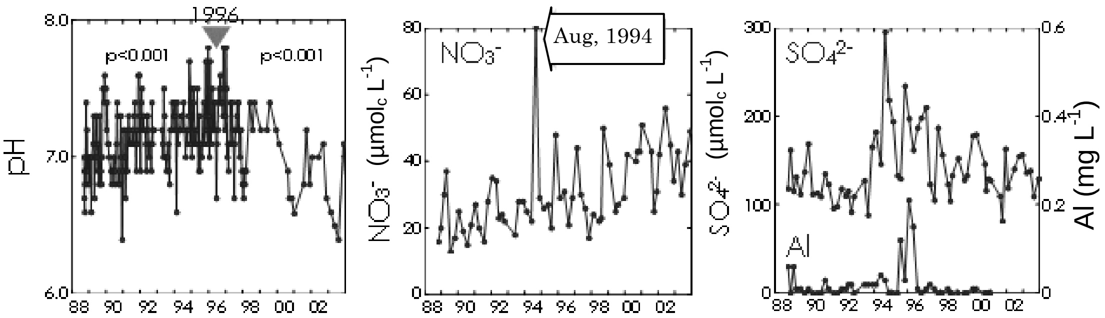


Figure 4.3.21. Chronological changes of concentrations of pH (left), NO_3^-(middle), and SO_4^{2-} and Al (right).

Moreover, it was estimated by the preliminary budget analysis that the output of SO_4^{2-} from the river exceeded the input to the catchment, and it was suggested that S accumulated in the catchment has been leached into the river. In fact, extractable S in the soil was single- or double-digit larger than those in other previous study catchments by MOEJ, suggesting high S content in the soil.

As a possible mechanism of high-concentration ion leaching, reduction of tree growth caused by the cold summer in 1993 and the drought and torrid heat of summer in 1994 might induce changes in N cycle processes and affect the river water pH. Chronological changes in mean basal area increments (BAI) for two tree species, *Cryptomeria japonica* and *Chamaecyparis obtusa*, which were thinned by the forest management in the catchment, were shown in Figure 4.3.22. Both species showed significant reduction of BAI twice, since 1982 and 1994.

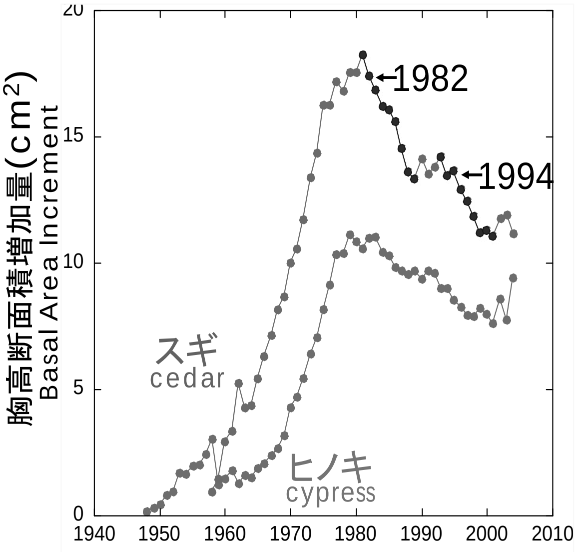


Figure 4.3.22. Chronological changes on basal area increment of Japanese cedar (*Cryptomeria japonica*) and Japanese cypress (*Chamaecyparis obtusa*) in the Lake Ijira catchment.

The plots for the respective species were the mean of 50 trees.

Although effects of the growth reduction since 1982 was not clarified in this study (started in 1988), N uptake must be reduced by the growth reduction since 1994. It can be considered that the reduction of N uptake caused NO_3^- leaching into the river and leaching of H^+ produced with NO_3^- decreased the river water pH. Moreover, rapid mineralization of soil organic matters induced by precipitation after drought in 1994 may also contribute to NO_3^- production. After this period, seasonality of NO_3^- concentration in the river was lost, and high NO_3^- concentrations could be seen even in summer, where N uptake by plants must be active. Thus, the N cycle in the catchment may be changed into the condition that NO_3^- can be easily leached into the river.

Moreover, it may be possible that mineralization of organic S was also accelerated by the drought event as well, although the detailed mechanism needs further discussion. Since H^+ can be produced also in the process of the organic S mineralization, this might contribute to decrease of the river water pH. After high-concentration leaching of the ions, a positive correlation between NO_3^- and SO_4^{2-} was seen, suggesting simultaneous leaching of these ions, although the positive correlation could not be seen in usual.

(4) Summary of hypothesis on acidification process in the Lake Ijira catchment

A hypothesis on the catchment-scale acidification and processes of ion leaching could be summarized as shown in Figure 4.3.23. In the catchment ecosystems, which received high acid loads, meteorological events functioned as a trigger of changes in material cycles. In particular, the N cycle changed from the N-retaining condition into the N-releasing condition (Nakahara et al, submitted). Then, acidification proceeded in the catchment. The process can be understood as follows:

a) Wet deposition in the Lake Ijira catchment is the largest level in Japan

b) Soil pH has decreased, and its effects on trees are concerned.

c) The Kamagatani catchment, one of the sub-catchments, has an acid-sensitive catchment with low alkalinity, reflecting geology and soil conditions.

d) It was estimated that the output of SO_4^{2-} from the river exceeded the input from the atmosphere to the catchment.

e) N deposition exceeds the threshold value of DIN input at which NO_3^- output increases in the river. In fact, the NO_3^- concentration increases year by year.

f) Tree growth, the main sink of N in the ecosystems, decreased due to meteorological events, such as cold summer and drought in mid-1990s. Reduction of N uptake by trees and enhanced mineralization of organic N after the drought caused high-concentration NO_3^- leaching, accompanied by much H^+ production and leaching in the catchment resulting declining of the river water pH.

g) The NO_3^- leaches into the river even during the tree-growing season in summer.

h) It is possible that mineralization of accumulated organic S is also accelerated by drought causing high-concentration leaching of SO_4^{2-} in mid-1990s.

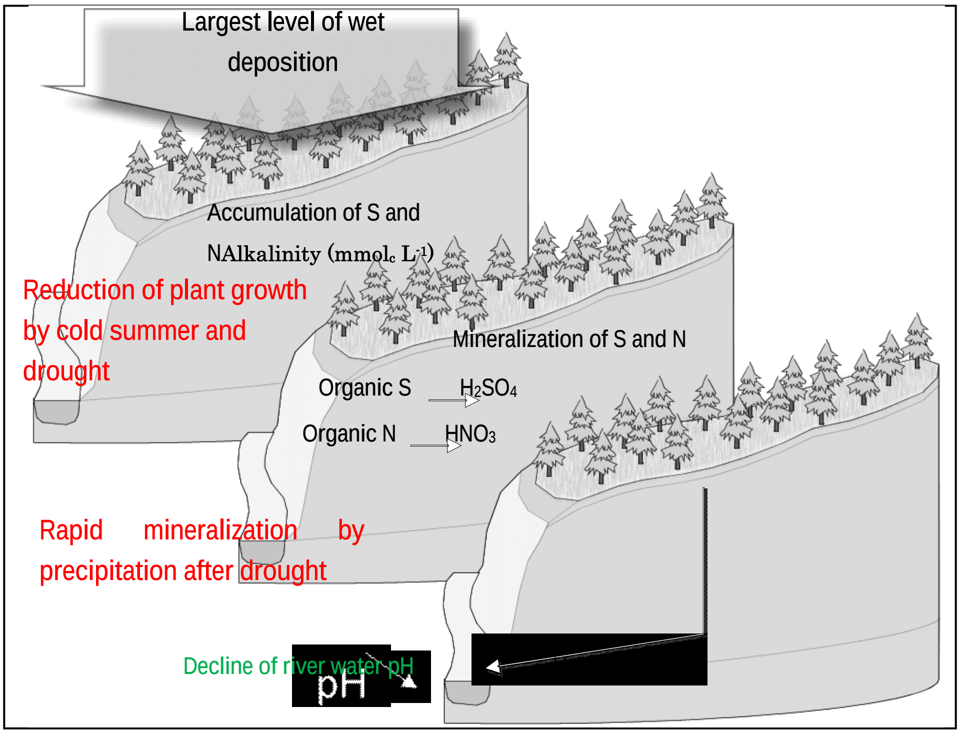


Figure 4.3.23. Hypothesis of acidification process in the Lake Ijira catchment.

Acidification process in the Lake Ijira catchment has been clarified by the Synthesis Report and subsequent discussions. However, to discuss the process above precisely, total input including wet and dry depositions, plant growth/uptake rate in the catchment-scale, and input-output budget should be precisely estimated. So far, enough data sets have not been obtained for precise quantitative discussion only by the regular monitoring; dry deposition has not been considered enough, river chemistry and discharge were measured only four times a year, and growth rate was measured. Taking the questions above into account, the Ijira intensive surveys, “Evaluation of mechanism on catchment-scale acidification”, was implemented from 2005 to 2007 to clarify the acidification process more quantitatively based on biogeochemical cycle analysis.

4.3.3.2. Summary methods of the intensive surveys

Intensive surveys on input and output were carried out in the Lake Ijira catchment to estimate total input (deposition) from atmosphere and output from the river. Intensive sampling of the river water was also conducted during heavy rain events to clarify runoff characteristics, and the acidification process was discussed in detail. Moreover, in other catchments/watersheds than the Lake Ijira, such as mountainous lakes/ponds and streams located in granite area, declining trends of pH and/or alkalinity were reported, and it was suggested that cumulative inputs (depositions) of acid substances might exceed the neutralizing capacity of these catchments. Therefore, to discuss the possibility of spread acidification of watersheds by atmospheric deposition, analysis of public data was also conducted for distribution of precipitation and wet deposition in the whole country and long-term trends of river water pH in the Chubu region. The measurement items are as follows:

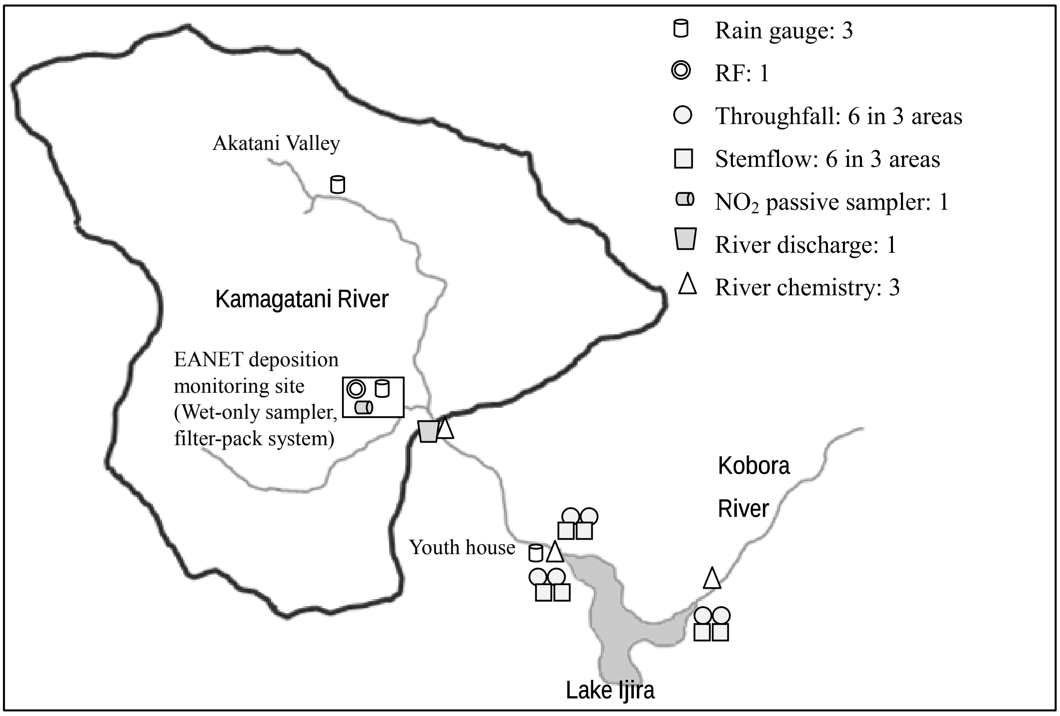


Figure 4.3.24. Layout of the collectors in the Lake Ijira catchment.

The area surrounded by bold line shows the catchment (approx. 298 ha) for budget analysis.

(1) Input-output surveys (Figure 4.3.24)

The following items were measured to estimate total input to the catchment and output from the river.

- For input:

Rainfall outside the forest canopy, throughfall, stemflow, precipitation amount, NO_2 measurement by a passive sampler

- For output:

Discharge from the river, river water chemistry (2 points at Kamagatani River and 1 point at Kobora River)

Water samples were collected every two weeks and analyzed for cations and anions. Alkalinity, total dissolved Al, SiO_2, and total organic carbon (TOC) were also analyzed for the river waters. As for estimate of total input, data on wet deposition by the wet-only precipitation sampler and dry deposition by the filter-pack method at the Lake Ijira EANET deposition monitoring site and also data of the passive sampler (for NO_2) were used.

(2) Intensive sampling of the river water during heavy rain events

Intensive sampling of the river water was implemented by using an automatic water sampler twice during heavy rain events. The water samples were collected at one-hour interval for two days (48 hours), respectively, from 18 to 20 July 2006 and from 13 to 16 July 2007. Cations, anions, alkalinity, total dissolved Al, SiO_2, and TOC were analyzed.

(3) Spatial evaluation of wet deposition in the whole country

Wet deposition amount at the Lake Ijira catchment is the highest level in Japan, because the ion concentrations are relatively high and also the precipitation amounts are significantly large, approximate 3,000 mm. As for the possibility of widespread acidification of watersheds, the precipitation data at Automated Meteorological Data Acquisition System (AMeDAS) stations, and wet deposition data at stations by MOEJ (from 1998 to 2004) and stations by JELA (from 1999 to 2004) were synthetically analyzed to identify spots to be monitored in terms of wet deposition, and the position of the Lake Ijira catchment in the whole country and other stations with high-wet-deposition were identified.

(4) Trend analysis and field measurements of rivers and streams in Niigata and Gifu prefectures

Long-term acidification has been reported for the mountainous rivers, which were located in areas dominated by acidic rocks such as granite, in Nagano prefecture (Kurita and Ueda, 2006). To discuss possibility of more widespread acidification of watersheds in Chubu region, long-term trend analysis on river water pH was carried out by using the Public Water Body data in cooperation with Niigata and Gifu prefectures.

4.3.3.3. Summary of the survey results

The major results of the intensive surveys can be summarized as follows:

(1) Acid loads in the Lake Ijira catchment and its effects on river water chemistry

a) Input-output surveys

Changes in monthly precipitation amounts in the Lake Ijira catchments and the water level at Kamagatani River were shown in Figure 4.3.25 for the period from August 2005 to November 2007. The precipitation amounts here included partly snowfalls in winter. The rain gauges were installed in three different altitudes, namely, Akatani Valley (upper slope), EANET station (middle slope) and Youth house (lower slope). Seasonal variation of the monthly precipitation amounts showed similar patterns among the positions, although the precipitation amounts are usually larger at the Akatani Valley on the upper slope. Changes in Kamagatani River reflected the precipitation pattern. The water year used for the following analyses was defined as starting at the beginning of November based on the seasonal variation of precipitation and water level.

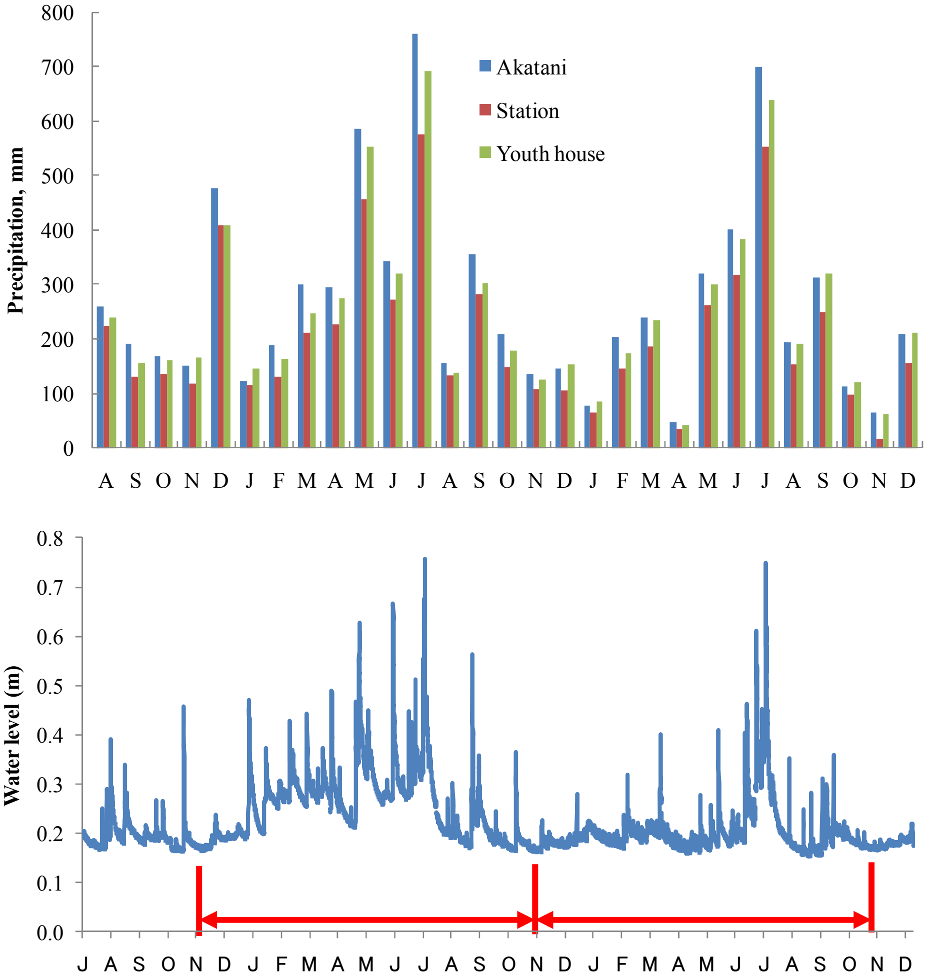


Figure 4.3.25. Changes in precipitation and water level, from August 2005 to November 2007.
Arrows show the water years.

Water balance in the Kamagatani sub-catchment was shown for two water years in Figure 4.3.26, which was calculated based on the precipitation and water level in Figure 4.3.25. Three slope positions showed different precipitation amounts and the precipitation was the highest at Akatani Valley on the upper slope, the second at Youth house on the lower slope, and then the lowest at EANET station on the middle slope. Since EANET station is located in a small valley of the branch river of the Kamagatani River, the precipitation amount may be underestimated there. The precipitation amount was approximately 800 mm lower in the water-year 2006-2007 than in the water-year 2005-2006. Runoff rate was approximately 77% and 49% in the first and second water years, respectively. The runoff rate in the first water year may be a reasonable value taking evapotranspiration rate into account, although the runoff rate in the second year seems to be low. Water balance may fluctuate depending on balance between precipitation and evapotranspiration in each water year. However, it can be considered the water balance applicable to the budget analysis was obtained at least for the first year, although long-term monitoring may be necessary for precise water balance.

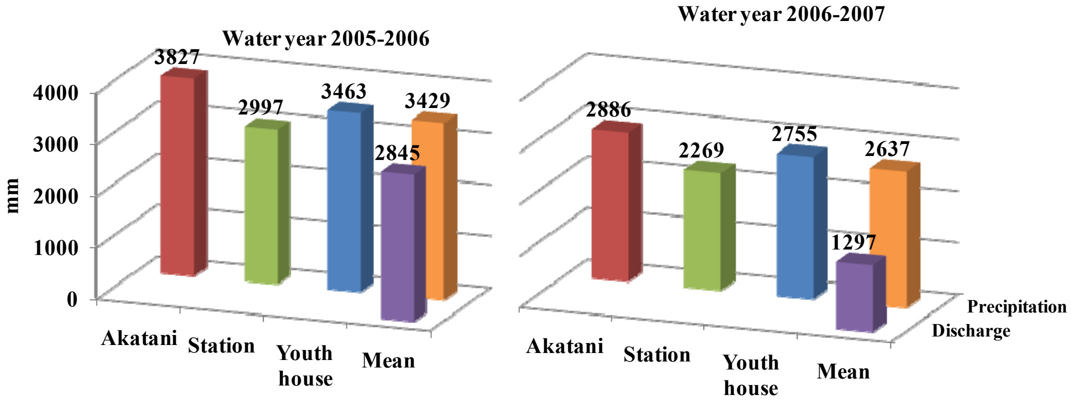


Figure 4.3.26. Water balance in the Kamagatani sub-catchment.
The water year 2005-2006: 364 days; the water year 2006-2007: 365 days.

Total deposition (wet and dry) and the contribution rate of dry deposition were shown for the respective water years in Figure 4.3.27. Wet depositions in the Lake Ijira catchment are the largest level in Japan because of the high precipitation amounts. Moreover, as described above, the precipitation amounts recorded at EANET station may be underestimated. Taking distribution of the precipitation amounts above into account, wet depositions were corrected by using the mean precipitation amounts of three slope positions. Therefore, the wet depositions in Figure 4.3.27 were larger than those at EANET station. It was clarified that the contribution rates of dry deposition to the total deposition were relatively small, 5 – 25%. For calculation of dry deposition, NO_2 measured by the passive sampler was also taken into account for estimation of the NO_3^- deposition.

It has been pointed out that N deposition was significantly large in the Lake Ijira catchment. The estimated dissolved inorganic N input was 28.7 and 18.2 kg-N ha^{-1} yr^{-1} in the first and second water years, respectively. The values significantly exceeded 10 kg-N ha^{-1} yr^{-1}, the threshold discussed in Europe and U.S., at which NO_3^- output increases in stream water. It was suggested that N saturation accompanying acidification of the catchment would be possible.

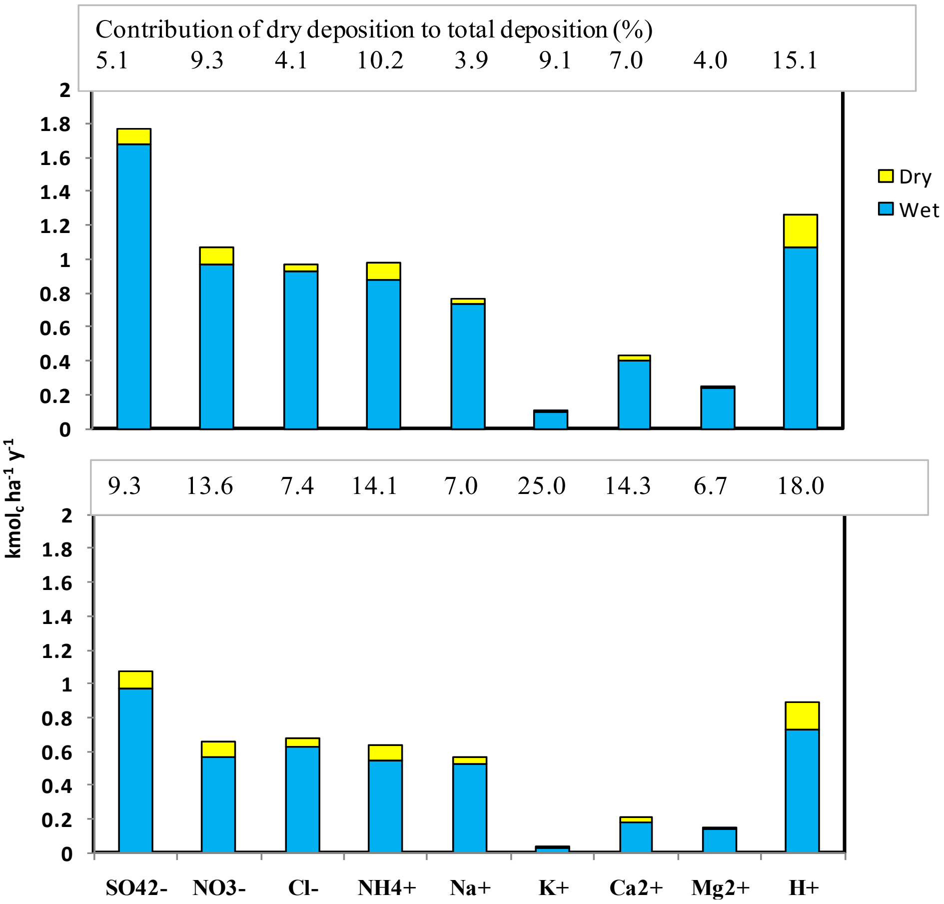


Figure 4.3.27.Total deposition and the contribution rate of dry deposition in the Kamagatani catchment.

Wet, wet deposition; Dry, dry deposition. Wet depositions were calculated by using air concentration measured at EANET station and the mean precipitation amounts of three different slope positions. NO_2 measured by the passive sampler was included in the NO_3^- deposition.

The throughfall-stemflow method cannot precisely estimate the ions, such as NH_4^+ and K^+, which may have large effects of canopy interactions, namely, uptake, consumption or leaching of ions on forest canopy. In the surveys, wet deposition and dry deposition was estimated independently in addition to the throughfall-stemflow method, and therefore, possibility of uptake or leaching of the ions on forest canopy can be discussed more practically. Since measurement of throughfall and stemflow was implemented in the forest area surrounding the Lake Ijira, variations derived from positional or topographical differences with EANET station might be included in the throughfall-stemflow data. However, it was suggested that most of the total deposition was loaded onto the forest floor in SO_4^{2-} and NO_3^- as reported in previous literatures. Uptake, consumption or leaching of the ions on the forest canopy was not mostly found especially in the second water year, while some uncertain differences were found in the first water year. On the other hand, it was suggested that a part of NH_4^+ and H^+ was absorbed, consumed or neutralized on the forest canopy and much amount of K^+ and Ca^{2+} was leached from the forest canopy. It was pointed out that estimate of dry deposition was essential for precise discussion of material cycles in ecosystems including the forest canopy.

b) Intensive sampling during heavy rain events

Specific variation of ion concentration was found in the intensive sampling during heavy rain events in summer. Results of the intensive sampling in 2006 were shown in Figure 4.3.28.

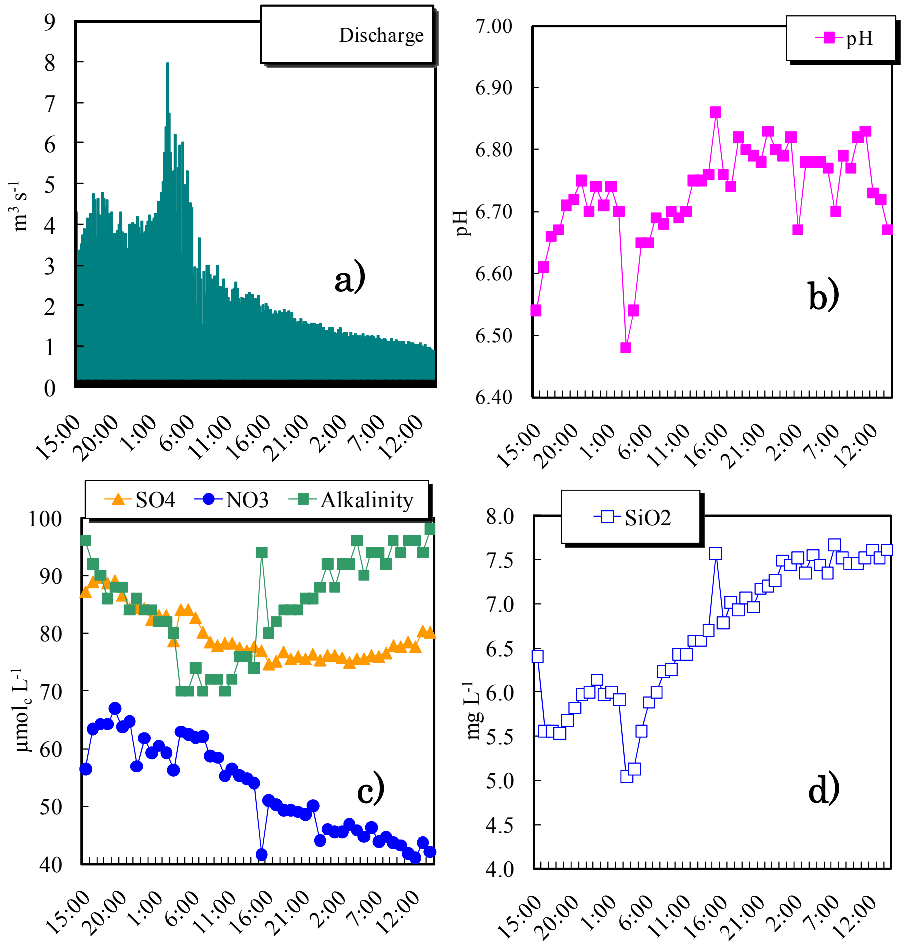


Figure 4.3.28. Variation of ion concentration during a heavy rain event in 2006.
(From 15:00 hr, July 18, to 14:00 hr, July 20 (at one-hour interval))

The sampling started at 15:00 hr in July 18, when the discharge had already increased into a certain level. The river water discharge started increasing again from around 1:00 hr in July 19 and then reached the peak at around 15:00 hr. The pH decreased quickly with increase of the discharge and then increased gradually with decrease of the discharge. At the same time, alkalinity showed the similar pattern to that of pH. On the other hand, ion concentrations of NO_3^- and SO_4^{2-} decreased tentatively with the peak discharge but increased quickly and then decreased with decrease of the discharge. As a result, positive correlation between NO_3^- and SO_4^{2-} concentrations can be found during the peak discharge (from 15:00 hr July 18 to 12:00 hr July 19), while no correlation is found in ordinary condition. Moreover, a concentration of SiO_2, which is an indicator of rock weathering and included much in deep groundwater, decreased with increase of the discharge similar to other ions. The similar phenomena can be seen also in the intensive sampling in 2007.

Leaching through shallow soil layers or surface runoff may largely contribute to the discharge during heavy rain events due to increase of groundwater level. Therefore, N distributed mainly in shallow soil layers can be leached into the river as NO_3^-. So far, many reports pointed out that SO_4^{2-}

concentration decreased with increase of the discharge. However, in the Lake Ijira catchment, SO_4^{2-} and NO_3^- were leached simultaneously with increase of the river water discharge. Therefore, it was suggested that leaching from shallow soil layer largely contributed to SO_4^{2-} leaching during heavy events. The leaching of NO_3^- and SO_4^{2-} may also contribute to the temporary acidification during heavy rain events. As described below, S output from the river is more than input (deposition) in this catchment, suggesting leaching of accumulated S. Further investigations are necessary for chemical form of accumulated S and its source.

c) Evaluation of the material budget

The input-output budget of major ions in the Kamagatani sub-catchment was shown in Figure 4.3.29. In the catchment, the output of SO_4^{2-} was estimated to be approximately 190% and 170% of the input in the water years 2005-2006 and 2006-2007, respectively. It was clarified that SO_4^{2-} was discharged from the catchment more than its input. In the first water year, the budget of Cl^-, which may not mostly be utilized in ecosystems, was not balanced. Even if the input and output of Cl^- were balanced, the corrected output of SO_4^{2-} became 110% of the input.

In Europe, it was reported that SO_4^{2-} was still being discharged from streams and rivers in the area which suffered high acid deposition loads even now, while the deposition has already decreased by reduction of the emission. It was suggested that accumulated S in the past was discharged in such areas. In the Kamagatani sub-catchment, the similar phenomenon may occur. The output pattern of SO_4^{2-} during heavy rain events suggested contribution of accumulated S in the catchment. Moreover, outputs of Ca^{2+} and Mg^{2+} were more than 900% of the inputs, suggesting reduction of ANC of soil, while the river water was well neutralized.

Reflecting much N deposition, certain amount of NO_3^- was leached into the river even in summer when plant N uptake must be active, suggesting acid loads to the river with the NO_3^- leaching. In fact, NO_3^- concentration in the river water increased for the last decade and the pH showed a declining trend. Possible acidification due to NO3- leaching should be monitored continuously in future.

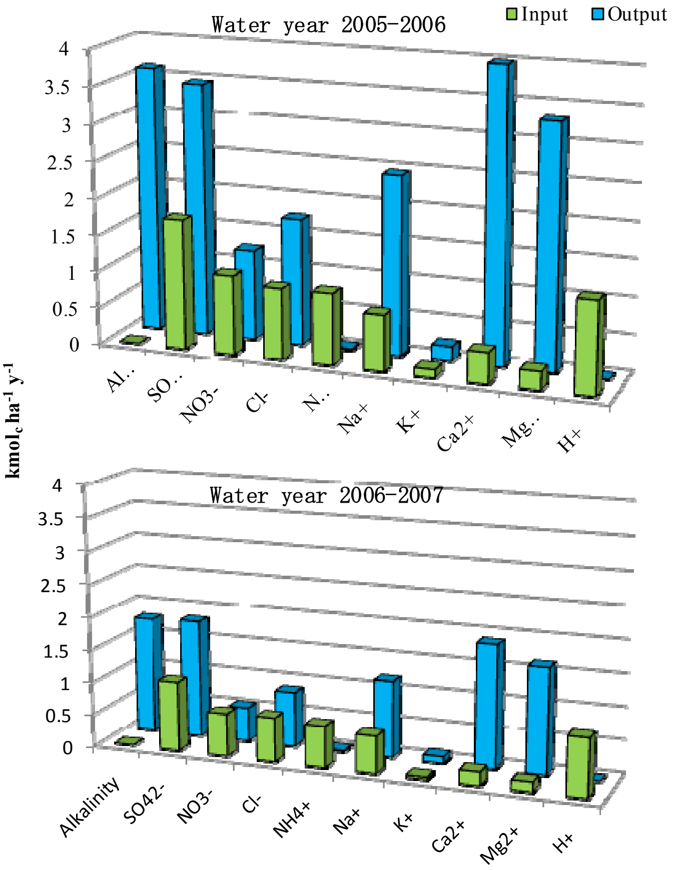


Figure 4.3.29. Material budget in the Kamagatani sub-catchment.

In-flow amount of alkalinity was assumed as 0.

For precise discussion on the catchment-scale acidification by acid deposition, sources of H^+ including acid deposition and internal production in forest ecosystems as well as sink of H^+ in the ecosystems should be taken into account and calculation of H^+ budget in the ecosystems may be informative (van Breemen et al., 1983). In most catchments of Japan, production of alkalinity is larger than H^+ load derived from an external source, acid deposition; ANC in forest ecosystems is quite large (Tokuchi and Ohte, 1998). However, as shown in Table 4.3.7., H^+ load derived from acid deposition is larger than alkalinity production, ANC of the river water, suggesting possible acidification of the catchment.

Table 4.3.7. External H^+ load and alkalinity production in the Kamagatani sub-catchment.

Water year	H^+ load		Alkalinity production
	kmol$_c$ ha^{-1} yr^{-1}		
2005-2006	4.04	>	3.61
2006-2007	2.12	>	1.78

Note: External H+ load was calculated based of N budget and transformation, and budgets of SO_4^{2-} and H^+. Alkalinity discharge was assumed as the net production here.

d) Summary

The intensive survey above provides not only quantitative data which can support the previous discussion but also important facts for future catchment analysis. The main outcomes are as follows:

i. Total deposition was precisely estimated based on wet deposition taking account of spatial variation of precipitation in mountainous area and dry deposition calculated from air concentration measurement. It was clarified that N deposition in the Kamagatani sub-catchment was significantly larger than the threshold value, 10 kg-N ha^{-1} yr^{-1}, at which NO_3^- discharge might be accelerated; it was 28.7 kg-N ha^{-1} yr^{-1} in the first water year.

ii. Specific trends on SO_4^{2-} discharge during heavy rain events suggested contribution of accumulated S in shallow soil layers in the catchment.

iii. The material budget in the Kamagatani sub-catchment showed that the output of S from the river was larger than the input, also suggesting contribution of accumulated S to the stream acidification.

iv. The NO_3^- discharge derived from much N deposition as well as accumulated S may contribute to the stream acidification.

The outcomes above concluded that accumulated S, which might be derived from atmospheric deposition in the past, has been discharged into the stream in the Lake Ijira catchment, while the N deposition, which exceeded the capacity of the ecosystems, has caused continuous acidification of the catchment.

(2) Possible widespread acidification of watersheds

a) Characterization of the Lake Ijira catchment and extract of hot spots based on the spatial distribution of wet deposition in Japan

We deposition amounts of nss-SO_4^{2-}, NO_3^-, NH_4^+ and H^+ at the Lake Ijira station were within 10% highest among 120 stations in Japan according the recent data from 1998 to 2004. In particular, the wet deposition of H^+ was the highest in Japan. Much wet deposition amounts of acidic components at the Lake Ijira station can be attributed to high precipitation amounts, 15% highest in Japan, and their relative high concentrations. The concentrations of nss-SO_4^{2-}, NO_3^- and H^+ were 27%, 19% and 2% highest in Japan, respectively (Figure 4.3.30).

On the other hand, the areas with high acid deposition load comparable to the Lake Ijira station were also identified by the analysis as shown in Figure 4.3.31. Wet deposition of nss-SO_4^{2-} was high in the area along the sea of Japan in Chubu and Chugoku region and Kyushu region in addition to Chukyo Industrial area and its surrounding area including the Lake Ijira station. The NO_3^- deposition was high in the area along the sea of Japan in Chubu and Chugoku region, Tokyo, and the North Kanto region. The NH_4^+ deposition was high in the area along the sea of Japan in Chubu region, Tokyo metropolitan area and the North Kanto region in addition to the Chukyo Industrial area and its surrounding area. The H^+ deposition was high in the area along the sea of Japan, Tokai region, and Kyushu region. Risk assessment of widespread watersheds acidification needs to discuss conditions of the ecosystems, such as geology, soil condition, vegetation, and topography.

The assessment above was based on the recent deposition data but cumulative deposition amounts for the last several decades should also be considered for possible effects on the ecosystems. In particular, S deposition must be significantly larger during the high-growth period of Japan in 1960s than present.

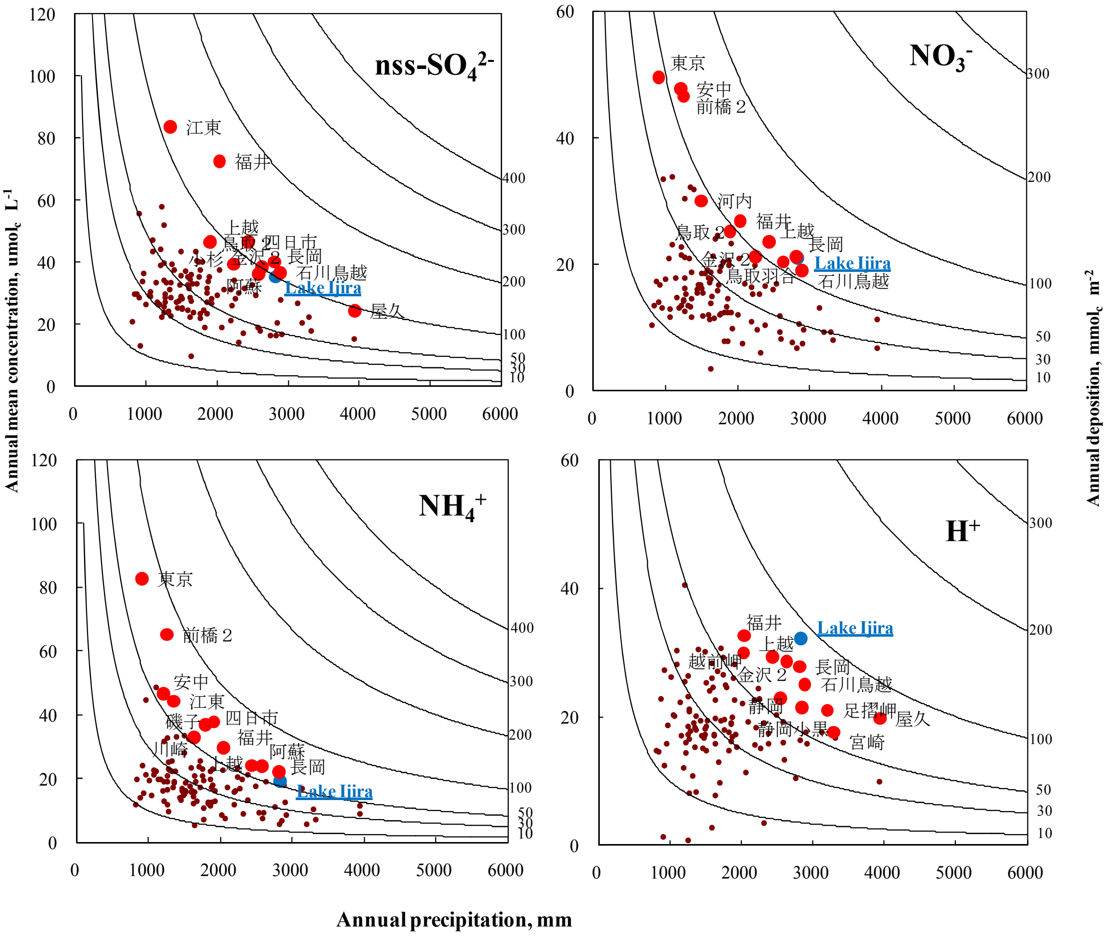


Figure 4.3.30. Relationship between precipitation, concentration, and wet deposition of nss-SO_4^{2-}, NO_3^-, NH_4^+, and H^+ at the monitoring sites by JELA (1999-2004) and MOEJ.

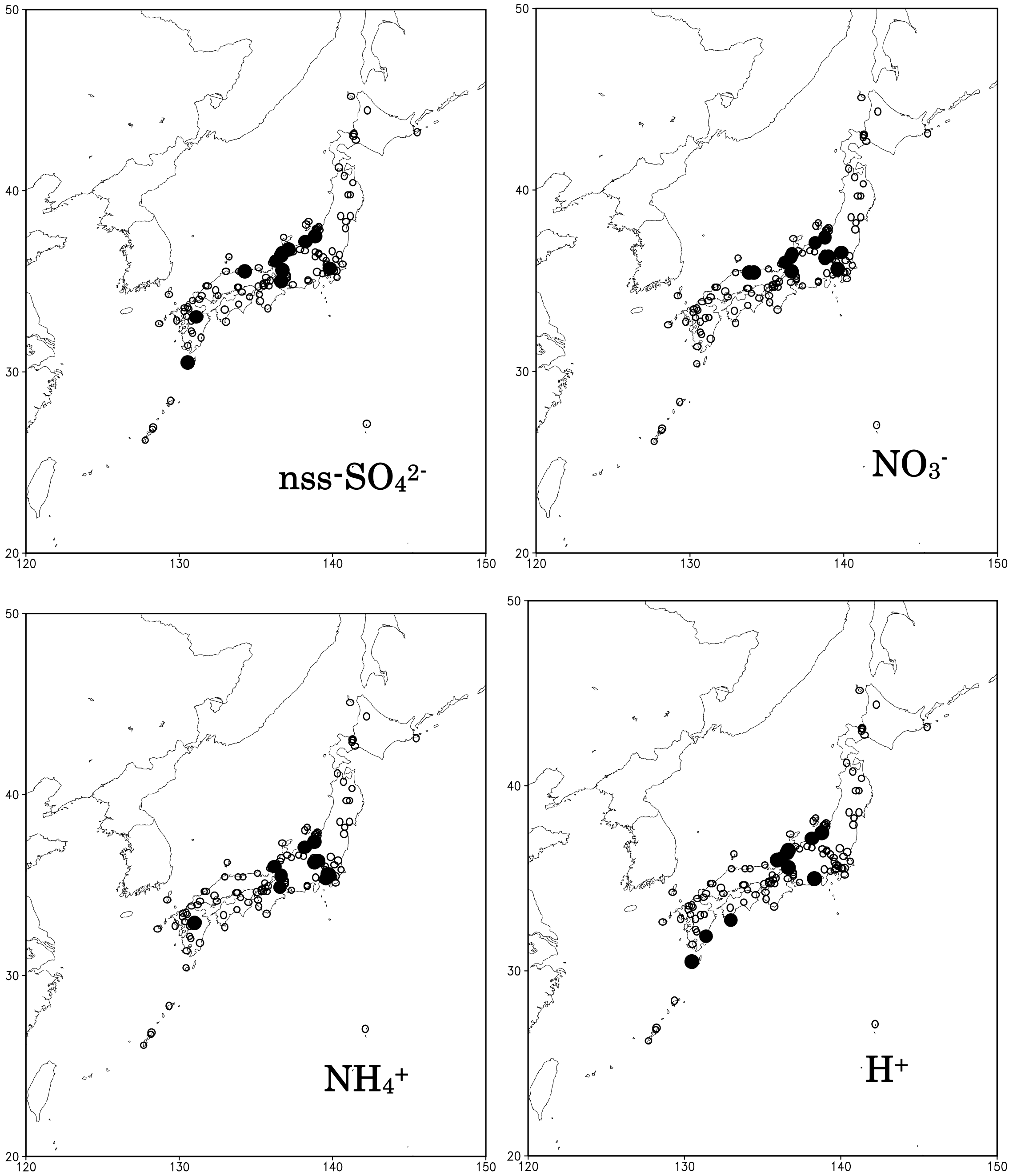


Figure 4.3.31. Spatial distribution of wet deposition of nss-SO_4^{2-}, NO_3^-, NH_4^+, and H^+ (based on Figure 4.3.30).

Large black circle shows the sites within 10% highest among the sites.

b) Acidification trends in rivers of Chubu region

Thirty four points in Niigata prefecture and 40 points in Gifu prefecture, whose BOD was lower than 1.0 mg L^{-1}, were selected from the total 140 points and 120 points respectively for the trend analysis (Figure 4.3.32).

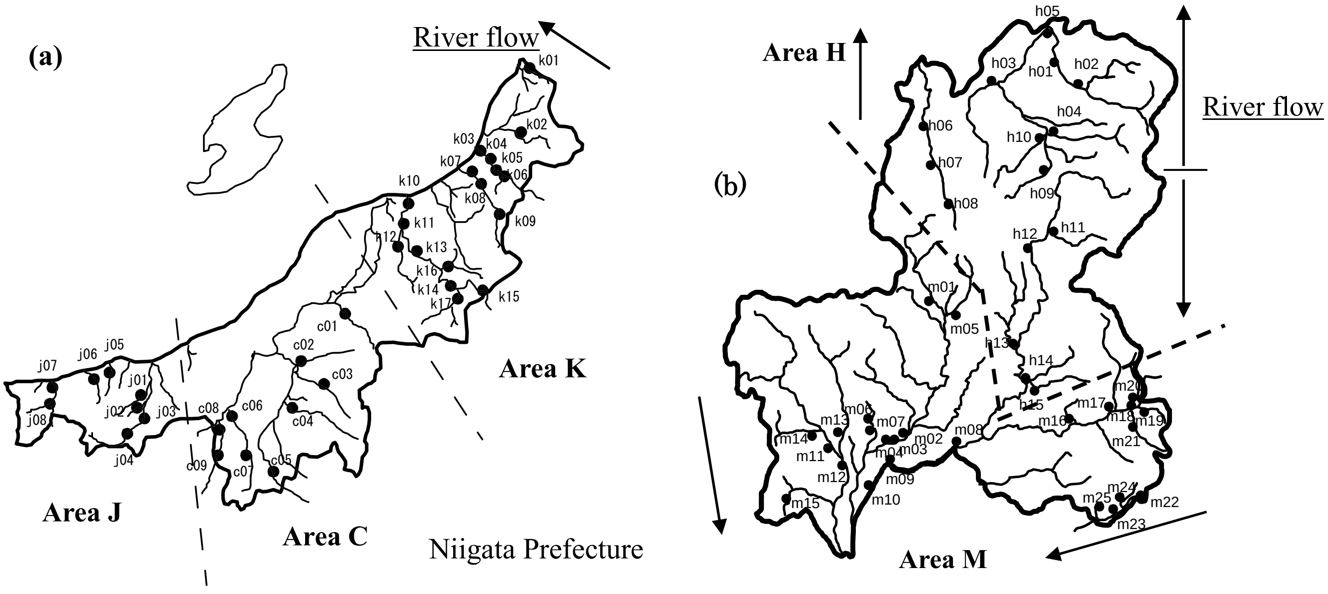


Figure 4.3.32. Points for the trend analysis of river water pH in Niigata prefecture (a) and Gifu prefecture (b).

The points, whose BOD was lower than 1.0 mg L^{-1}, were selected as the points with the minimum local contamination. Arrows show direction of the river flow.

The temporal trend analysis of the river water pH was carried out for the data from the mid 1980s to 2003 in the points above using the Seasonal Mann-Kendall method. For the points with the declining trend of pH, ion concentrations and alkalinity were analyzed by field sampling and literature study on land-use was carried out. Moreover, effects of hot spring were investigated by sampling along the river flow in the rivers having suspicious for hot spring contamination.

The long-term acidification trend of the river water pH was found by the temporal trend analysis at 11 points in Niigata prefecture and 13 points in Gifu prefecture as shown in Table 4.3.8. In particular in Niigata prefecture, all the points with the declining pH trend are located especially in the Northern part, area K (Ka-etsu). In Gifu prefecture, locality of the trend was not obvious and the declining trend was found mostly in the upstream rivers.

Table 4.3.8. The long-term trend of the river water pH in Niigata Prefecture (a) and Gifu prefecture (b).

(a)

Area	River system	River name	Points	n	Zscore
K	Ou River	Omata	k01	213	-2.45*
	Miomote River	Miomote	k02	213	-3.06**
	Ara River	Aara	k03	211	-4.92***
			k04	215	-4.71***
			k05	213	-7.34***
			k06	215	-8.22***
	Tinai River	Tainai	k07	205	-1.25
			k08	211	-2.27*
			k09	215	-1.42
	Agano River	Agano	k10	213	-0.28
			k11	213	-0.95
			k12	214	-1.12
			k13	215	0.24
			k14	213	-3.53***
			k15	213	-3.58***
		Araya	k16	214	-3.31***
		Tokonami	k17	212	-3.78***
C	Shinano	Ikarashi	c01	214	-1.29
		Hama	c02	213	0.13
		Sanashi	c03	213	-0.64
		Mikuni	c04	196	1.03
		Uozu	c05	212	0.11
		Kisyosu	c06	215	2.65**
			c07	212	0.66
		Nakatsu	c08	214	7.50***
			c09	209	3.54***
J	Ski River	Yashiro	j01	212	0.58
		Sibue	j02	215	2.90**
		Seki	j03	215	1.49
			j04	214	5.50***
	No River	No	j05	215	1.08
	Haya River	Haya	j06	213	-0.95
	Hime River	Hime	j07	212	0.65
			j08	214	0.38

*=p<0.05 **=p<0.01 ***=p<0.001

(b)

Area		River system	River name	Point	n	Zscore
H		Takahara River	Takahara	h01	191	-3.00**
				h02	191	-2.99**
		Miya River	Odori	h03	96	3.24**
			Kohachiga	h04	191	-3.08**
			Miya	h05	191	-1.70
		Sho River	Sho	h06	96	-2.87**
				h07	64	-1.55
				h08	64	-1.61
		Miya River	Miya	h09	191	-6.65***
			Kawakami	h10	96	1.55
		Kiso River	Osaka	h11	96	-0.78
			Hida	h12	192	-1.68
			Maze	h13	186	0.01
			Shira	h14	96	5.76***
			Kuro	h15	96	5.15***
M	Western part	Nagara River	Nagara	m01	192	3.42***
				m02	192	-5.78***
				m03	192	-3.95***
				m04	192	-3.77***
			Yoshida	m05	192	6.00***
			Ijira	m06	192	8.53***
				m07	192	0.489
		Kiso River	Kiso	m08	192	-6.28***
				m09	192	-0.79
				m10	192	-1.48
		Ibi River	Ibi	m11	192	-5.03***
				m12	192	-2.63**
			Neo	m13	192	-2.62**
			Kasu	m14	188	1.27
			Makita	m15	192	2.37*
	Eastern part	Kiso River	Nakanokata	m16	96	3.11**
			Tukechi	m17	96	1.35
			Kawaue	m18	96	1.39
			Ochiai	m19	96	2.16*
			Kiso	m20	192	0.89
			Nakatsu	m21	96	2.98**
		Yahagi River	Yahagi	m22	191	3.33***
				m23	192	-4.28***
			Kamimura	m24	180	2.86**
			Azuma	m25	96	3.07**

*=p<0.05 **=p<0.01 ***=p<0.001

Note: n, number of the data; Z-score shows the trend and its strength, the positive value shows increasing trend and the negative value shows declining trend; Hatched cells show significant declining trends.

According to the field surveys in Niigata prefecture, alkalinity and EC were lower than 0.200 mmol$_c$ l^{-1} and 10 mS m^{-1} respectively, suggesting their high acid sensitive, in most points of the area K, whose upstream area was dominated by granite. On the other hand, alkalinity and EC were higher, suggesting low acid sensitive, in area J and area C (Jo-etsu and Chu-etsu), whose upstream area was dominated by andesite or limestone. The long-term trend of the river water pH may reflect the bedrock geology. In Gifu prefecture also, acid-sensitive geology, such as granite, rhyolite and chert, can be found. Although locality of the pH trend relationship between the geology and the river water chemistry were not obvious, the long-term declining trend of pH was observed in the upstream points, such as h02, h09, and m11.

The river water chemistry may have large effects of land use in the watershed. Moreover, in case of Japan, there are many volcanoes, and hot springs or mineral springs may exist in upstream area of mountains. The investigation along the river flow near hot springs found clear effects of hot spring on the river water chemistry in c06, c07, c08 and c09 of Niigata prefecture and h02 of Gifu prefecture, in which EC and SO_4^{2-} concentration increased significantly near hot springs. On the other hand, in k01, k06, k16 and k17 of Niigata prefecture and h09 and m11 of Gifu prefecture, it was suggested that effects of hot spring drainage and mines were minimum. Moreover, 90% of the watersheds were occupied by forest and the percentage of agricultural field was significantly low in these points.

The typical declining trends of pH in the points with minimal effects of land use and hot spring were shown in Figure 4.3.33. Most points of Niigata prefecture shows relatively monotonous declining trend as seen in k16 of Figure 4.3.33a). In case of Gifu prefecture, as seen in m11 of Figure 4.3.33b), the pH declined clearly after 1996, which was similar to the phenomenon observed in the Kamagatani River flowing into the Lake Ijira. However, slight increase can be seen after 2000, which was different from the Kamagatani River. The upstream area of Araya River (k16) was dominated by granite, and the area of Ibi River was dominated by sedimentary rocks including chert and granite. As the seasonal variation, the lowest pH was recorded in Niigata and Gifu prefectures in April or May, snow-melting season of high mountainous area,, which may reflect so-called acid shock phenomena.

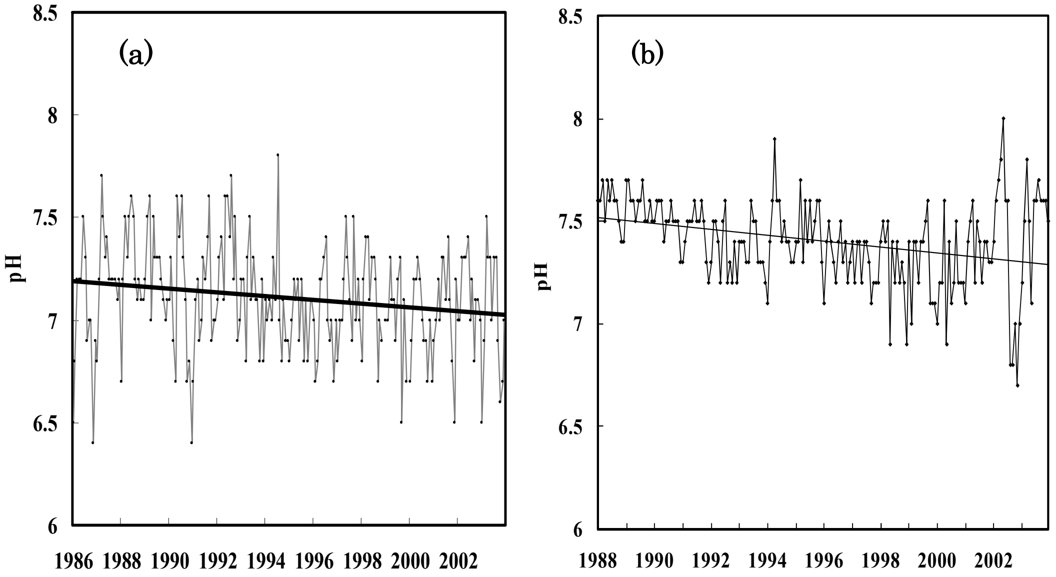


Figure 4.3.33. Typical declining trends of pH in a) k16, Kotobukibashi Bridge in Araya River, Niigata prefecture and in b) m11, Okajima Bridge in Ibi River, Gifu prefecture.

As shown in the spatial distribution of wet deposition in Japan, the area along the sea of Japan represented by Niigata prefecture and Chubu region represented by Gifu prefecture can be characterized as the area with high wet deposition load. The trend analysis above was not a direct evidence of acid deposition impacts on the river water chemistry. However, the natural environmental factors such as hot spring and volcano and the anthropogenic factors such as land-use change, agriculture and mining cannot explain adequately the long-term declining trend of pH in several points of Niigata and Gifu prefectures. It may be possible that similar phenomena occur in other acid-sensitive areas. Acidification of streams or rivers should be further focused on. Moreover, similarity between the long-term declining trends in Gifu prefecture and the trend in the Lake Ijira should be investigated.

4.3.3.4.Current status of watershed acidification in Japan and future directions of the catchment analysis

Synthesis analysis based on the previous monitoring activities and the intensive surveys suggested that atmospheric deposition of S, N, and H^+, which is the highest level among Japan, affected the river water chemistry through biogeochemical cycles in forest ecosystems in the Lake Ijira (Kamagatani) catchment.

Based on precise estimates of wet deposition and dry deposition, N deposition in the catchment was significantly higher than the threshold value, , at which NO_3^- leaching into streams or rivers would be accelerated in Europe and U.S. In fact, NO_3^- concentration in the river showed the increasing trend and no seasonality with relatively high concentrations even in summer, when vegetation N uptake must be active. The river pH showed declining trend. It was suggested that significant high N deposition contributed to the river acidification. Although the trigger of the phenomena may be meteorological events in the mid-1990s, the catchment is continuously acidified by NO_3^- leaching derived from high N deposition, which may exceed the capacity of the ecosystems.

On the other hand, S output exceeded the input in the catchment. It was suggested that S accumulated in the past was discharged from the catchment, possibly contributing to the acidification above. Since concentrations of NO_3^- and SO_4^{2-} increased simultaneously with increase of the water discharge during heavy rain events, it was suggested that the accumulated S was discharged with N from shallow soil layers.

The Lake Ijira catchment is a typical forested catchment in Japan, where Japanese cedar and cypress were planted, and the similar acidic rocks are distributed in many areas. The acidification of watersheds may not be a specific phenomenon in this area. The acid-sensitive catchment, high deposition load, and meteorological events as a trigger functioned as the necessary conditions for the acidification. The spatial distribution of wet deposition indicated existence of the areas with high deposition load comparable to the Lake Ijira. In particular, in the area along the Sea of Japan in Chubu region, the wet deposition amounts are recently the highest level in Japan. Moreover, the long-term declining trends of the river water pH in Niigata and Gifu prefectures indicated possible acidification of watersheds in the areas with acid-sensitive geology and high acid deposition.

As described in the section 4.3.2, taking these phenomena into consideration, the area with acid sensitive ecosystems and high acid deposition should be identified as hot spots, and possible effects of acid deposition on the river water chemistry should be investigated in further detail. Moreover, since soil pH decreased to lower than pH 4.0 in the Lake Ijira catchment, leaching of Al^{3+}, which is toxic to plant growth, may increase accordingly. Continuous monitoring including effects on trees may be necessary.

As the reasons why the acidification trends could be identified in the Lake Ijira catchment, in addition that the area had necessary conditions as a hot spot, it can be pointed out that an integrated monitoring including atmospheric deposition, soil, vegetation, and inland water has been implemented here. The catchment-scale analysis of biogeochemical material cycles may allow more quantitative discussion on effects of acid deposition on forest ecosystems. For further development of the catchment-scale analysis as the integrated monitoring in future, the following subjects should be discussed.

1) Strengthening of the stream/river monitoring and promotion of catchment analysis
   The monitoring on streams and rivers should be more focused on, which may reflect changes in material cycles more directly. Taking hot spots into account, widespread information should be accumulated. As for the Lake Ijira catchment, monitoring in the Kamagatani River will be carried out continuously at two-week interval, and the long-term assessment of the river water chemistry and input-output budget will be carried out. In future, more effective monitoring methodologies should be discussed with development of the catchment-scale model.
2) Development of effective methods to estimate forest growth and nutrient uptake
   Tree growth and nutrient uptake may be closely related to acidification of the catchment as discussed above. To evaluate acidification derived from external H^+ sources such as acid deposition quantitatively, it is important to estimate plant growth and nutrient uptake in the whole forest area. The precise estimation of forest growth requires detailed and continuous field observations. In future, more effective and simplified estimation methodologies should be developed for the catchment analysis.
3) Collaboration with existing study sites
   Research outcomes in existing study sites managed by universities and research organizations should be referred for further collaboration between the long-term acid deposition surveys and the research activities. Cooperative intensive observations or standardization of the monitoring methodologies should be promoted. In future, synthesis assessment of Japanese watersheds including the Lake Ijira catchment should be discussed. Through the assessment, the position of the catchment analysis should be clarified in the long-term acid deposition surveys.
4) Dissemination of the catchment analysis to the East Asian region
   The catchment analysis will be an effective tool for assessment of ecological impacts in the East Asian region, where emission of acid substances is being increased. Studies of the catchment analysis should be promoted in the region.
5) Development of the catchment-scale model
   Quantitative data obtained through the intensive surveys, the data in existing study sites in Japan, and case studies in the East Asian region should be integrated for development of the catchment-scale model including comparison of existing models. For validation of the acidification mechanism in the Lake Ijira catchment, modeling may be essential. The data obtained by 1) and 2) above will be informative as validation data of the model.

Taking the subjects into account, the catchment-scale analysis should be promoted as the integrated monitoring and assessment methodologies for impacts of acid deposition on ecosystems.

4.4 References

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National Assessment on Acid Deposition in Lao PDR

5.1. Basic Information on National Monitoring Activities

5.1.1. Outline of the activities on acid deposition and national monitoring plan

Realizing the need to protect the country from the acid deposition problem, Lao PDR became one of the participating countries of EANET in November 2002. Since then, in order to ensure the monitoring activities of acid deposition in Lao PDR, the country has nominated the National Center for developed and implementing the nation monitoring plan as well as collecting the national monitoring data, promoting national QA/QC activities, public awareness raising through the acid deposition brochure and dealing with technical matters on the network activities in the country.

The national monitoring activities on acid deposition monitoring was established and started monitoring wet deposition in Vientiane capital city by collecting daily sample (during rainy season) and established the dry deposition monitoring at the same site of wet deposition monitoring. The activities also were surveyed the appropriate monitoring site for inland aquatic at the Namhum lake and collected samples and analysis for observed data.

All activities were carried out by Environment Quality Monitoring Center (EQMC), the National Center until the year 2007 was changed its name to Environment Quality Monitoring and Hazardous Chemical Center (EQMHCC), under Water Resources and Environment Research Institute (WERI) of Water Resources and Environment Administration (WREA).

5.1.2. Monitoring program from 2005-2009

The national monitoring plan was developed and implemented for the year 2005 to 2009 were covers the generation of the relevant data and activities, operation and maintenance of field and laboratory facilities and conduct of QA/QC activities.

- For wet deposition monitoring to continue collecting daily sample and analyzed parameters: Precipitation amount, pH and Electric Conductivity (EC). Anion: SO_4^{2-}, NO_3^-, Cl^-, NO_2^-, PO_4^{3-}, and Cation: Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+} by using Ion Chromatometry.
- For dry deposition monitoring, surveyed and established monitoring site in Vientiane (2009) and start to collecting weekly sample in 2010 and analyses 12 parameters as follows: SO_2, HNO_3, HCl, NH_3, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+} by using the Ion Chromatography.
- For inland aquatic monitoring to survey monitoring site at Namhum lake and collected sample in 2010 and analyses follow the EANET manual parameters: pH, EC, Alkalinity. Anion: SO_4^{2-}, NO_3^-, Cl^- , NO_2^-, PO_4^{3-} and cation: Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, by using IC.
- For raising awareness on acid deposition to conducted national awareness workshop on acid deposition for relevant ministries and for the primary school teacher.
- To participant the activities on laboratory comparison analysis.

5.1.3. Monitoring stations

The acid deposition station in Lao PDR

Table 5.1.1. Acid deposition monitoring sites in Lao PDR.

Site category	Site classification	Location
Acid deposition monitoring Site: Wet deposition	Urban	Vientiane capital city (Department of Meteorology)
Acid deposition monitoring Site: Dry deposition	Urban	The same as the wet deposition monitoring site
Ecological survey site: Inland aquatic monitoring	Rural	Namhum lake Vientiane capital city
Ecological survey site: Soil and Vegetation monitoring	not start yet	

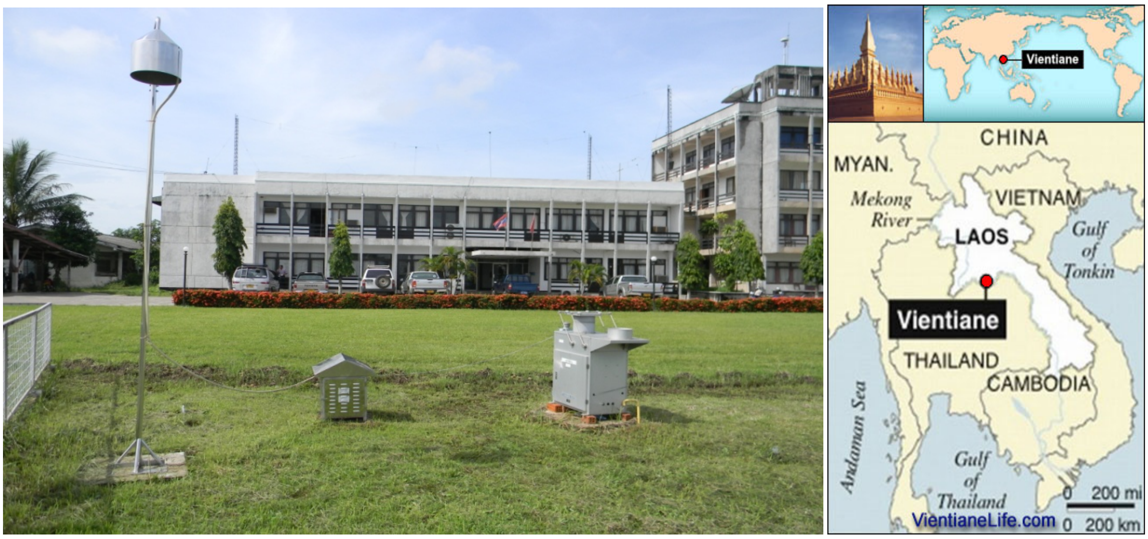


Figure 5.1.1. Monitoring station for wet and dry deposition.

5.1.4. Sampling and measurements

Rainwater samples for wet deposition monitoring were collected by the “Wet only sampler” installed on site. Gas and aerosol samples for dry deposition monitoring were collected by filler pack. Lake water samples were collected directly to the sample containers. The analytical methods were following by the EANET manuals.

5.2. State of Acid Deposition in Lao PDR

5.2.1 Atmospheric deposition

The global climate is changing. All witness changes are in average temperatures, shifts in seasons and an increasing intensity of extreme weather events. In Lao PDR, the effects of climate change are already visible and will become more evident in the future. Currently accurate predictions of the potential changes in climatic conditions and resulting adverse impact of such changes have not been developed nationally by the Lao PDR but some indication can be taken from preliminary regional level predictions.

5.2.1.1. State of wet deposition

For the period 2005-2009, a total of 188 wet deposition sample were collected in the Vientiane monitoring station and analyzed for pH, Electrical conductivity, Anion and Cation.

Table 5.2.1. Annual mean of pH and EC.

Station	Year	pH			EC (mS.m^{-1})		
		Max	Min	Annual mean	Max	Min	Annual mean
Vientiane capital city monitoring site	2005	7.33	5.88	6.32	3.95	0.22	0.10
	2006	7.10	6.01	6.49	3.43	0.22	0.76
	2007	6.21	5.26	5.67	0.74	0.24	0.40
	2008	6.83	5.55	6.01	4.04	0.18	0.64
	2009	5.66	5.32	5.48	0.86	0.30	0.53

The pH values were of the range 5.26 - 7.33. The overall mean pH values were 5.48 ± 6.49. It is observed that the mean pH values were higher in 2005 and lower in 2007, the time series concentration show that there were slightly decrease and increase value in 2005-2007.

The electrical conductivity values were of the range 0.18 - 4.04 mS.m^{-1}. The overall mean electrical conductivity was 0.10 ±0.76 mS.m^{-1}. It is observed that the mean EC value higher in 2006 and lower in 2005, the time series concentration show that there were slightly decreased and increase value in 2006-2009.

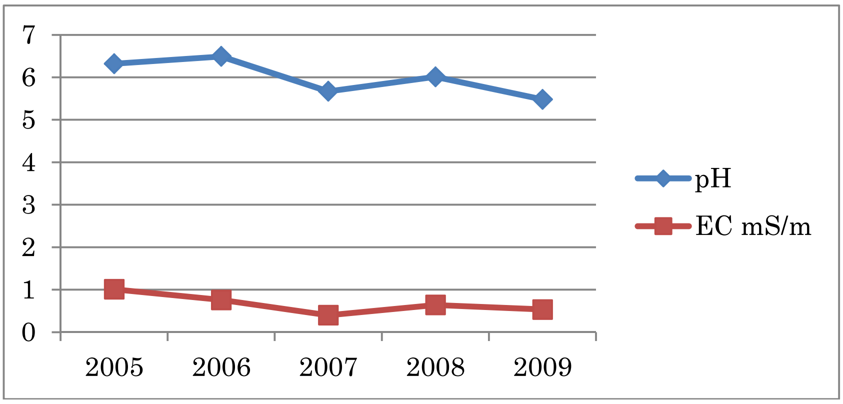


Figure 5.2.1. The values of pH and EC.

For anions, period 2005-2009, a total of 188 samples were collected in Vientiane monitoring station and analyzed for Sulfate (SO_4^{2-}), Nitrate (NO_3^-), Chloride (Cl^-), Ammonium (NH_4^+), Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}) and Magnesium (Mg^{2+})by using Ion Chromatography.

Table 5.2.2. The mean concentrations of anion and cation for 5 years period in Vientiane capital city monitoring station.

Year	SO_4^{2-} µmol.L^{-1}	NO_3^- µmol.L^{-1}	Cl^- µmol.L^{-1}	NH_4^+ µmol.L^{-1}	Na^+ µmol.L^{-1}	K^+ µmol.L^{-1}	Ca^{2+} µmol.L^{-1}	Mg^{2+} µmol.L^{-1}
2005	0	0	0	0	0	0	0	0
2006	2.45	4.92	3.38	5.47	5.04	2.49	6.2	2.47
2007	6.54	9.65	10.4	15.3	3.32	2.37	4.25	0.98
2008	8.43	9/95	12.4	14.0	4.86	2.82	9.62	2.18
2009	0.73	1.76	1.12	3.13	1.66	0.16	0.99	0.13

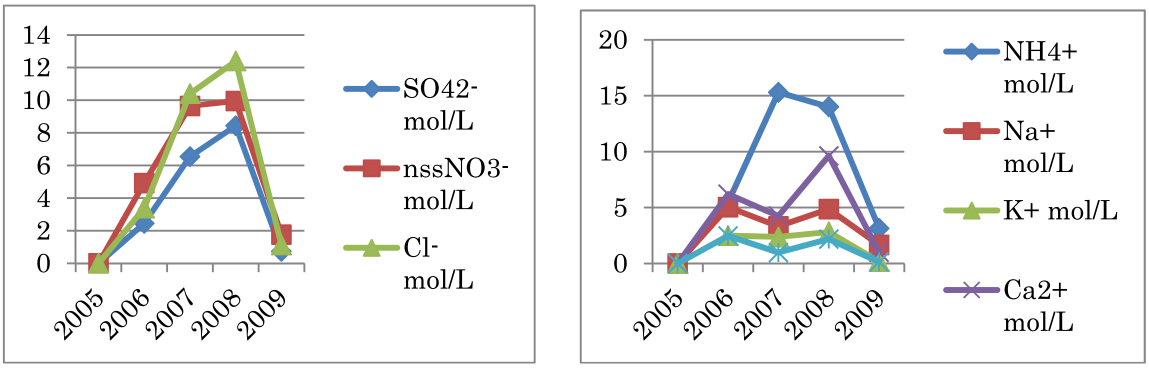


Figure 5.2.2. The values of sulfate, nitrate and chloride, ammonia, sodium, potassium, calcium and magnesium.

5.2.1.2. State of dry deposition

Lao PDR established the dry-deposition monitoring station in Vientiane (same as the wet deposition monitoring site) at the end of 2009 and will start collecting sample and analyses in 2010.

5.2.2. State of inland aquatic environment

For inland aquatic in Lao PDR were surveyed for candidate sites in Vientiane in 2005 at Namhum lake and collected sample and analyzed at the end of 2009 for observed data to consider Namhum lake as the monitoring site for inland aquatic environment. In 2010 Lao PDR started to collect sample and analyzed the parameters as the EANET manual, but the result not available because the quality of deionized water.

Figure 5.2.3. View of Namhum lake monitoring site

5.2.3. State of soil and vegetation

Lao PDR has not yet decided for soil and vegetation monitoring activities at this time due to constraints for instruments and capacity building. However, the national center will consider conducting soil and vegetation monitoring in the future.

5.3. Review of National Measures Against Acid Deposition

Acid deposition status and its negative impact still can be accepted in Lao PDR. However, the Water Resources and Environment Administration (WREA) as the agency responsible for environment quality protection at the national level. Furthermore, the government has established and implemented some programs below:

- Accessed the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and is also a signatory to the Kyoto Protocol which it was accessed in 2003.
- Completed the "National Environmental Standard" in January 2010. The standard covers ambient air, water and soil quality and emissions sources from factories and in-use motor vehicles.
- Set up the Climate Change Steering Committee, Technical Working Group and established Climate Change Office.
- Set up the Cleaner Production Project and operated by Ministry of Industry and Handicraft;
- Formulated the Sustainable Transport Strategy up to the year 2020.
- Developed the National Environment Strategy up to the year 2020 and National Environment Policy.

Concerning to the acid deposition monitoring in the country, due to the limited financial support, therefore, only wet deposition has been monitoring. However, the National Center has planned to monitor for dry deposition and inland aquatic as soon (2010).

5.4. References

EANET. 2000. Technical Document for Wet Deposition, Dry Deposition and Inland Aquatic Monitoring. Niigata, Japan

EANET. 2005-2009. Data reporting for year 2005, 2006, 2007, 2008 and 2009. Niigata, Japan.

WERI. 2009. Executive Summary of National Adaptation Programme of Action to Climate Change, April 2009. Lao PDR.

National Assessment Report of Malaysia

6.1. Basic Information on National Monitoring Activities

6.1.1. Outline of the activities on acid deposition and national monitoring plan

Malaysia participated in the preparatory phase of the Acid Deposition Monitoring Network in East Asia (EANET) during 1998-2000 and jointly implemented EANET activities on a regular basis since 2001. The Environmental Management and Climate Change Division under the Ministry of Natural Resources and Environment was appointed as the National Focal Point whereas Malaysian Meteorological Department under the Ministry of Science, Technology and Innovation as the National Center for EANET.

Acid deposition covers four environmental media: wet and dry deposition, soil and vegetation and inland aquatic environment. Wet and dry deposition monitoring are implemented so as to measure concentrations and fluxes of acidic substances to the ground, while monitoring for soil, vegetation and inland aquatic environment are implemented to assess adverse impacts on the terrestrial and aquatic ecosystem.

6.1.2. Monitoring program from 2005 – 2009

6.1.2.1 Wet and dry deposition monitoring

There are 4 monitoring sites for wet and dry deposition in Malaysia which are designated as EANET monitoring sites. These are regional GAW Tanah Rata station (rural site), Malaysian Meteorological Department (MMD) Headquarters, Petaling Jaya (urban site), Global GAW Danum Valley station (remote site) and Meteorological Observation Kuching station (urban site). The measured parameters and monitoring intervals are tabulated below:

Table 6.1.1. Measurement parameters and monitoring interval.

Items	Measurement parameters	Monitoring interval
Wet deposition	pH, EC, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, CH_3COO^-, $HCOO^-$, $C_2O_4^{2-}$	Weekly
Dry deposition	Gas: SO_2, HNO_3, NH_3, HCl, Components in PM: NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-	Weekly / Biweekly
Soil	pH (H2O), pH (KCl), exchangeable (Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, H^+), exchangeable acidity	3-5 years
Inland aquatic environment	Water Temp, pH, EC, alkalinity, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-,	4 times a year

The Department of Chemistry conducted the chemical analysis for wet and dry deposition and also inland aquatic. From 2005 until 2009, the laboratory has actively participated in the inter-laboratory comparison study conducted by EANET and the World Meteorological Organization (WMO). The measurements and analytical methods are tabulated below:

Table 6.1.2. Measurement and analytical methods.

Parameter	Measurements/analytical methods	Manufacturer/Type of equipment	Detection limit
pH	Glass electrode	ACCUMET Research / ACCUMET AR20	0.06
EC	Conductivity Cell	HANNA Instrument / HANNA HI9032	0.1 µS/cm
SO_4^{2-}	Determination of Anions by Electrochemically Suppressed Ion Chromatography	DIONEX USA / DX600 Anion System	0.03 µmol.L^{-1}
NO_3^-			0.14 µmol.L^{-1}
Cl^-			0.20 µmol.L^{-1}
CH_3COO^-			0.05 µmol.L^{-1}
$HCOO^-$			0.10 µmol.L^{-1}
$C_2O_4^-$			0.07 µmol.L^{-1}
NH_4^+	Determination of Anions by Electrochemically Suppressed Ion Chromatography	DIONEX USA / DX600 Cation System	0.20 µmol.L^{-1}
Na^+			0.40 µmol.L^{-1}
K^+			0.08 µmol.L^{-1}
Ca^{2+}			0.50 µmol.L^{-1}
Mg^{2+}			0.40 µmol.L^{-1}

6.1.2.2. Soil and vegetation

The soil and vegetation monitoring are conducted by the Universiti Putra Malaysia (UPM).

6.1.2.3. Inland and aquatic

The inland aquatic environments monitoring is conducted by the Universiti Teknologi MARA (UiTM) and MMD.

6.1.3. Monitoring Stations

The monitoring sites for Malaysia designated as EANET monitoring sites are as follows:

a) Wet and dry deposition
  i. Regional GAW Tanah Rata station (rural site)
  ii. Malaysian Meteorological Department (MMD) Headquarters, Petaling Jaya (urban site)
  iii. Global GAW Danum Valley station (remote site)
  iv. Station Meteorological Kuching (urban site)

b) Soil and vegetation
  i. Sg. Lallang Forest Reserve

ii. Pasoh Forest Reserve
iii. UPM Bintulu Campus

c) Inland aquatic
i. Danum Valley (Sg. Tembaling)
ii. Semenyih Dam

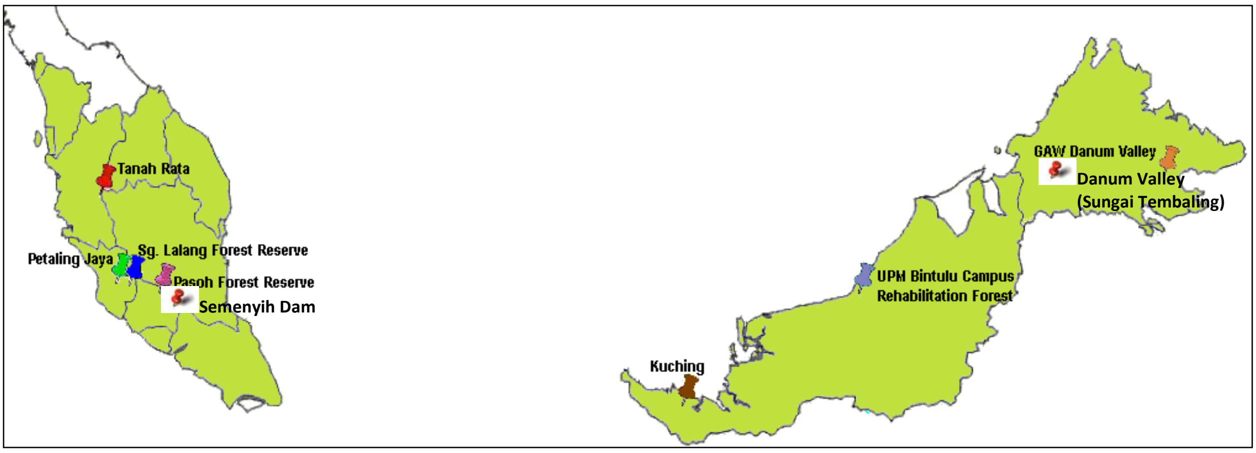


Figure 6.1.1. EANET monitoring sites in Malaysia.

Monitoring activities include:
i. Wet deposition monitoring
ii. Dry deposition monitoring (gases and aerosols)
iii. Soil and vegetation monitoring
iv. Inland aquatic environment monitoring
v. Meteorological monitoring

6.1.4. Sampling and measurements

6.1.4.1. Wet deposition sampling and collection

Wet deposition was monitored by using the ‘wet-only sampler’ for concentration measurement with standard rain gauge for precipitation amount measurement. The rainwater samples were collected weekly and stored in the polyethylene bottles. The samples were sent to the Department of Chemistry, Malaysia for chemical analysis of the principal anions and cations. A biocide, thymol, was used to prevent biological degradation of the samples.

6.1.4.2. Dry deposition sampling and collection

Dry deposition was monitored by using the filter pack for both gases and aerosols at all three sites. Sampling in Tanah Rata and Petaling Jaya was done weekly whereas in Danum Valley it was biweekly due to low concentrations at the surrounding area.

Passive sampler was used to monitor the gases on an experimental basis. The sampling started on a monthly basis in July 2007 for Tanah Rata and Danum Valley. The Department of Chemistry is in the process of adopting the analytical methodology.

6.1.4.3. Monitoring and analytical methodologies

The monitoring methodologies for wet and dry deposition are continuously reviewed and much effort has been taken to standardize methods and instruments used in all 22 monitoring stations of MMD, and particularly in the three EANET sites.

The Department of Chemistry (DOC) has purchased two Ion Chromatographs (ICs) in 2005 and 2006, one for the analysis of cations and the other for anions. The ICs were utilized for analysis of samples related to EANET activities.

6.1.4.4. Soil sampling and analysis

Soil sampling:

Three plots, occupying areas of 9 m x 9 m, were established in both the sites (Pasoh and Sg. Lallang Forest Reserves). Two subplots of 1 m x 1 m in size were selected in principle at the center and at the right side of each plot. Subplot 1 and subplot 41 were located at the side and center of the plot respectively. A total of six subplots were dug up to 1 m depth and soil profiles were observed. Soil sample was taken from every layer between 10 cm to 100 cm.

Soil analysis:

Soil samples were brought back to Department of Environmental Science laboratory. Laboratory analysis for the soil sample of each layer of the subplot were carried out using standard method recommended by Technical Manual for Soil and Vegetation Monitoring in East Asia (Acid Deposition Monitoring Network in East Asia, 2000).

6.1.4.5. Inland and aquatic sampling and collection

Sampling method

Surface water samples were collected at 30 cm depth using a grab sampler 4 times a year. The sampling point is in the center of the dam for Semenyih Dam, while for Danum Valley (Sungai Tembaling) the sampling point is at the estuary. pH and temperature were measured in situ. The water samples collected in clean polyethene bottles and sent to the Chemistry Department for chemical analysis.

6.1.4.6. Submission of data to the Network Center

The data from the monitoring done by the respective agencies were submitted to MMD. MMD compiled, validated and submitted to National Focal Point for approval before submission to the Network Center.

Malaysia also participated in the Inter-laboratory comparison project on wet deposition, dry deposition, soil and inland aquatic environment. The Department of Chemistry Malaysia has conducted the Inter-laboratory comparison project on wet deposition (10th Attempt) and dry deposition (3rd Attempt) in early 2008. The analytical results were submitted to the Network Center in March 2008.

Under the Inter-laboratory comparison project 2007 on soil (9th Attempt), two soil extract samples were sent to the participating laboratory at UPM for analysis in early February 2008. The analytical results have also been submitted to the Network Center in late June 2008.

6.2. State of Acid Deposition in Malaysia

6.2.1 Atmospheric deposition

This assessment examines the wet deposition of sulphates and nitrates and the gaseous substances such as sulphur dioxide (SO_2) and nitric acid (HNO_3) at Petaling Jaya urban GAW station, Tanah Rata regional GAW station and Danum Valley baseline GAW station from 2005 to 2009. The wet deposition for Kuching station (new monitoring urban site) is reported from 2008 onwards.

6.2.1.1 State of wet deposition

The wet deposition sample was collected using the Ecotech wet-only sampler on a weekly basis. Figures 6.2.1, 6.2.2 and 6.2.3 show the time series of monthly wet deposition of sulphate and nitrate from 2005 to 2009 at Tanah Rata, Danum Valley and Petaling Jaya sites, respectively. Figure 6.2.4 shows the time series of monthly wet deposition of sulphate and nitrate from 2008 to 2009 at the Kuching station. The high variability of wet deposition at all four sites maybe due to the inherent high rainfall variability in the tropics.

Generally, the highest monthly wet deposition for sulphate and nitrate at Petaling Jaya was observed during April or March Whereas for Tanah Rata, the highest monthly wet deposition was observed in May or September. The monthly wet deposition at Danum Valley is lower than 2.5 mmol.m^{-2} except for sulphate in October 2006. The monthly wet deposition of sulphate and nitrate at Kuching is lower than 4.0 mmol.m^{-2}.

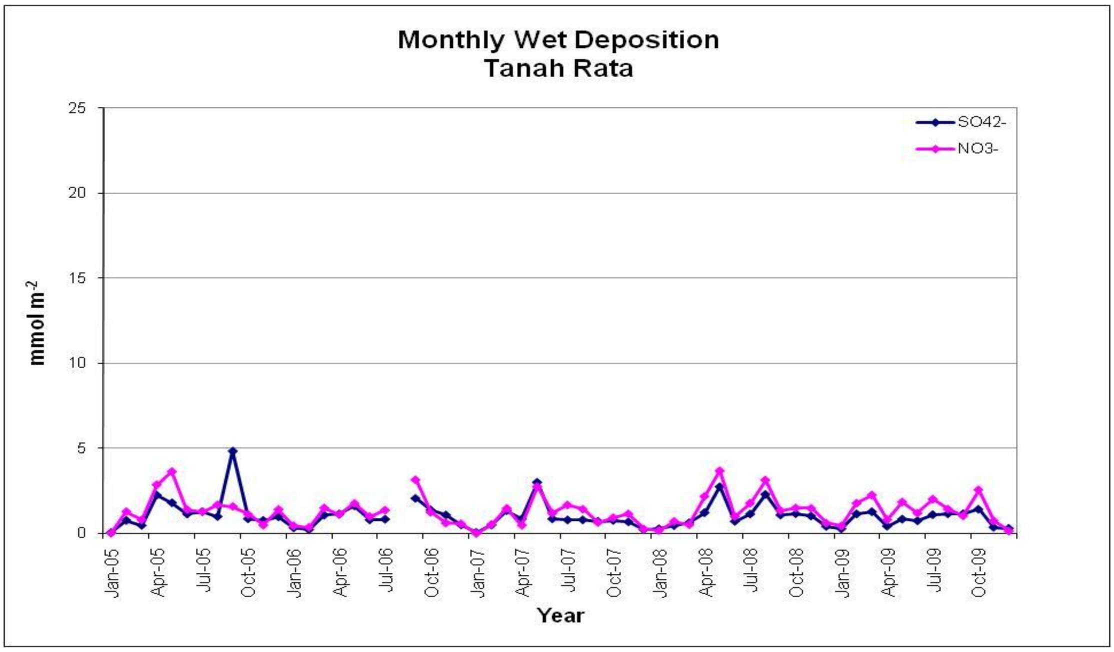


Figure 6.2.1. Time series of monthly wet deposition of sulphate and nitrate at Tanah Rata regional GAW station from 2005 – 2009.

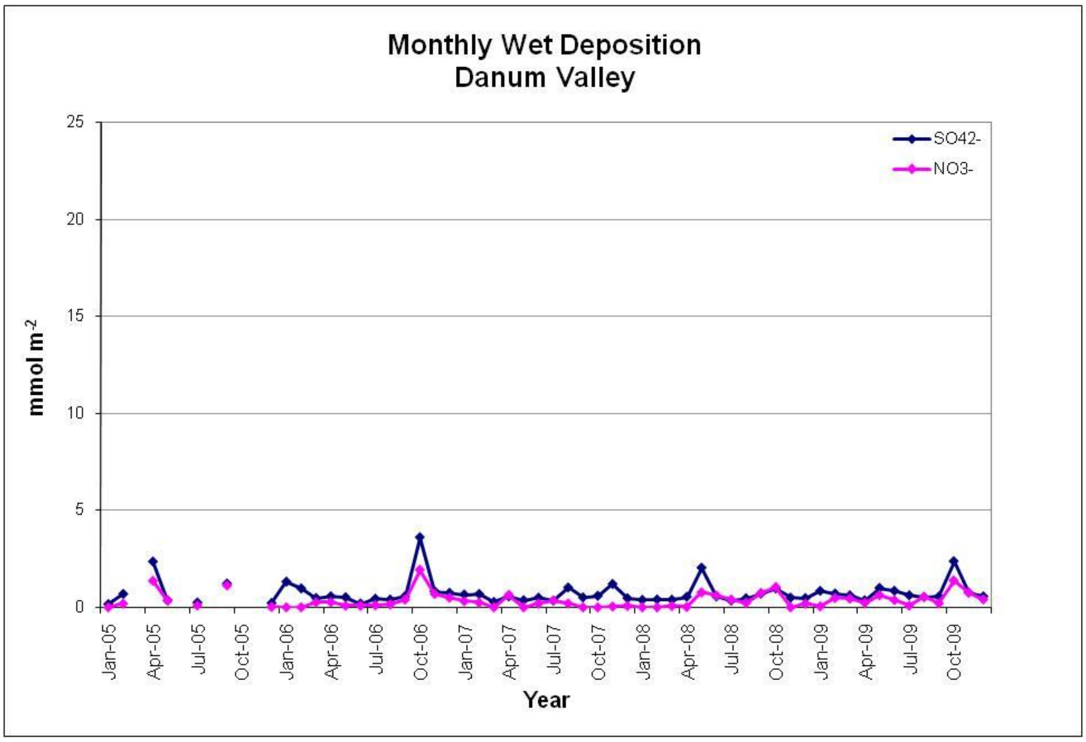


Figure 6.2.2. Time series of monthly wet deposition of sulphate and nitrate at Danum Valley GAW station from 2005 – 2009.

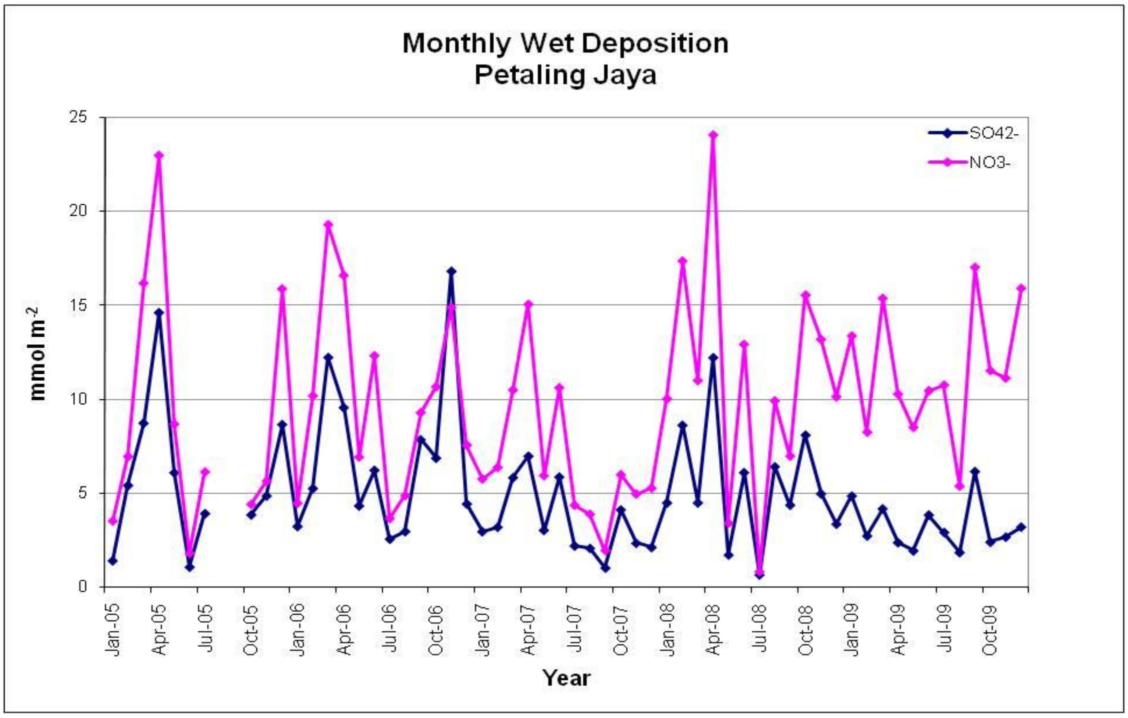


Figure 6.2.3. Time series of monthly wet deposition of sulphate and nitrate at Petaling Jaya station from 2005 – 2009.

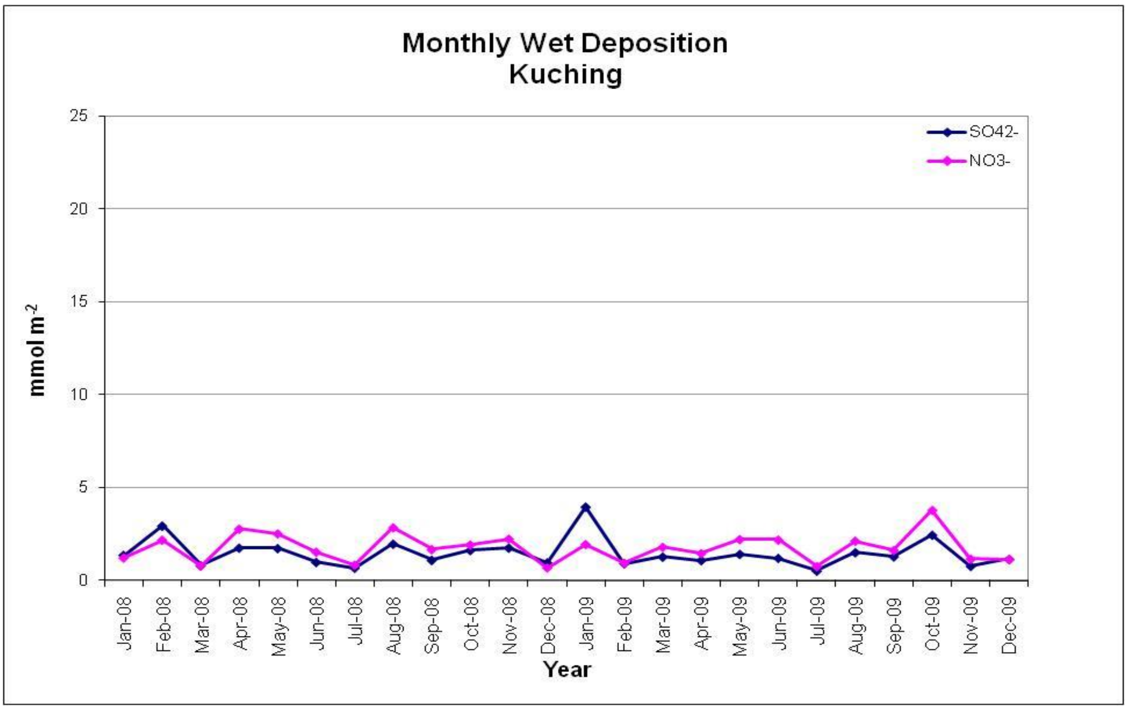


Figure 6.2.4. Time series of monthly wet deposition of sulphate and nitrate at Kuching station from 2008 – 2009.

Figures 6.2.5 and 6.2.6 show the Annual wet deposition of sulphate and nitrate at Tanah Rata, Danum Valley and Petaling Jaya sites, respectively.

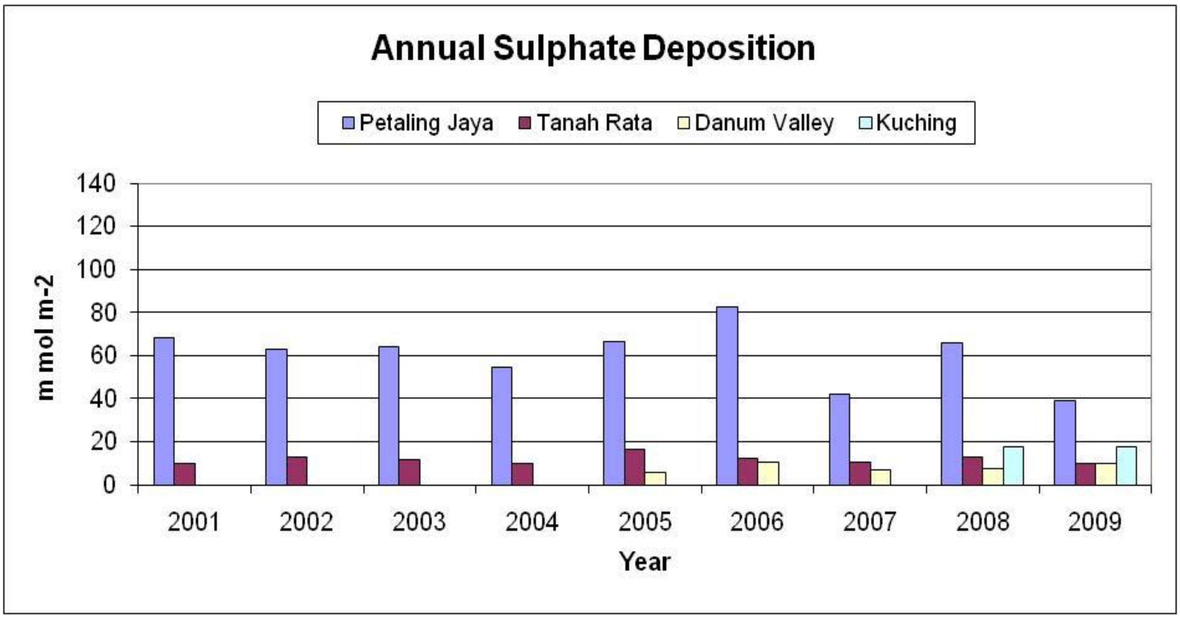


Figure 6.2.5. Annual sulphate deposition from 2001 – 2009.

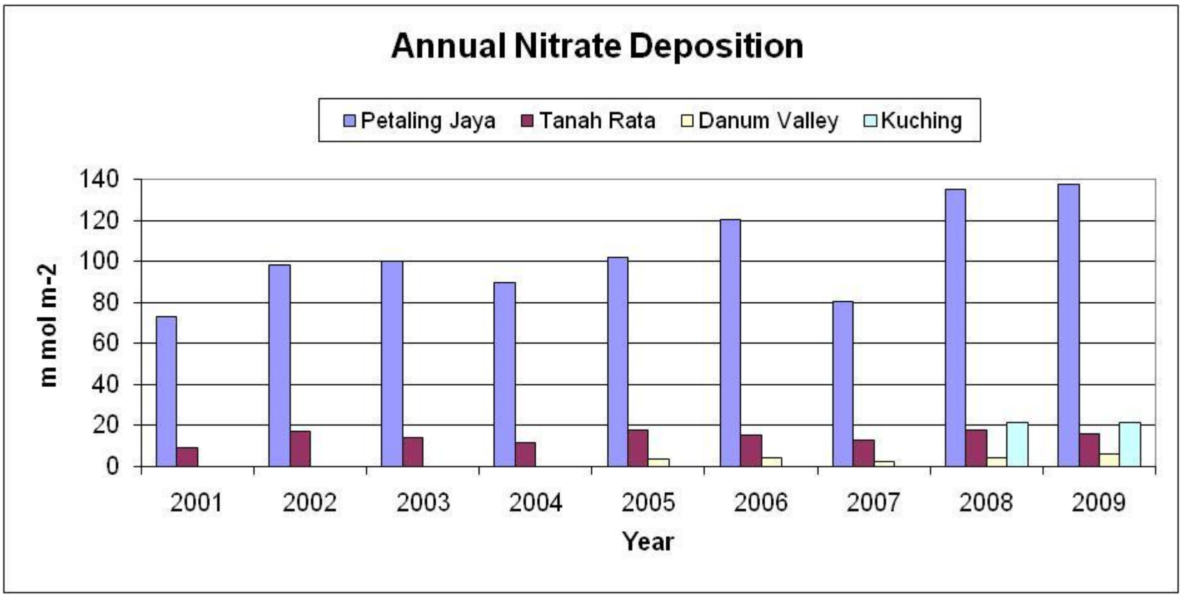


Figure 6.2.6. Annual nitrate deposition from 2001 – 2009.

From the figures, the following conclusions are made:

a) Petaling Jaya (urban site) showed much higher concentration as compared to the other three sites for both sulphate and nitrate. This might be due to the close proximity of the industrial area to the monitoring site. In addition, the higher value is possibly due to larger amount of precipitation received in this site as compared with the other sites.

b) Comparing between nitrate and sulphate wet deposition, Petaling Jaya, Tanah Rata and Kuching had higher nitrate concentrations; whereas in Danum Valley, sulphate concentration was higher. The higher sulphate in Danum Valley may be contributed from greater decomposition of organic matter activities.

6.2.1.2. State of dry deposition

The filter pack method was used in Tanah Rata, Danum Valley and Petaling Jaya sites to monitor the dry deposition fluxes in Malaysia. To estimate the magnitude of dry deposition flux, the ambient air concentration of gaseous substances of SO_2 and HNO_3 are presented and discussed.

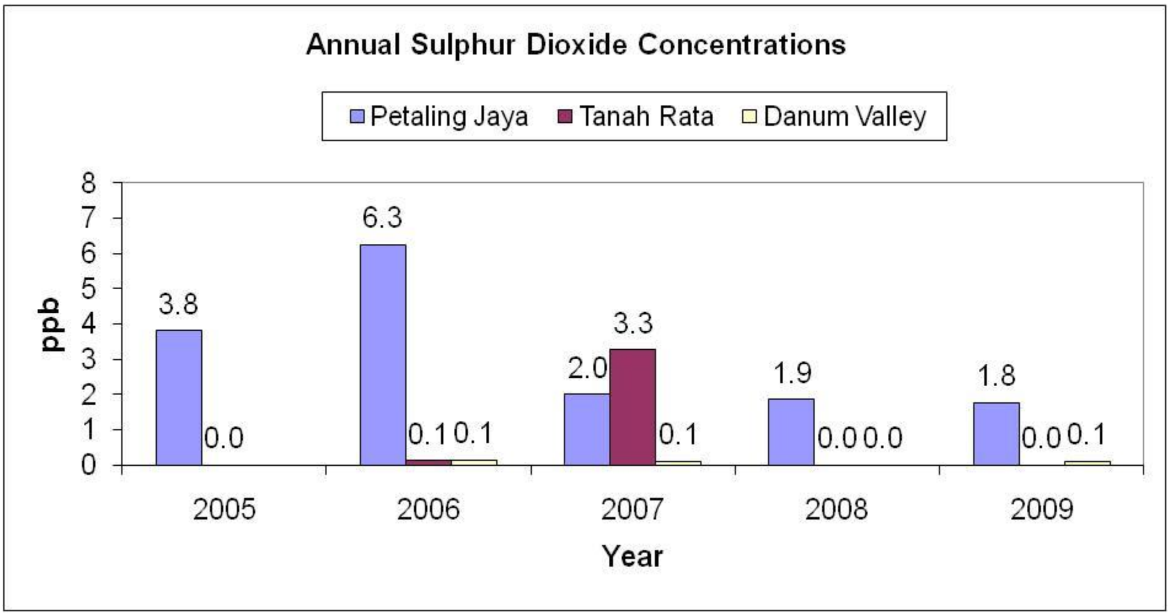


Figure 6.2.7. Annual sulphur dioxide concentrations from 2005 – 2009.

Data under the detection limit were depicted as 0.0 in Figures 6.2.7 and 6.2.8. Figure 6.2.7 shows that Petaling Jaya (urban site) has higher annual SO_2 concentrations than Tanah Rata and Danum Valley. In Danum Valley, the annual concentration of SO_2 is below 0.1 ppb. The SO_2 concentrations in Tanah Rata are mainly below 0.1 ppb except for 2007 which recorded 3.3 ppb.

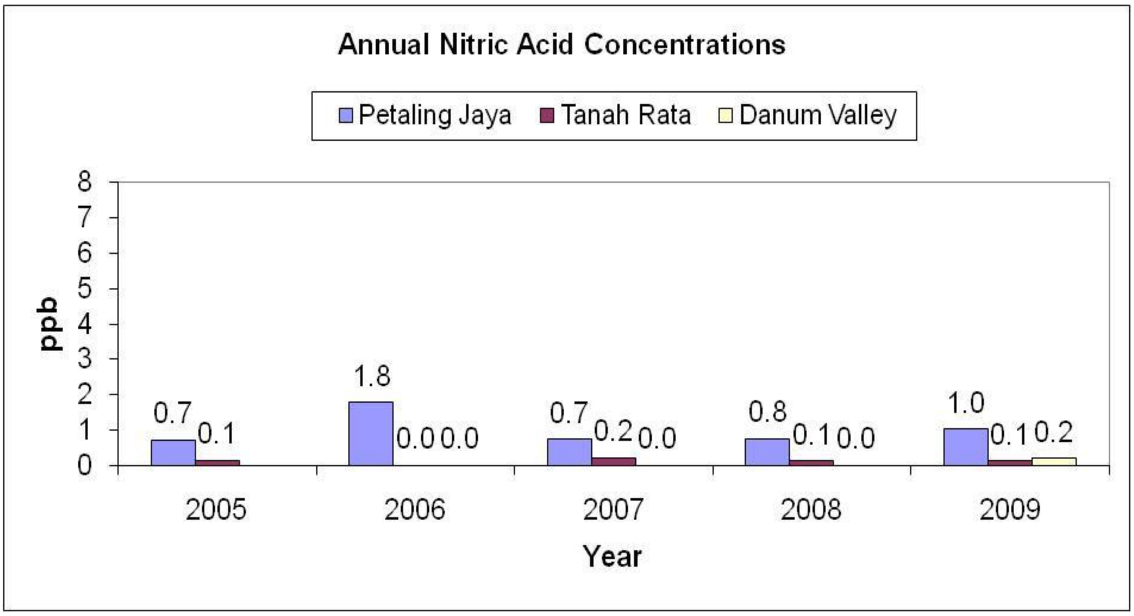


Figure 6.2.8. Annual nitric acid concentrations from 2005 – 2009.

In Tanah Rata and Danum Valley, the annual concentrations of HNO_3 are mainly below 0.2 ppb while the nitric acid concentration in Petaling Jaya is ranged between 0.7 ppb and 1.8 ppb.

6.2.2. State of inland aquatic environment

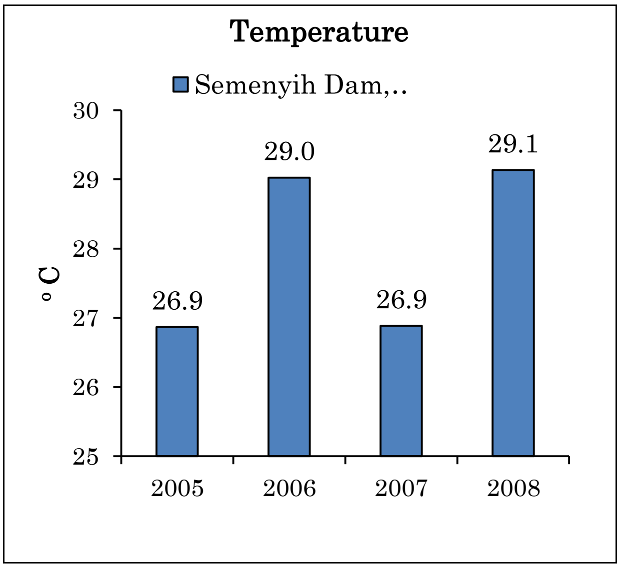
6.2.2.1. Sampling site

Two sampling sites were selected for the inland acidification study. They are the Semenyih Dam in West Malaysia and Sungai Tembaling in East Malaysia. The geographical characteristics and location are summarized in Table 6.2.1.

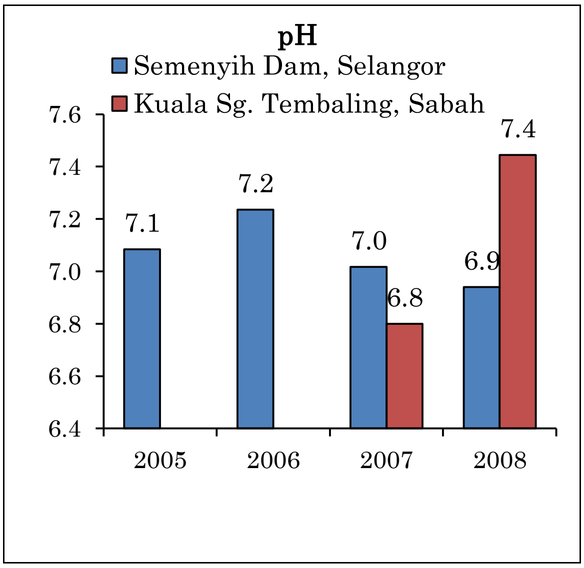
Semenyih Dam is located 25 km from Kajang town and 20 km from Bangi town. Beranang, Seremban, and Nilai are also located within 25 km from Semenyih Dam while Shah Alam is 80 km away. All these towns have industries, businesses and housing areas, which could contribute to anthropogenic pollution. There is also an agricultural area located on the west side of the reservoir and forest areas on the east side. However, due to insufficient data on Sungai Tembaling site, there no further explanation and conclusion can be made based on the collected data.

Table 6.2.1. Geographical characteristics and location of sampling sites.

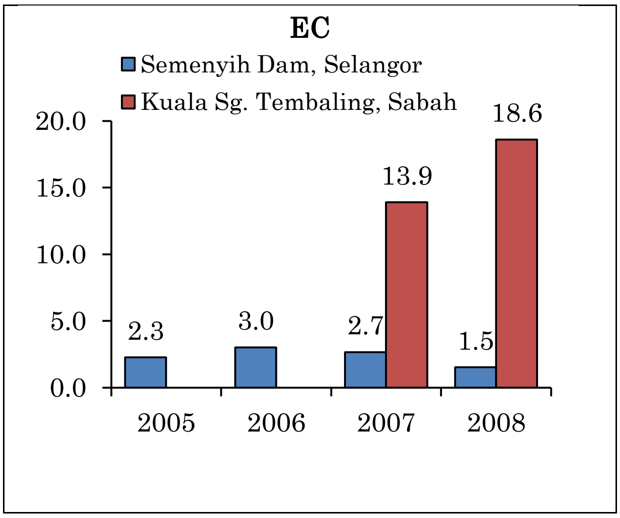
	Semenyih Dam	Sungai Tembaling
Altitude	230 m above sea level	427 m above sea level
Longitude	101° 53.058′ E	117° 51′ E
Latitude	3° 04.574′ N	4° 59′ N
Type of site	Semi urban	rural



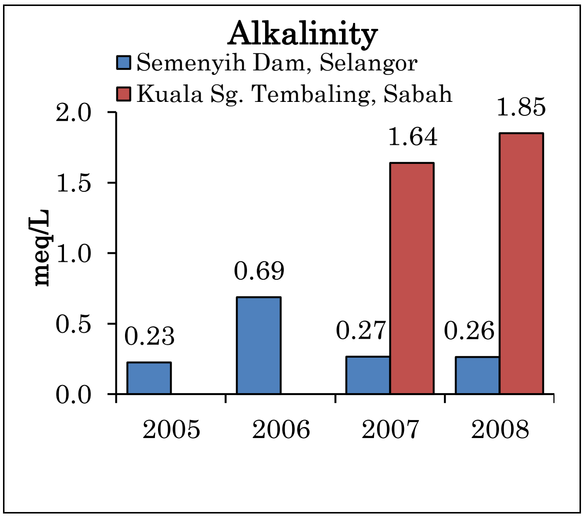
(a)



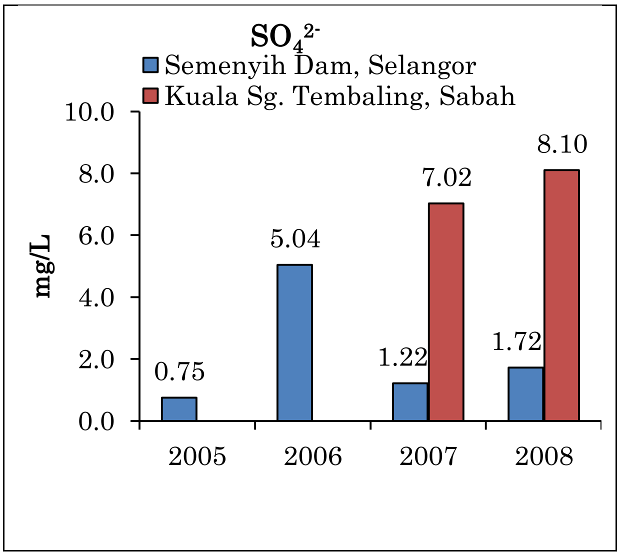
(b)


EC
Semenyih Dam, Selangor
Kuala Sg. Tembaling, Sabah
20.0
15.0
10.0
5.0
0.0
2.3
3.0
2.7
13.9
1.5
18.6
2005
2006
2007
2008

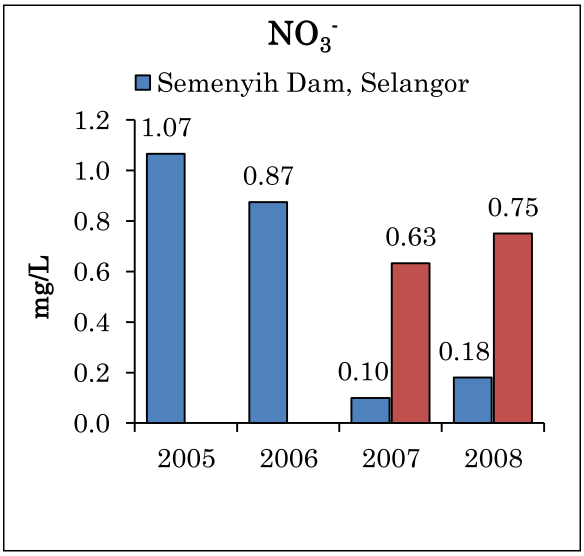
(c)


Alkalinity
Semenyih Dam, Selangor
Kuala Sg. Tembaling, Sabah
meq/L
2.0
1.5
1.0
0.5
0.0
0.23
0.69
0.27
1.64
0.26
1.85
2005
2006
2007
2008

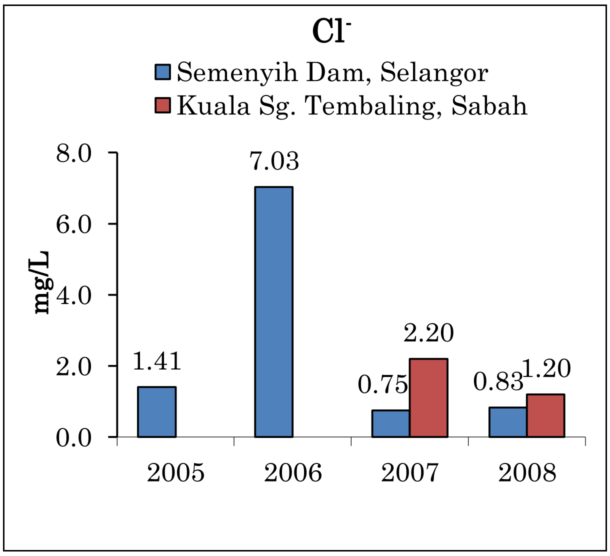
(d)


SO_4^{2-}
Semenyih Dam, Selangor
Kuala Sg. Tembaling, Sabah
mg/L
10.0
8.0
6.0
4.0
2.0
0.0
0.75
5.04
1.22
7.02
1.72
8.10
2005
2006
2007
2008

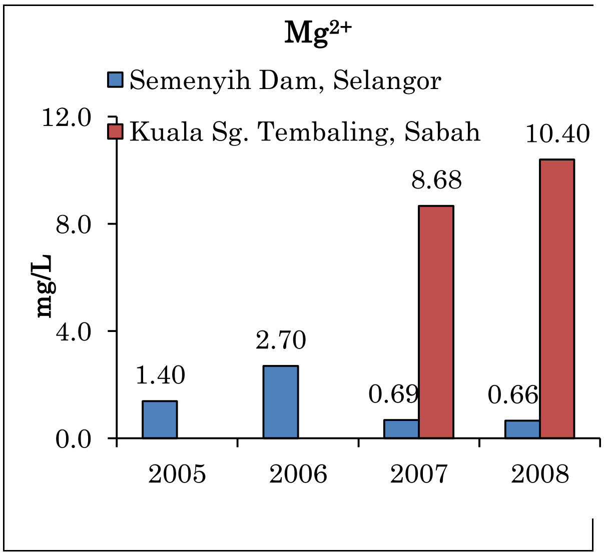
(e)


NO_3^-
Semenyih Dam, Selangor
mg/L
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.07
0.87
0.10
0.63
0.18
0.75
2005
2006
2007
2008

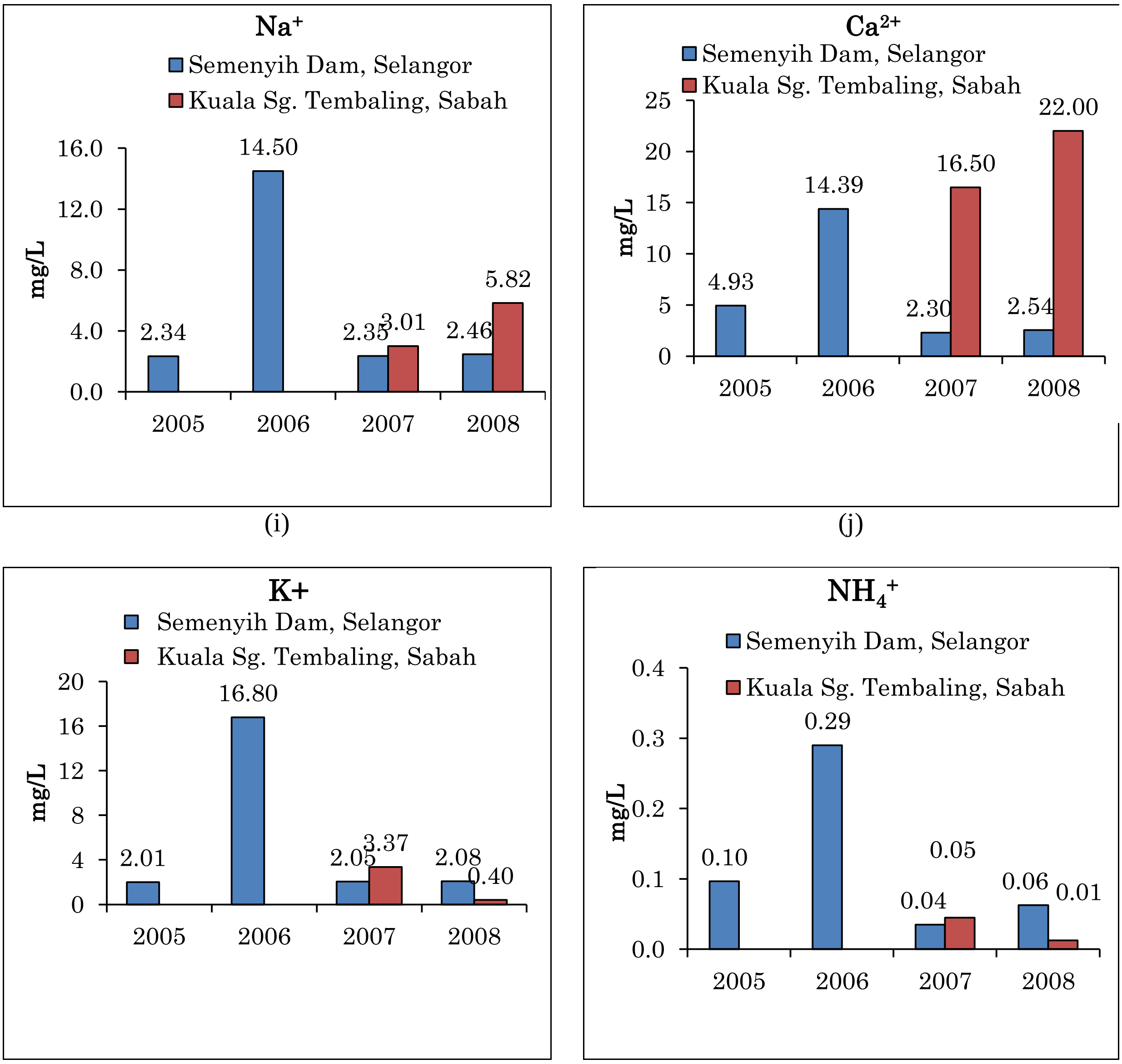
(f)


Cl^-
Semenyih Dam, Selangor
Kuala Sg. Tembaling, Sabah
mg/L
8.0
6.0
4.0
2.0
0.0
1.41
7.03
0.75
2.20
0.83
1.20
2005
2006
2007
2008

(g)


Mg^{2+}
Semenyih Dam, Selangor
Kuala Sg. Tembaling, Sabah
mg/L
12.0
8.0
4.0
0.0
1.40
2.70
0.69
8.68
0.66
10.40
2005
2006
2007
2008

(h)



(i) (j)

(k) (l)

Figure 6.2.9 (a)-(l). Annual mean concentrations for physical and chemical compositions of surface water for Semenyih Dam (2005-2008) and Tembaling River (2007-2008).

Table 6.2.2. Statistical analysis for Semenyih Dam, Selangor.

Year	**Temp.** (^{o}C)	**pH**	**EC** (mS.m^{-1})	**Alkalinity** (meq.l^{-1})	**SO$_4^{2-}$** (mg.l^{-1})	**NO$_3^{-}$** (mg.l^{-1})	**Cl^{-}** (mg.l^{-1})	**NH$_4^{+}$** (mg.l^{-1})	**Na^{+}** (mg.l^{-1})	**K^{+}** (mg.l^{-1})	**Ca^{2+}** (mg.l^{-1})	**Mg^{2+}** (mg.l^{-1})
2005	26.9	7.1	2.3^{a}	0.23^{a}	0.75^{a}	1.07	$1.41^{a,b}$	$0.10^{a,b}$	2.34^{a}	2.01	4.93	1.40
2006	29.0	7.2	$3.0^{a,b}$	$0.69^{a,b}$	5.04	0.87	$7.03^{a,b}$	$0.29^{a,b,c}$	$14.50^{a,b,c}$	16.80	14.39	2.70
2007	26.5	7.0	$2.6^{b,c}$	0.24^{b}	1.25	0.10	0.70^{a}	0.04^{b}	2.20^{b}	2.00	2.28	0.68
2008	29.1	6.9	1.5^{c}	0.26	1.73^{a}	0.18	0.83^{b}	0.06^{c}	2.46^{c}	2.08	2.54	0.66

$^{a, b, c}$ *Means with different superscript letters in a column are significantly different ($p<0.05$)*

Note: In 2006, frequent release of dam water to Semenyih river for operational purposes by the dam management caused turbulence which affected concentrations of cations and anions causing elevated levels of physical and chemical parameters.

pH

Figure 6.2.9 (b) shows that between 2005-2008, the pH values were mostly ≥ 7.0, the lowest annual mean recorded were 6.8 for Kuala Sg. Tembaling in 2007 and 6.9 for Semenyih Dam in 2008. These pH values indicate that the water of Semenyih Dam and Sg. Tembaling are not threatened by acidic compositions deposition. The pH values also reflect the concentration of anions and cations in the water.

Major contributors of acidic ions in water are SO_4^{2-}, NO_3^- and Cl^-, while major contributors of basic cations are NH_4^+, Na^+, K^+, Ca^{2+} and Mg^{2+}. The later ions have neutralizing effect towards acidity contributed by the acidic anions.

Alkalinity

Figure 6.2.9(d) indicates that Sg. Tembaling in Sabah contained more basic ions compared to Semenyih Dam in Selangor, thus the alkaline or neutral pH values for 2007 and 2008. By contrast the alkalinity of Semenyih Dam was relatively much less than Sg.Tembaling, and this is well reflected in lower annual pH at 6.9 in 2008 for Semenyih Dam.

Statistical analysis for Semenyih Dam reveals that there is significant differences between alkalinity values of 2005, 2006 and 2007. In 2005, alkalinity was 0.23 meq/L while in 2006, it became 0.69 meq/L an increase of 0.46 meq/L or 200%. In 2007, alkalinity decreased to 0.27 meq/L which was statistically significant (decrease of 41%). In 2006, alkalinity was 0.26 meq/L which showed no significant difference from 2007. For Sg. Tembaling there is significant difference between 2007 alkalinity of 1.64 meq/L and 2008 alkalinity of 1.85 meq/L to the confidence level of 95%.

Anions

For Semenyih NO_3^- showed no significant difference in concentration during the study period from 2005 to 2008. Concentration of NO_3^- showed gradual but insignificant decrease in concentration from 2005 to 2007. In 2008, there was a slight increase in NO_3^- concentration compared to the previous year. The main source of NO_3^- is from NO_2 from fossil fuel combustion. The NO_3^- concentration in Sg. Tembaling was much higher than that of Semenyih Dam during 2007-2008 (Figure 6.2.9(f)).

For Semenyih Dam, Cl^- showed significant statistical difference between 2005, 2006 and 2007 but not 2008. For Sg. Tembaling, Cl^- showed a decrease of 45% concentration in 2008, thus indicating a significant change between concentration of Cl^- in 2007 and 2008.

Cations

The annual mean concentration for cationic ions, K^+, Ca^{2+}, and $Mg2^+$ for Semenyih Dam showed no significant difference for the reported period (Figure 6.2.9 (h)). For NH_4^+ there was a significant difference in concentration for period between 2005 and 2006; 2005, 2006 and 2007; as well as 2006 and 2008. There was significant difference for annual Na^+ ion for 2005 and 2006; 2006-2007 and 2006-2008. There was an exceptionally elevated concentration of all cations in

2006 compared to the other years for Semenyih Dam. Sg. Tembaling on the other hand showed higher concentrations of Na^+, Ca^{2+} and Mg^{2+} from 2007 to 2008

6.2.3. State of soil and vegetation

6.2.3.1. Description of the soil and vegetation and ecological impact monitoring activities in Malaysia

Three locations have been identified for soil and vegetation and ecological impact monitoring in Malaysia namely Pasoh Forest Reserve, Sungai Lallang Forest Reserve and Universiti Putra Malaysia Bintulu Campus (UPMKB).

6.2.3.2. Sungai Lallang Forest Reserve

Location

Sungai Lallang Forest Reserve is an inland forest reserve lying at about latitude 3° 05'N the center is located on the South eastern part of State of Selangor. The area situated in the Sungai Lalang Forest Reserve covering an area of 5,478 hectares. It is about 50 km from Kuala Lumpur and easily accessible by main road through Kajang town and 9th Mile Cheras, Ulu Langat. It comprises the Sungai Tekala Forest Recreation area and four demonstration plots representing the various profile of the forest which managed under the sustainable forest management following the Malayan Uniform System.

Climate

The nearest meteorological station for the center is at Ulu Langat Dam. The rainfall is distributed fairly throughout the year with the mean annual rainfall of 2,648.9 mm. The highest and lowest rainfall was recorded in November and January with 432 mm and 514 mm respectively. The annual air temperature is moderate and uniform with the mean annual temperature of 26.5°C.

Flora and Fauna

The area is considered rich in flora and fauna which ecologically classified as the lowland dipterocarp forest characterized by the predominance of the family of Dipterocarpaceae with many of the species of the genera *Anisoptera, Dipterocarpus, Hopea* and *Shorea*. Apart from the flora there is an abundant number of fauna which contribute the richness in the biodiversity of the area. This is evident from the survey conducted by the Wildlife Department in 1983, which there are 27 species of mammals and 212 species of birds has been found in the area. Details of the list of mammal and bird species are shown in Appendices 1 and 2.

PLOT 1:

Compartment 24, Sungai Lallang Forest Reserve (Virgin Jungle Reserve)

Area Description

i. Area : 81.7 ha
ii. Topography : Lies between 50 to 150 meter elevation with slope between 1-3%

iii. Forest type : Lowland Dipterocarp Forest.

The predominate species are:-

a) Meranti tembaga (*Shorea leprosula*)
b) Meranti Kepong (*Shorea ovalis*)
c) Meranti rambai daun (*Shorea acuminata*)
d) Keruing gombang (*Dipterocarpus cornutus*)

iv. Status of forest : The current stocking is estimated to be as follows:-

a. For all trees 15 cm dbh and above

Species Group	Number of tree.ha^{-1}	Basal Area m^2.ha^{-1}	Volume m^3.ha^{-1}
Dipterocarp	42.2	10.4	109.7
Non-Dipterocarp	224.2	19.5	124.9
Total	266.4	29.9	234.6

b. For all tree 45 cm dbh and above

Species Group	Number of tree/ha	Basal Area m^2.ha^{-1}	Volume m^3.ha^{-1}
Dipterocarp	18.0	8.8	100.7
Non-Dipterocarp	32.9	9.2	81.9
Total	50.9	18.0	182.6

PLOT 2:

Compartment 31, Sungai Lallang Forest Reserve
Regenerated Forest: 20 year old forest stand

Area description

i. Area : 61.0 ha
ii. Topography : Lies between 250 to 600 meter elevation with slope between 15 to 15%
iii. Forest type : Hill Dipterocarp Forest.

The predominate species are:-

a) Meranti seraya (*Shorea curtisii*)
b) Meranti sarang punai (*Shorea parvifolia*)
c) Balau kumus (*Shorea laevis*)
d) Meranti nemesu (*Shorea pauciflora*)
e) Keruing (*Dipterocarpus species*)

iv. Status of Forest:
This area was harvested under 55 year felling cycle (Malayan Uniform System). Under this forest management system, all trees having 45 cm diameters at breast height (dbh)

and above were felled. The total volume harvested from this area was 3,459.3 m^3 (56.7 m^3/ha). The current stocking is estimated to be as follows:-

a. For all trees 15 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	56.6	5.4	66.0
Non-Dipterocarp	219.0	17.4	222.1
Total	275.0	22.8	288.1

b. For all tree 45 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	4.0	1.6	17.9
Non-Dipterocarp	19.0	4.3	49.2
Total	23.0	5.9	67.1

PLOT 3
Compartment 27, Sungai Lallang Forest Reserve
Regenerated Forest: 34 Year old forest stand

Area description

i. Area : 201.0 ha
ii. Topography : Lies between 150 to 400 meter elevation with slope between 4 to 10%
iii. Forest type : Hill Dipterocarp Forest.

The predominate species are:-

a) Meranti bukit (*Shorea platyclados*)
b) Meranti seraya (*Shorea curtisii*)
c) Meranti sarang punai (*Shorea parvifolia*)
d) Balau kumus *(Shorea laevis*)
e) Meranti rambai daun (*Shorea acuminata*)

The current stocking is estimated to be as follows:-

a. For all trees 15 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	30.0	6.1	71.4
Non-Dipterocarp	202.0	12.4	178.8
Total	232.0	18.5	250.2

b. For all tree 45 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	13.0	4.8	54.9
Non-Dipterocarp	8.0	3.5	37.7
Total	21.0	8.3	92.6

PLOT 4

Compartment 17, Sungai Lallang Forest Reserve

Regenerated Forest: 43 Year old forest stand

Area description

i. Area : 222.0 ha
ii. Topography : Lies between 50 to 150 meter elevation with slope between 1 to 3%
iii. Forest type : Lowland Dipterocarp Forest.

The predominate species are:-

a) Meranti kepong (*Shorea ovalis*)
b) Meranti tembaga (*Shorea leprosula*)
c) Meranti gombang (*Dipterocarpus cornutus*)
d) Kempas *(Koompassia*)
e) Damar hitam katup (*Shorea dolichocarpa)*

iv. Status of Forest:
The current stocking is estimated to be as follows:-

a. For all trees 15 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	68.0	10.1	122.4
Non-Dipterocarp	319.0	17.1	266.4
Total	387.0	27.2	388.8

b. For all tree 45 cm dbh and above

Species Group	Number of tree/ha	Basal Area $m^2.ha^{-1}$	Volume $m^3.ha^{-1}$
Dipterocarp	21.7	7.0	81.0
Non-Dipterocarp	20.1	5.3	60.6
Total	41.8	12.3	141.6

6.2.3.3. Pasoh Forest Reserve

Pasoh Forest Reserve covers an area of 6,000 ha and is located at 2^0 58'- 2^0 59'N and 102^0 17' – 102^0 20'E, about 140 km southeast of Kuala Lumpur (Kochummen *et al*, 1990). Total precipitation annually is 2,178 mm approximately with maximum temperature of 34.9^0C, minimum temperature of 19.7^0C, solar radiation of 15.08 MJ m^{-2} and relatively humidity of 85.8%. The vertical structure of the tropical rainforest can be conveniently divided into a profile of layers: emergent trees, main canopy of tree crowns, under storey trees, shrub and ground vegetation (Manokaran & La Frankie, 1990).

Species identification in 1 ha biodiversity plot at Pasoh Forest Reserve has been established. About 2,394 trees (Kochummen *et al*, 1990) with DBH (Diameter at Breast Height) ≥ 5 cm were found in this new plot. There are 76 plant families dominated by Dipterocarpaceae, Leguminosae, and Euphorbiaceae, and 723 species have been identifying covering 1 ha plot.

SUMMARY

Name of Plot: Pasoh Forest Reserve (1 ha plot)
Date: Starting from April 2008 until January 2009
Surveyor: Ahmad Makmom Abdullah

The vegetation features for Pasoh Forest Reserve is summarized below. It is noted that no new recruits or species have been lost since the first assessment. The total above ground biomass is 278 t/ha. The maximum tree height is 50 m and the diameter at breast height is 100 cm.

A. Vegetation

i. General Features

Location: Located about 2^0 58'- 2^0 59'N and 102^0 17' – 102^0 20'E.
Forest type: Natural, **Secondary**, Man-made
Major tree species: *Dacryodes rugosa*

ii. Measurement of trees

Maximum height:	50	m
Maximum diameter:	100	cm
Number of trees:	149	

Total above ground biomass (TAGB): 277.7 tonnes/ ha

iii. Understory Vegetation

Number of species: 723 species
Number of family: 76 families
Name of dominant species: *Dacryodes rugosa*
Name of dominant family: Dipterocarpaceae
New comer species: None
Lost species: None

B. Soil

Site name	Pasoh Forest Reserve (1 ha plot)
Sampling date	
Soil type	Granite and characterized by a pale coloured soil with abundant quartz gravel
Collection subplot	Total six subplots (1 m x 1 m) from three plots (9 m x 9m)
Collection method	A total of six subplots were dug until 1 m depth and soil profiles were observed. Soil sample was taken from every layer of 10 cm until 100 cm
Mean time of sampling to analysis	1-2 Day(s)

Soil chemistry

The soil pH (H_2O) ranged from 3.57 to 4.79 while the pH (KCl) was between 3.50 to 4.00.

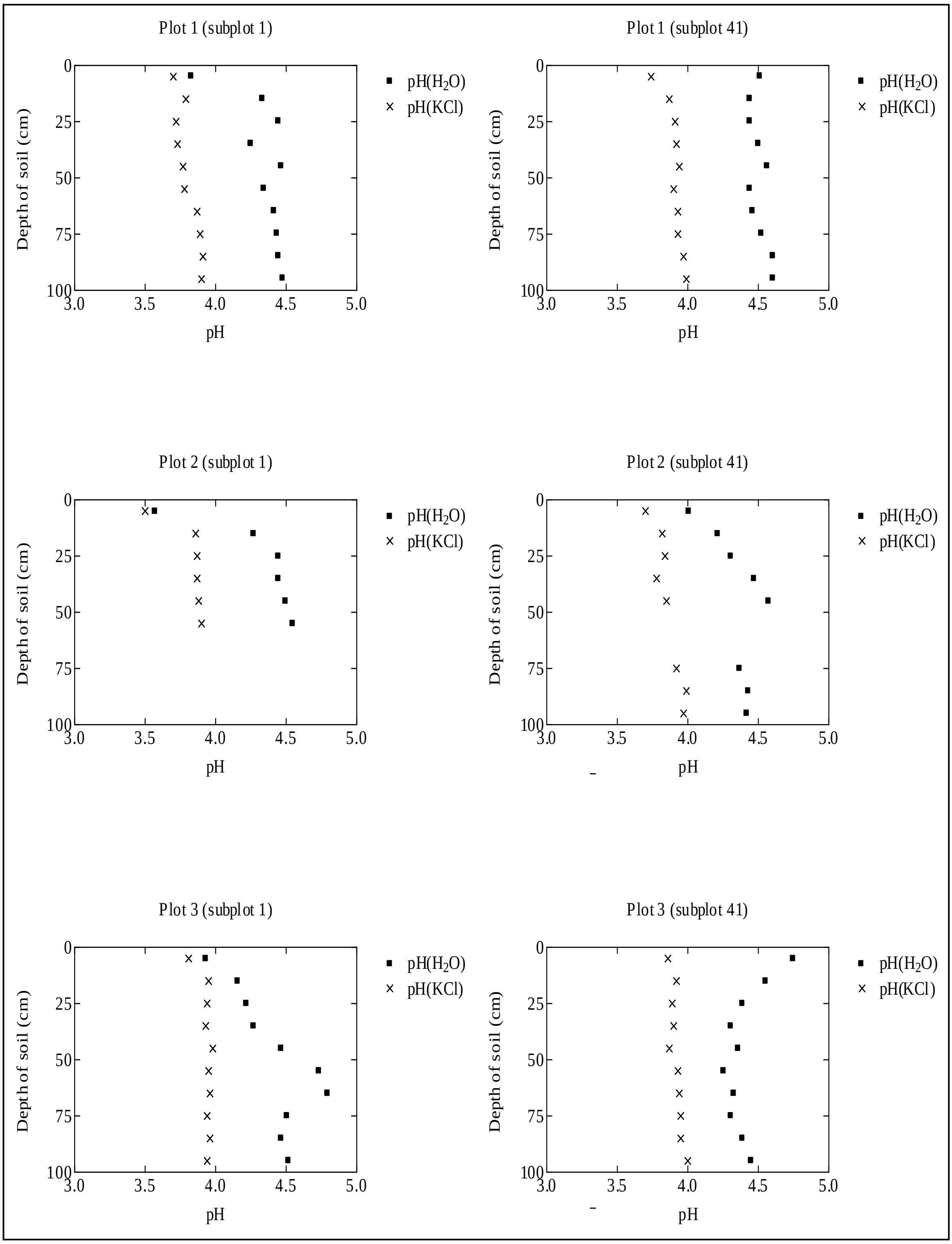
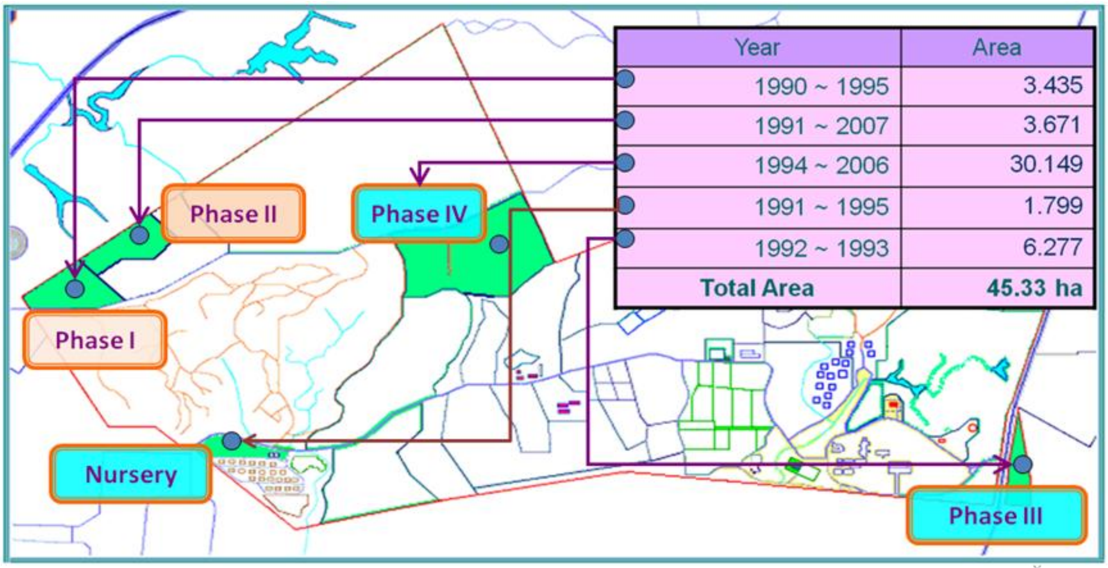


Figure 6.2.10. Variation of pH within 1 m depth of soils at Pasoh Forest Reserve.

3. Exchangeable (Mg^{2+}, K^{+}, Na^{+}, Ca^{2+}): range from 0.00 to 1.56, 0.001 to 3.82, 0.03 to 14.17 and 1.16 to 14.96 cmol(+) kg^{-1},
4. Exchangeable Acidity: ranged from 2.35 to 5.00 cmol(+) kg^{-1}.

6.2.3.4. Universiti Putra Malaysia, Bintulu Campus



Year	Area
1990 ~ 1995	3.435
1991 ~ 2007	3.671
1994 ~ 2006	30.149
1991 ~ 1995	1.799
1992 ~ 1993	6.277
Total Area	**45.33 ha**

Figure 6.2.11. Mitsubishi-UPM forest rehabilitation research project planting sites and area.

Phase I and Phase II have been choosen for monitoring acid deposition in soil. In Phase I seedling was planted in 1991 while Phase II in 2008. Plot 1 and Plot 2 were choosen from each site.

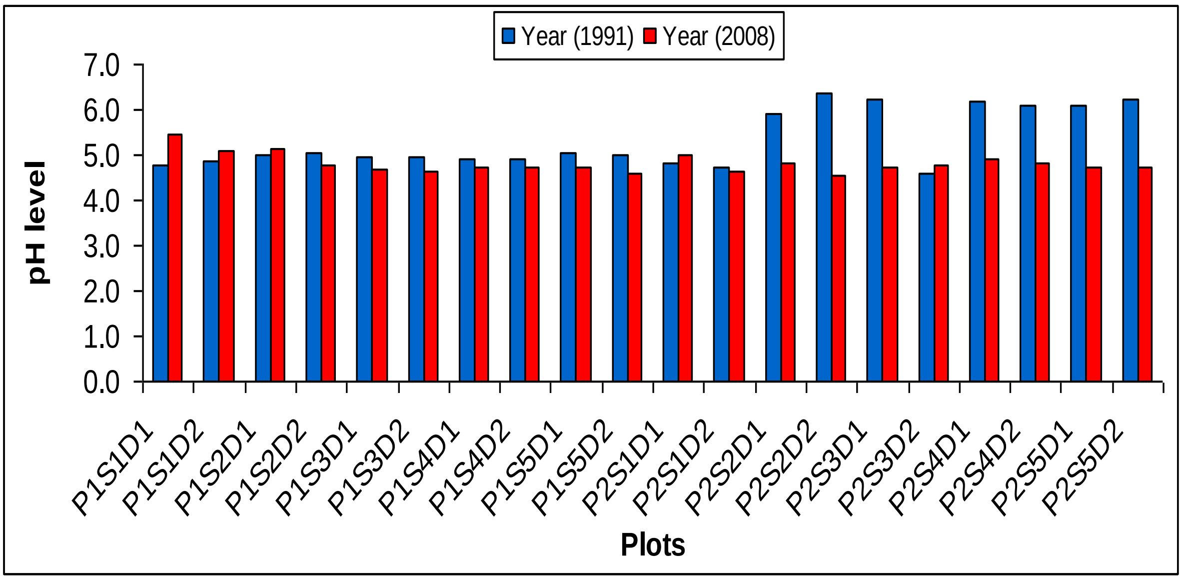


Figure 6.2.12. pH values in H_2O for 1991 and 2008 for Plots 1 and 2 for soil monitoring.

P = Plot

S = Subplot

D= Depth (D1:0-10cm, D2: 10-20)

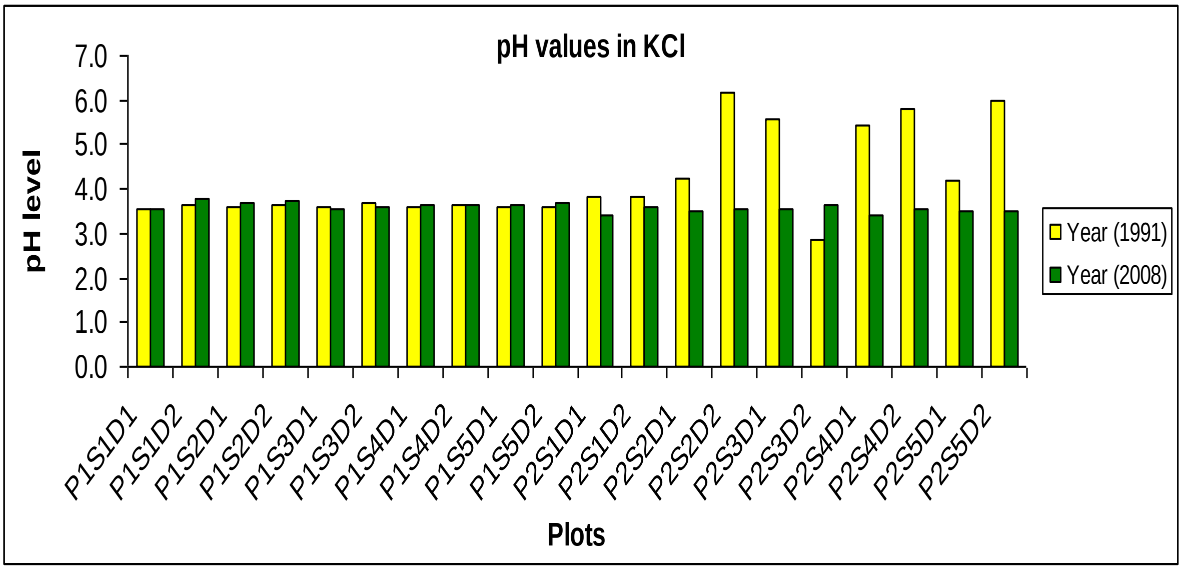


Figure 6.2.13. pH values in KCl for 1991and 2008 of Plots 1 and 2 for soil monitoring.

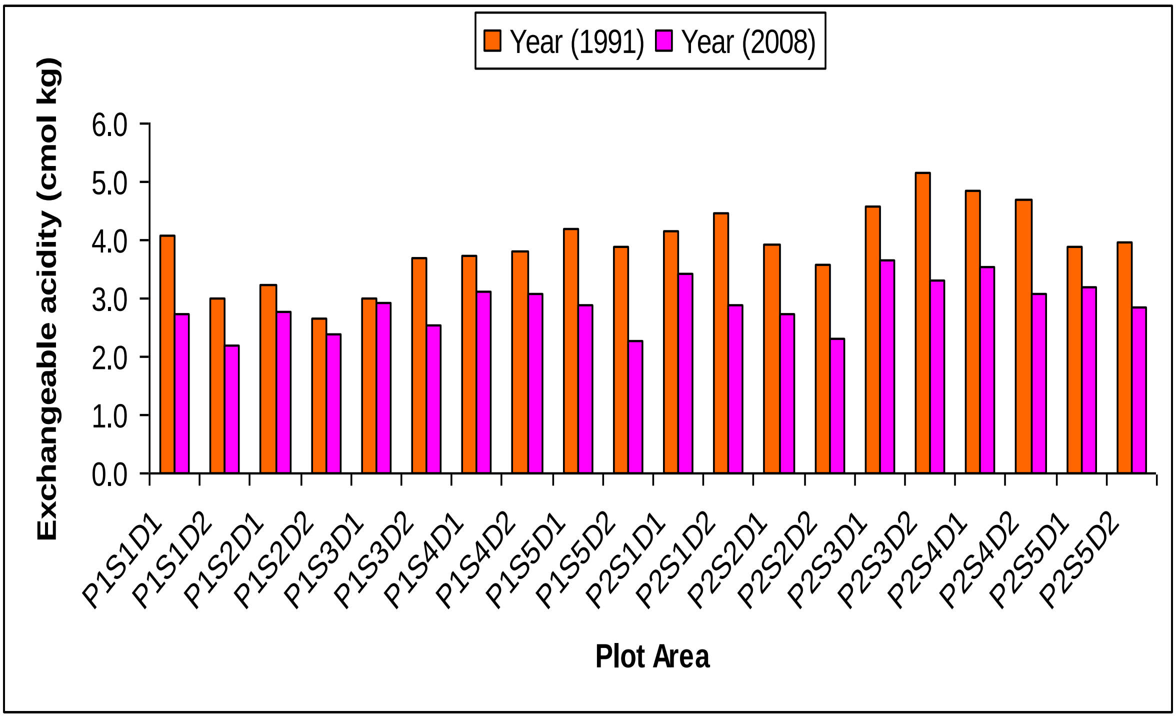


Figure 6.2.14. Exchangeable acidity values for 1991 and 2008 of Plot 1 and plot 2 for soil monitoring.

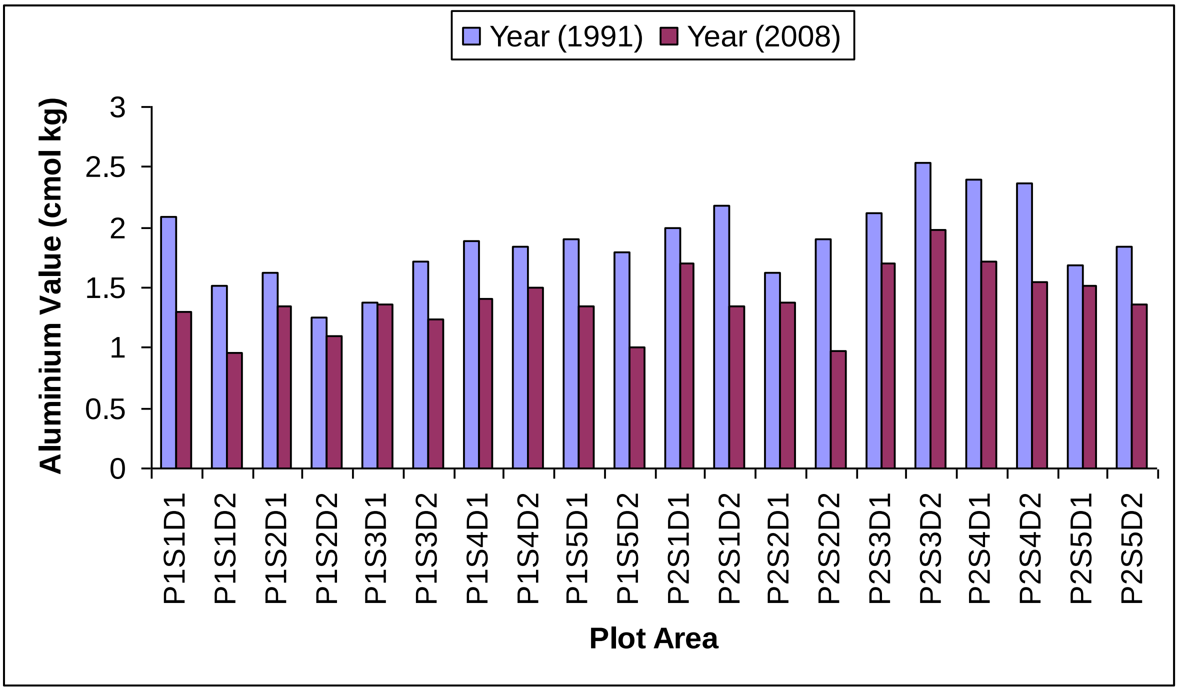


Figure 6.2.15. Exchangeable aluminium values for 1991 and 2008 of Plots 1 and 2 for soil monitoring.

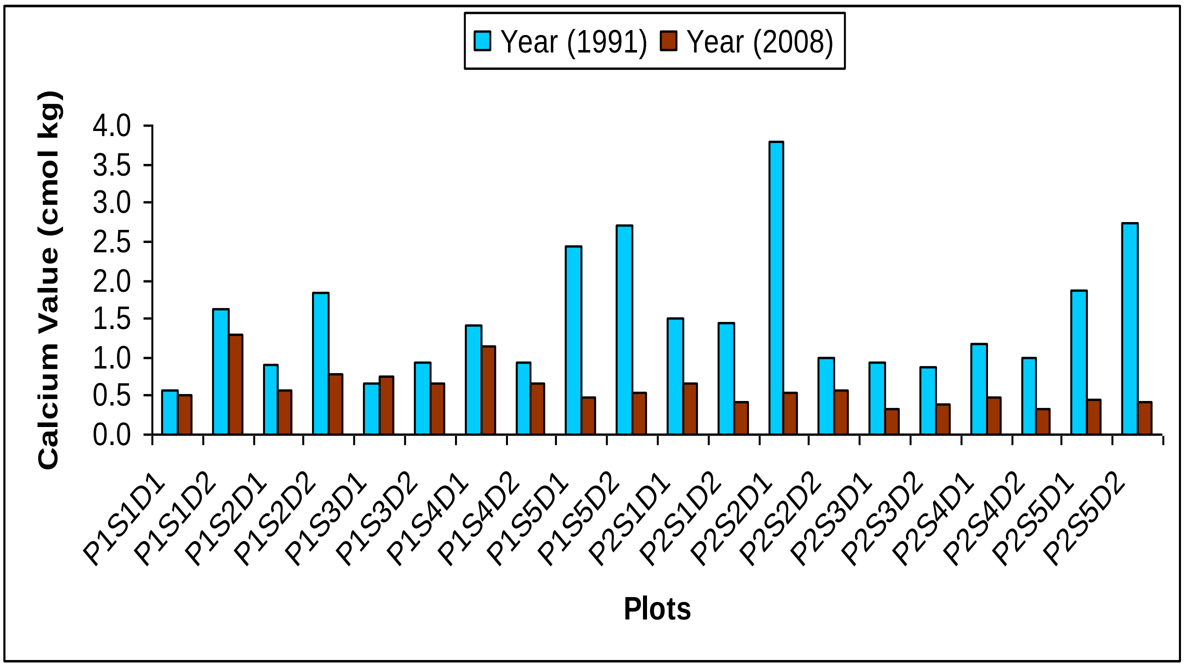


Figure 6.2.16. Exchangeable calcium values for 1991 and 2008 of plot 1 and plot 2 for soil monitoring.

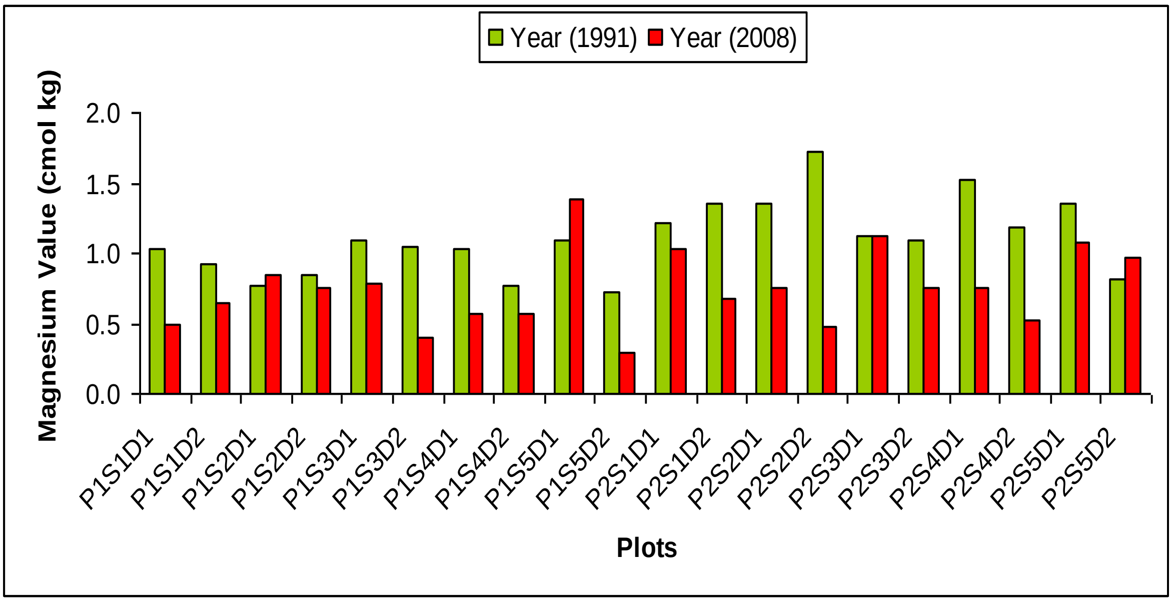


Figure 6.2.17. Exchangeable magnesium values for 1991 and 2008 of plot 1 and plot 2 for soil monitoring.

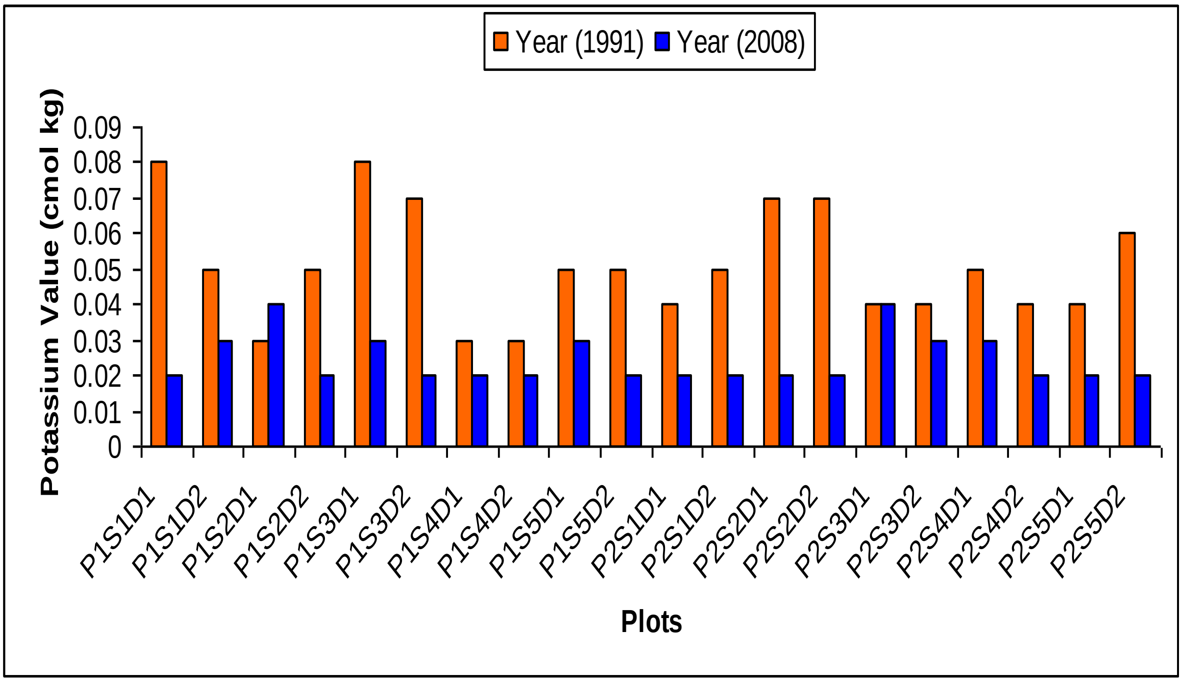


Figure 6.2.18. Exchangeable potassium values for 1991 and 2008 of plot 1 and plot 2 for soil monitoring.

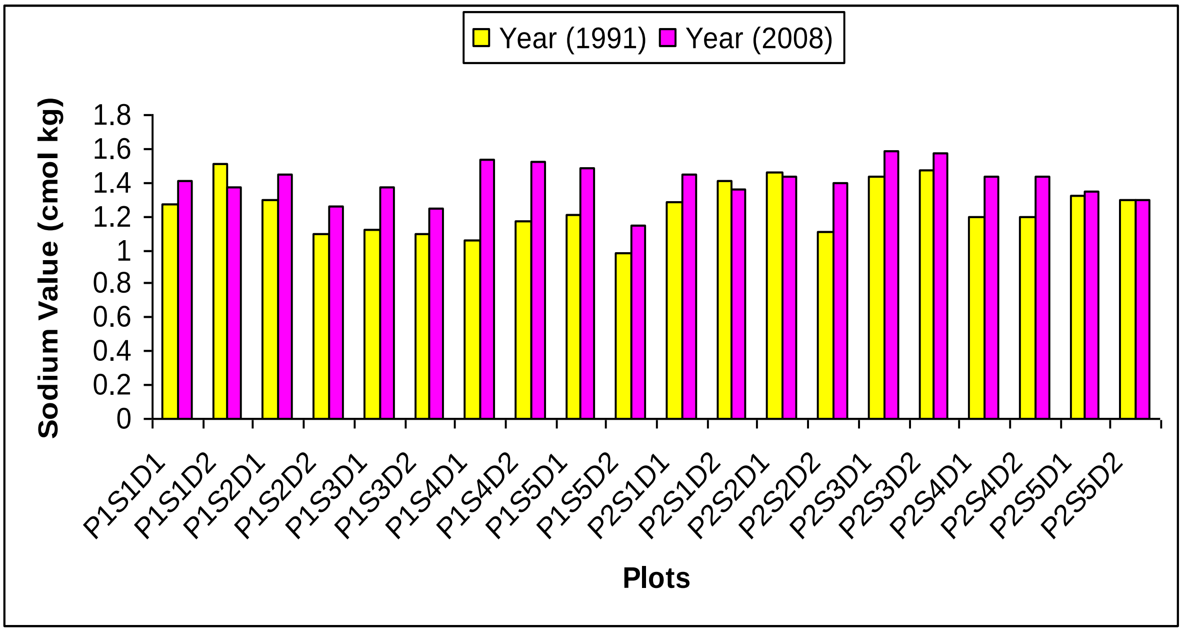


Figure 6.2.19. Exchangeable sodium values for 1991 and 2008 of plot 1 and plot 2 for soil monitoring.

6.2.4. Overall analysis/summary

Results showed that the soil pH (either in water or KCl) was acidic in all the plots (Figure 6.2.12 and Figure 6.2.13). These plots of phase 1 showed high pH value (both in water and KCl) as compared to the plots of phase 2. Higher pH value was recorded in plot 2 of phase1 (1991) in both sampling depth except subplot 1. The enrichment of microbial activity may be one of the factors which affecting the results. Soil sampling depth did show any significant different in both plots of both phases. There was small difference and this might be due to small range used to divide depth 1 and depth 2 (with 10 cm difference).

Similar trend was found for exchangeable acidity and Al concentrations in both phase 1 (1991) and phase 2 (2008). Al concentrations may be responsible for significant effect on the exchangeable acidity of forest soils. In phase 1 (1991), the exchangeable acidity and Al concentrations were higher as compared to phase 2 (2008). These results indicated that the organic matter accumulated in the plots of phase 1 (1991). It was also observed that cations concentrations increased in rehabilitated forest soils, except Na. The increased cations concentrations might be due to the increase of cation exchange capacity of organic acids from the organic matters. The selected cations (K, Ca, Mg) concentrations were higher in the plots of phase 1 (1991) as compared to 2008 and the year of establishment. This is one of the recovery indicators where cations started to accumulate in forest soils. Inconsistent results were observed for Na concentrations in rehabilitated forest soils. Generally higher Na concentrations were found in the plots of phase 2 (2008) especially surface soil (or depth 1).

6.3. Review of National Measures Against Acid Deposition

In Malaysia, the Ministry of Natural Resources and Environment through the Department of Environment is the lead agency entrusted with the management and conservation of the environment.

The mission of the Department of Environment is to promote, ensure and sustain sound environmental management in the process of nation building. A number of strategies have been identified towards this goal, namely :

- Sustainable development through conservation of resources
- Integration of environmental factors in development planning
- Pollution prevention and control
- Promotion of environmental education and awareness
- Inter-agency and federal-state cooperation
- Public participation in environmental management
- Bilateral, regional and international cooperation

Although Malaysia does not have specific national measures against acid deposition, there are sufficient rules and regulations in the country to control pollution emissions in the country. In particular the Environmental Quality Act (EQA) 1974, the first enactment in the country to protect and conserve the environment. This act was amended in 2001 to further strengthen the existing regulations to protect the environment. From time to time a number of legal instruments such as the Environmental Quality (clean air) Regulations 1978 were gazetted and enforced to maintain environmental quality. The Malaysian government has also developed the Malaysian Recommended Ambient Air Quality Guidelines for the major air pollutants.

Environmental impact assessment (EIA) has been used as a tool to incorporate environmental considerations into project planning. It has enabled us to avoid costly mistakes in project implementation as well as minimize project cost. Where development projects are not subjected to the Environmental Quality Order 1987, presiting evaluation of proposed site suitability were carried out to identify issues that could potentially arise in the future, besides complementing project monitoring. The Environmental Quality Regulations 1979 and the Environmental Quality (Clean Air) Regulations 1978 require written permissions and approvals to be obtained from the Director General of Environment before any new potentially plants are installed. The Department of Environment also operates an Advisory Services Desk at the Malaysian Industrial Development Authority which serves to provide environmental information and advice to prospective local and foreign investors pertaining to project site suitability, buffer zones, environmental consultancy expertise and government policy on waste management.

6.3.1 Air quality

The Department of Environment monitors air quality at 51 automatic and 21 manual sites throughout the country. Sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone and particulate matter are continuously monitored while several heavy metals are measured once in six days. The data collected is used to compute the Air Pollutant Index (API). The air quality status for Malaysia is reported based on the API which is made readily available to the public.

Several studies have been conducted relating to air pollution sources as measures to control air pollution which also includes acid deposition.

The government carries out enforcement against activities that contravene the regulations such as enforcement against open burning. In 2009 alone, a total of more than 3,000 open burning cases were detected and investigated.

Then there is also the National Airborne Surveillance Programme to monitor and detect environmental pollution such as open burning activities, emission from industries, coastal and marine pollution, land clearing activities for development on highlands and islands.

Regular checks on compliance with the Environment Quality (Clean Air) Regulations are conducted throughout the year on activities that releases air pollutants. Action is taken against parties that are noncompliant.

Emission of smoke and gaseous pollutant such as carbon monoxide, hydrocarbons, oxides of nitrogen and particulate matter emitted from motor vehicle exhausts are controlled under the Environmental Quality (Control of Emission from Diesel Engines) Regulations 1996 and Environmental Quality (Control of Emission from Petrol Engines) Regulations 1996.

The emission from motorcycle exhausts is controlled under the Environmental Quality (Control of Emission from Motorcycles) Regulations 2003. Motorcycles importers are required to comply with the new emission standards. Type Approval Certificate was issued to manufacturers, assemblers and importers of motorcycles for the domestic market.

6.3.2. Water quality

6.3.2.1. River water quality monitoring

In addition to air quality, a National River Water Monitoring Programmes was started in 1978 with monitoring conducted at 926 stations located within 120 river basins in Malaysia. Water samples were analysed to compute the Water Quality Index based on the following parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen (NH_3N), pH, dissolved oxygen (DO) and suspended solids (SS). Depending on site requirement, other parameters such as heavy metals and bacterial contamination are also measured. In addition, 10 automatic water quality monitoring stations monitor river quality changes on a continuous basis. An Action Plan is being prepared for enhancement and maintenance of the water quality of selected rivers in each state taking into account pollution load and the integrated river basin management concept. This programme is aimed at seeking the cooperation of other stakeholders for river quality enhancement.

In 2003, the Department of Environment established a River Division to manage the River Pollution Prevention and Water Quality Improvement Programme. Cameron Highlands was chosen as one of three river basins to be studied in 2004 with the objectives of:

- Identifying all pollution sources in the selected river basins and to determine the pollution loading from each source;
- Determine the impact of pollution on the water quality; and
- Formulate action plans for water quality improvement

In order to enhance the effectiveness of the River Pollution Prevention and Water Quality Improvement Programme in the selected river basins, enforcement visits are conducted to ensure compliance of discharge standards.

6.3.2.2. Marine water quality

As marine water quality is important for the conservation of marine resources such as corals reefs, fisheries and mangroves which contribute to the stability of the marine ecosystem, the National Marine Water Quality Monitoring Programme was started in 1978 for Peninsular Malaysia and the whole country in 1985. This programme's aim is to provide early warning of marine water quality changes and to identify the origin, pathway and fate of pollutants. More than 200 monitoring stations were set up all over the country for this purpose.

6.3.3. Public awareness programmes

Public awareness programmes on pollution prevention such as seminars, dialogues, workshops, exhibitions and community campaigns are conducted for targeted groups such as industries, development project proponents, local communities, school children and teachers within the selected areas. Among the public awareness programmes are Bandar Lestari-Environment Award, Environmental Awareness Camp (KeKAS), Inter-Varsity Environmental Debate, Malaysia Environment Week (MASM), Sustainable School-Environment Award, "Wira Alam Project" (PWA), Rakan Alam Sekitar (RAS) Programme, Langkawi Award, environmental conferences, exhibitions, environmental awareness quiz, camps, competitions, websites, dissemination of information, responses to public questions and enviro-library services.

6.3.3.1. Bandar Lestari – environment award

This programme is the collaboration with the Ministry of Housing and Local Government and Institute for Environment and Development (LESTARI), UKM which provides technical support initiated this award to give recognition to Local Authorities for incorporating environmental dimensions in planning, administration and implementation of policies, programs and activities.

6.3.3.2. Environmental awareness camp (KeKAS)

The Environmental Education Integrated Module was used in this camp. Other activities such as talks on coastal ecology, solid waste management and beach cleaning were conducted.

6.3.3.3. Inter-varsity environmental debate

This programme is organized by the Malaysian Universities Debating Council in collaboration with other lead agencies where universities debate issues related to the environment. Awards and cash prizes are given to the winning teams.

6.3.3.4. Malaysia environment week (MASM)

This is an annual event organized by the DOE primarily to inculcate and enhance environmental awareness among Malaysians. The main venue of the event changes every year to be closer to the people. Various activities are organized throughout the country.

6.3.3.5. Sustainable school-environment award

This programme was launched on 27 January 2005 is a collaboration programme with the Ministry of Education with technical support from the Institute of Environment and Development (LESTARI) Universiti Kebangsaan Malaysia. The Sekolah Lestari concept is hinged on an integrate approach, which involves the school community as a whole, their families, local communities, government, private sector and non-governmental organizations. This concept encompasses the integrated approach in management curriculum, co-curriculum and greening activities.

6.3.3.6. Wira Alam project (PWA)

This annual project was launched in 1998 with the cooperation of three agencies, the DOE, Malaysian Nature Society and Ministry of Education. The programme is aim at students completing environmental task assigned to them to promote environmental awareness and conservation.

6.3.3.7. Rakan Alam Sekitar (RAS) programme

The programme is targeted to increase awareness and participation of local communities in every Parliamentary area in environmental conservation and preservation as well as combating environmental pollution. The RAS programme serves as an effective channel for environmental complaints because with the involvement of local communities, immediate action can be taken by the respective government agencies.

6.3.3.8. Langkawi award

The Langkawi Award is given to individuals who have contributed significantly to the protection of the environment.

6.3.3.9. Others

Environmental conferences, exhibitions, quiz, camps and competitions are conducted regularly throughout the country to instill environmental awareness among the people of Malaysia. Information and services on environmental matters are made readily available to the people through the mass media and other channels.

6.3.4. International environment affairs

Measures against acid deposition are not only confined to national borders as it is well documented that air pollution is a transboundary issue. Malaysia has taken measures to address this problem through a number of initiatives namely, ASEAN Working Groups on Sub-Regional Fire Fighting Arrangement for Sumatra and Borneo, ASEAN Haze Agreement, Sustainable Development Strategy for Seas of East Asia, EANET activities, multilateral and bilateral agreements.

6.3.5. Data collection and archive

Part and parcel of any efforts and measures to control air pollution in particular and acid deposition in general is the collection and archive of data related to air pollution. The Department of Environment (DOE) is the central agency in Malaysia entrusted with this task. Annual emission inventory of the major air pollutants are published and distributed to all users for the management of air pollution. Figures below show the amount of the major air pollutants emitted in 2003 and the contribution of the different sources.

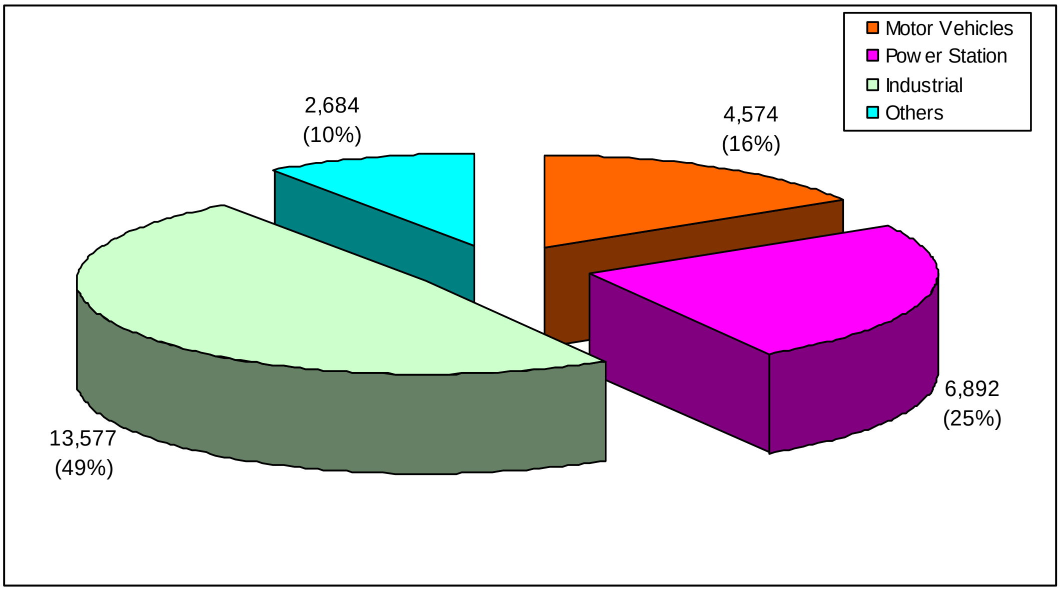


Figure 6.3.1. Malaysia: Particulate matter (PM) emission load by sources (metric tonnes), 2009.

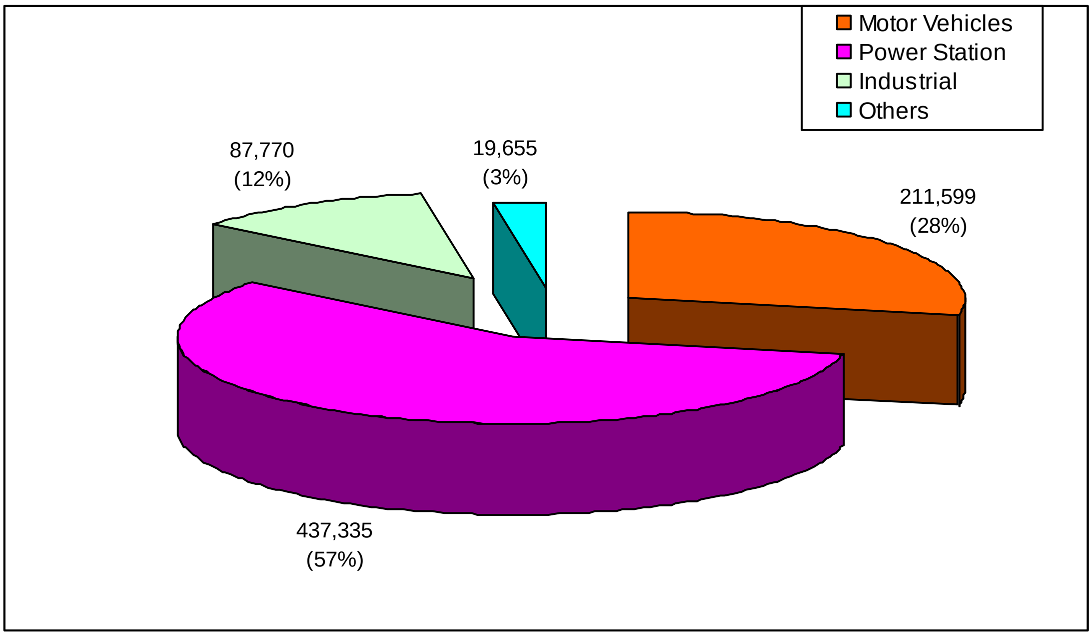


Figure 6.3.2. Malaysia: NO_x emission by sources (metric tonnes), 2009.

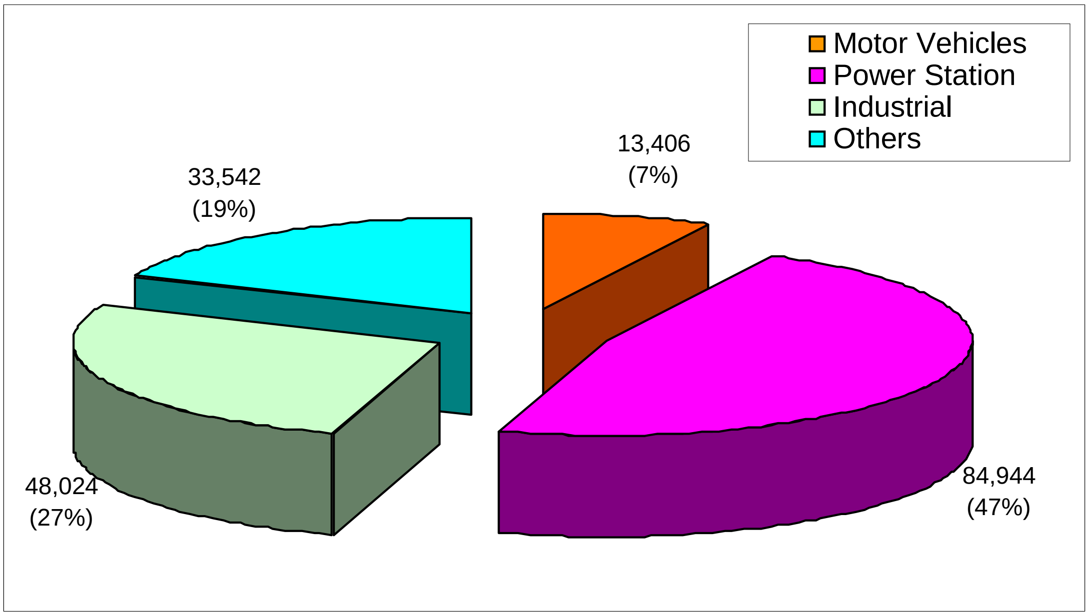


Figure 6.3.3. Malaysia: SO_2 emission by sources (metric tonnes), 2009.

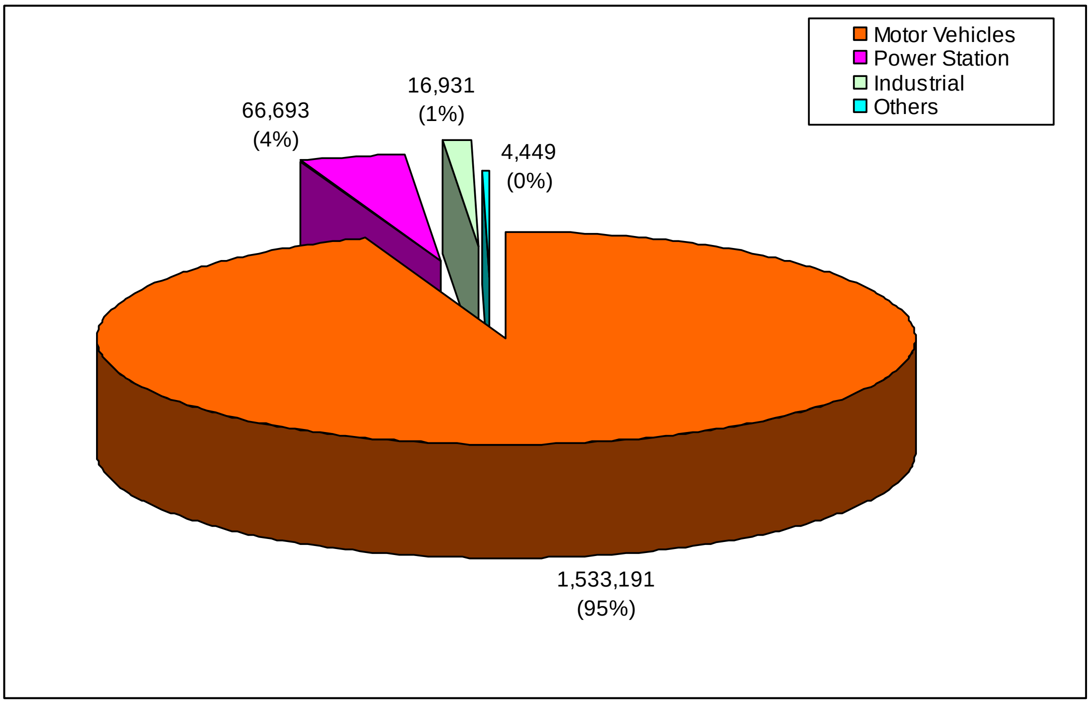


Figure 6.3.4. Malaysia: CO emission by sources (metric tonnes). 2009.

6.4 References

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National Assessment Report for Mongolia

B. Altantuya

Central Laboratory of Environmental Monitoring, Ulaanbaatar-36, Mongolia

7.1. Basic Information on National Monitoring Activities

Mongolia is a landlocked country located between latitudes 41^0 35'- 52^0 06' North and 87^0 47'-119^0 57' East, with 1,564,116 sq km land areas. The country has a severe continental climate due to the fact that it is landlocked and a great distance from oceans, surrounded by high mountains and has a high elevation of more than one and half km above sea level. The annual mean temperature is about -8 ^{0}C to 6 ^{0}C and the annual precipitation varies from 50 mm in the Gobi desert to 400 mm in the northern mountainous area. About 85 percent of total precipitation falls from April to September.

7.1.1. Outline of the activities on acid deposition and national monitoring plan

The acid deposition monitoring in Mongolia was initiated in August 1998 at two sites of wet and dry deposition that were supplied with equipment within the EANET activities. Now there are 2 sites of wet and dry deposition monitoring and one site of inland aquatic environment monitoring being operated for the EANET.

Central Laboratory of Environment and Metrology (CLEM) was designated and has been operating as the National Center of Mongolia for the EANET.

7.1.2. Monitoring program from 2005 to 2009

Wet and dry deposition monitoring at the urban monitoring site in Ulaanbaatar has been carried out only from May to October and it has been suspended during cold season due to technical problem caused by climatic factors. The monitoring program is presented in Table 7.1.1.

Table 7.1.1 The monitoring program for 2005-2009.

Items	**Monitoring site**	**Monitoring period**	**Monitoring interval**	**Monitoring parameters**
Wet deposition	Terelj Ulaanbaatar	2005-2009	Daily (May-October)	pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
Dry deposition	Terelj Ulaanbaatar	2005-2009	Weekly (May-October)	Gases: SO_2, HNO_3, HCl, NH_3 Aerosol: SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
Inland aquatic environment	Terelj river	2005-2009	4 times/year	pH, EC, alkalinity, SO_4^{2-}, NO_2^-, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, PO_4^{3-}

7.1.3. Monitoring stations

a. Wet and dry deposition monitoring sites:

Ulaanbaatar-urban site, 47^0 55' N, 106^0 54' E, 1275 m asl (above sea level).

The site is situated in the center of Ulaanbaatar city (on the building roof of the National Agency of Meteorology and Environmental Monitoring) and well isolated from intensive stationary sources of air pollution.

Terelj – remote site, 47^0 59’ N, 107^0 27’ E, 1550 m asl.

The site is located in central part of Mongolia, in the western part of the Khentei mountain ranges and away from major industrial pollution sources. The nearest major city is Ulaanbaatar of 50 km far to the Southwest.

7.1.4. Sampling and measurements

a. Sampling method and sample handling:

The wet-only sampler with refrigerator (collection diameter is 357 mm) manufactured by Ogasawara Co. Ltd installed for rain sampling. The equipment is uninstalled once a year before frost time and kept in the store during winter season because it does not meet the operation conditions under cold weather. After the winter season, the equipment is installed again and samples are collected on a daily basis. During winter a plastic basket with 395 mm diameter was used for snow sample (bulk) collection at the Terelj site.

The sampler with four-stage filter packs MB-01T manufactured by Tokyo Dylec Co. Ltd was used for the dry deposition monitoring. The first membrane filter collects particles, the second cellulose filter is designed for absorption of SO_2, HCl, HNO_3, and the third alkaline impregnated filter is for residual SO_2, HCl and the fourth acid impregnated filter-for NH_3 absorption.

Wet and dry deposition samples at Terelj remote site are collected and transported to the analytical laboratory twice per month by local staffs and then analyzed by the Central Laboratory of Environment and Metrology (CLEM). Samples at Ulaanbaatar urban site are handled by CLEM.

b. Measurements:

Table 7.1.2. Analytical methods and equipment.

Items	Monitoring parameters	Measuring method	Equipment
Wet deposition	pH	pH-meter	HM-30V, TOA
	EC	EC-meter	DS-12, Horiba
	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
Dry deposition	Gases: SO_2, HNO_3, HCl, NH_3 Aerosol: SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
Inland aquatic environment	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
	Alkalinity	Titration	Titration with 0.02n H_2SO_4
	PO_4^{3-}	Colorimetric	Using ammonium molibdate
	NO_2^-	Colorimetric	Using Griss reagent

7.2. State of Acid Deposition in Mongolia

7.2.1 Atmospheric deposition

7.2.1.1 State of wet deposition

The state of acid rain and chemical composition of rainwater is presented in this report for central part of Mongolia during the period 2005-2009, since the acid deposition monitoring sites are located in central area of the country and the monitoring period was extended only from May to October.

pH. The pH of rainwater was in the range from 3.68 to 7.32 in remote site Terelj. At urban site Ulaanbaatar, the pH varied from 4.80 to 8.74 and the rain with pH below 5.0 was observed several times in 2005, 2006, 2007 and 2008. The annual means of pH for 2005-2009 are presented in Table 7.2.1. The average of pH variations by years is presented in Figure 7.2.1.

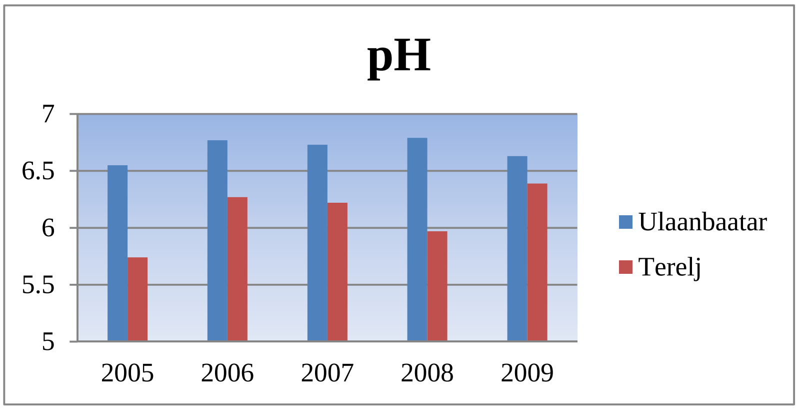

Figure 7.2.1. The average of pH variations by year.

Electrical conductivity. For the period 2005-2009, a total of 172 and 226 samples from Ulaanbaatar and Terelj, respectively, were collected and analyzed for electrical conductivity (EC). EC values were of the range 0.61-11.60 mS.m^{-1} and 0.21-28.90 mS.m^{-1} in Ulaanbaatar and Terelj, respectively. The annual means of EC for 2005-2009 are presented in Table 7.2.1.

Table 7.2.1. Annual means of pH and EC.

Station	Year	pH			EC, mS.m^{-1}		
		Annual mean	Min	Max	Annual mean	Min	Max
Ulaanbaatar	2005	6.55	4.80	8.29	2.42	0.61	8.67
	2006	6.77	5.36	7.66	3.00	0.61	11.60
	2007	6.73	5.73	8.74	2.75	0.65	8.70
	2008	6.79	5.43	7.92	3.65	0.64	9.53
	2009	6.63	5.54	7.79	3.15	0.78	11.61
Terelj	2005	5.74	4.28	7.20	1.48	0.22	5.54
	2006	6.27	3.80	7.32	2.17	0.39	12.35
	2007	6.22	3.68	7.13	3.67	0.49	28.90
	2008	5.97	4.22	7.14	2.39	0.21	12.49
	2009	6.39	5.45	7.09	2.37	0.48	16.66

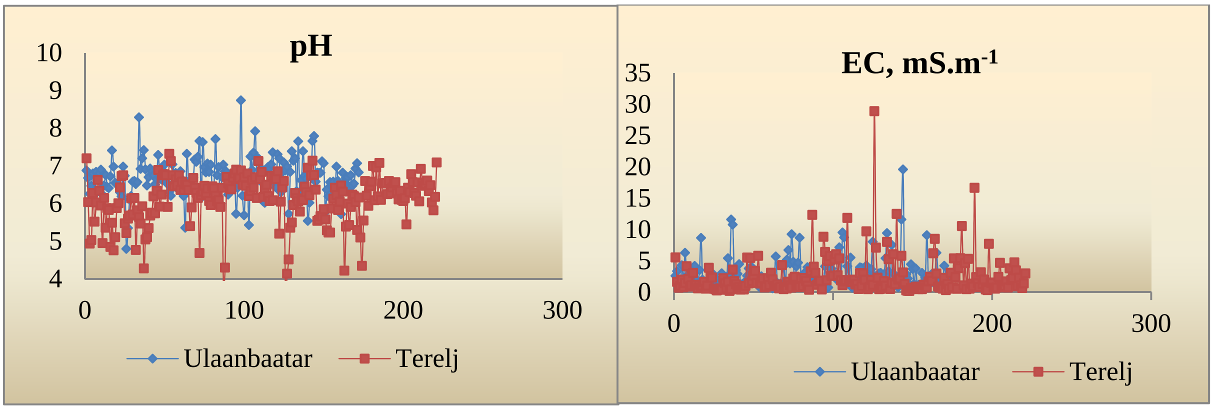

Figure 7.2.2. pH and EC measurements of two sites.

Regarding the Figure 7.2.2, you can see the difference between two sites measurement. Total sampling number of Terelj (remote) is more than the Ulaanbaatar (urban) site. Also, Ulaanbaatar rain water is more alkaline than the Terelj but electric conductivity measurement hasn't any big differences.

Anions. During the period of 2005-2009, a total of 172 and 226 samples from Ulaanbaatar and Terelj, respectively, were collected and analyzed for sulphate, nitrate and chloride using ion chromatography (Table 7.2.2).

Table 7.2.2 Annual mean anion flux.

Station	**Year**	**SO_4^{2-}, μeq.l^{-1}**	**NO_3^-, μeq.l^{-1}**	**Cl^-, μeq.l^{-1}**
Ulaanbaatar	2005	54.3	19.4	7.7
	2006	35.2	16.3	7.2
	2007	74.2	26.0	9.4
	2008	37.7	20.4	10.2
	2009	40.4	19.7	9.9
	mean	**48.4**	**20.4**	**8.9**
Terelj	2005	28.7	13.4	6.6
	2006	27.5	11.6	9.2
	2007	40.7	16.8	11.7
	2008	32.4	19.2	9.8
	2009	32.5	20.2	9.1
	mean	**32.4**	**16.2**	**9.3**

Mean concentration comparison between the two sites of three measured anions in rainwater presented in Figure 7.2.3. The contribution of SO_4^{2-} to precipitation acidity was much higher than NO_3^-.

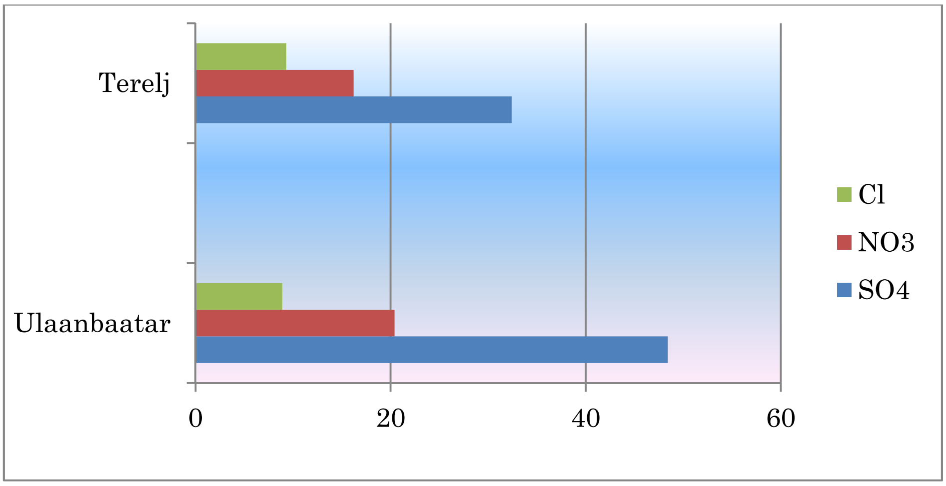

Figure 7.2.3. The anion concentration comparison between two sites, µeq.l^{-1}.

Cations. During the period of 2005-2009, a total of 172 and 226 samples from Ulaanbaatar and Terelj, respectively, were collected and analyzed for ammonia, sodium, potassium, calcium and magnesium using ion chromatography (Table 7.2.3).

Table 7.2.3. Annual mean cation flux.

Station	**Year**	**NH_4^+ µeq.l^{-1}**	**Na^+ µeq.l^{-1}**	**K^+ µeq.l^{-1}**	**Ca^{2+} µeq.l^{-1}**	**Mg^{2+} µeq.l^{-1}**	**H^+ µeq.l^{-1}**
Ulaanbaatar	2005	54.6	7.1	4.4	96.6	11.2	1.1
	2006	45.8	7.8	4.3	74.7	7.5	0.4
	2007	91.6	9.6	3.8	97.8	12.4	0.5
	2008	51.3	6.0	5.0	63.0	10.4	0.5
	2009	48.4	4.7	2.5	83.9	9.7	0.8
	mean	**58.3**	**7.0**	**4.0**	**83.2**	**10.2**	**0.7**
Terelj	2005	29.8	9.4	5.4	38.9	9.1	3.4
	2006	40.0	13.5	8.0	61.3	11.2	1.5
	2007	55.8	25.2	10.4	79.4	10.7	1.8
	2008	55.2	10.5	12.5	56.2	10.7	2.9
	2009	39.1	6.4	3.7	74.5	11.3	0.6
	mean	**44.0**	**13.0**	**8.0**	**62.1**	**10.6**	**2.0**

Mean concentration comparison between the two sites of cations in rainwater presented in Figure 7.2.4.

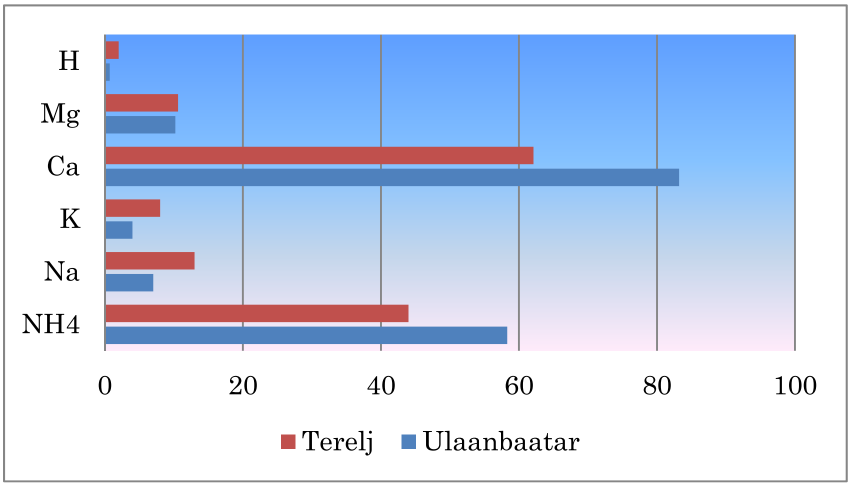

Figure 7.2.4. The cations concentration comparison between two sites, µeq.l^{-1}.

Ammonium and calcium ions mostly have predominated among the cations in the precipitation water.

7.2.1.2 State of dry deposition

Sulphur. The mean annual concentrations of sulphur dioxide and particulate suphfate in air at remote site Terelj have ranged 0.07-31.86 µg.m^{-3} and 0.04-5.17 µg.m^{-3}, respectively. The mean annual concentrations of sulphur dioxide and particulate sulphate in air at urban site Ulaanbaatar have ranged 0.32-73.10 µg.m^{-3} and 0.10-25.02 µg.m^{-3}, respectively. The trends of sulphur compounds in air at Terelj and Ulaanbaatar are presented in Figure 7.2.5.

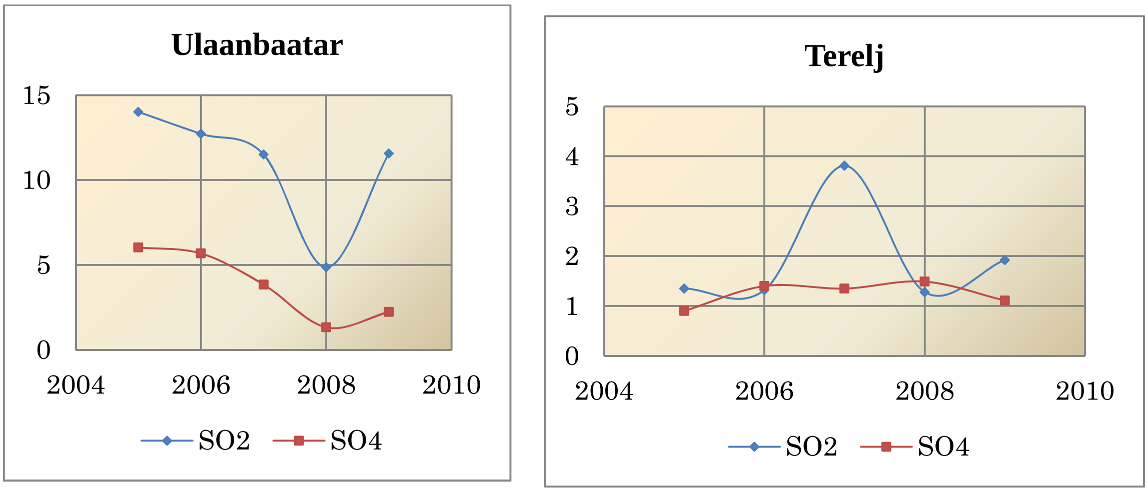

Figure 7.2.5. The mean annual concentrations of sulphur dioxide and particulate sulphate in air, µg.m^{-3}.

Sulphur dioxide concentrations were characterized by a strong pronounced seasonal variation with winter maximum at both sites indicating both effect of contributing climatic factors such as stable temperature inversions and influence of increased local emissions due to heating requirements, especially in urban area.

Nitrogen.The yearly changes of mean annual concentrations of nitrogen compounds at Terelj and Ulaanbaatar are presented in Figure 7.2.6. In Ulaanbaatar, the mean concentrations of particulate nitrate were higher than gaseous HNO_3 and there were no clear trends.

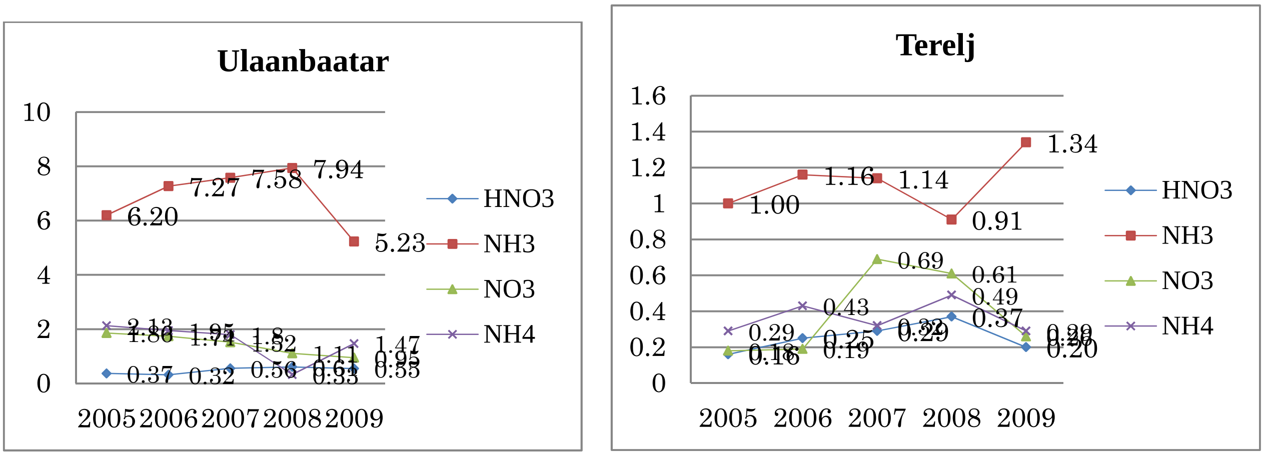

Figure 7.2.6. The mean annual concentrations of nitrogen compounds, µg.m^{-3}.

7.2.2 State of inland aquatic environment

Terelj river has been selected for the inland aquatic environment monitoring purpose because its water has quite low electric conductivity. The river is started at the western slope of Khentei mountain range and flows into the Tuul river. River water has very low mineralization with electric conductivity in the range of 47-66 µS.cm^{-1} and pH variations within 6.9-7.2. Composition of the major ions in the river water is presented in Figure 7.2.7.

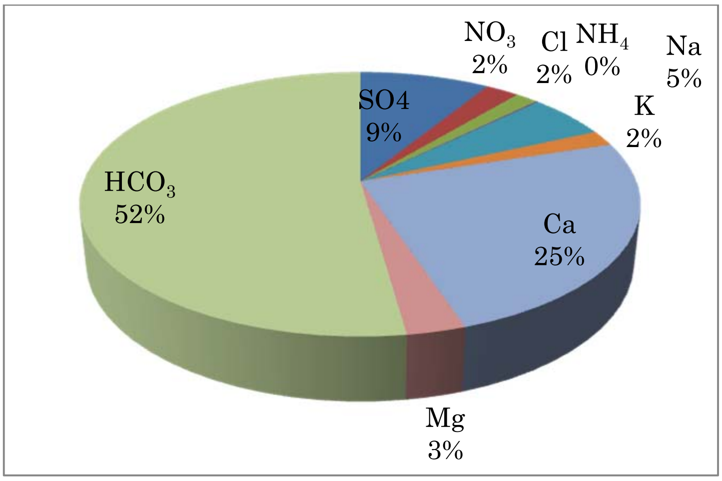

Figure 7.2.7. Composition of the major ions in river water.

The main dominated ions are bicarbonate and calcium.

The average (2005-2009) chemical composition of the Terelj river water is presented Table 7.2.4.

Table7.2.4. Mean annual concentration of the Terelj river, mg. l^{-1}.

	pH	EC	Alk.	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}
2005	6.94	4.84	0.367	3.18	0.82	0.56	0.05	1.95	0.68	8.90	1.04
2006	7.05	5.07	0.327	3.60	0.79	0.46	0.11	2.07	0.62	9.04	1.07
2007	7.01	5.06	0.340	3.18	0.79	0.57	0.37	2.22	0.56	8.63	1.03
2008	7.12	6.59	0.280	3.82	1.33	0.73	-	1.93	0.60	13.70	1.00
2009	7.15	4.70	0.331	3.47	0.48	0.42	-	1.65	0.58	5.40	0.75

7.3. Review of National Measures Against Acid Deposition

At the end of 2009, the resident population of Mongolia was 2,735,800, representing an increase of 52,300 or 1.9% in comparison to the previous years. The flow of migration to Ulaanbaatar city remains high and its population is increasing year by year. Due to this concentration, there are increasing trend of production and services and loss of environmental capacity of the city such as increasingly polluting the air in Ulaanbaatar as in condition of disaster. The air pollution problems are mainly linked to cold days with temperature inversions over Ulaanbaatar. Air pollution is aggravated because of four developments: increasing traffic, growing cities, rapid economic development, and industrialization, which have gradually become a problem. The Mongolian

Government has played important roles in activities such as raising public awareness and initiated some measurements of air pollutants.

7.4. References

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National Assessment on Acid Deposition in Myanmar

8.1. Basic Information on National Monitoring Activities

8.1.1. Outline of activities on acid deposition and national monitoring plan

The rapid industrialization in the East Asian countries has helped in achieving economic growth. Along with industrialization, energy consumption such as coal, oil and natural gas has also rapidly increased in East Asia. The combustion of these fossil fuels is the main source of air pollutants such as HNO_3, H_2SO_4. The emission of air pollutants will increase, if there is no proper management to control it efficiently. For this reason there is a need for a better understanding in these problems in Myanmar. To protect the country from the acid deposition problem, it is required to monitor the state of acid deposition in the country. So, Myanmar had joined Acid Deposition Monitoring Network in East Asia (EANET) in November 2005. After Myanmar became member country of EANET, Department of Meteorology and Hydrology (DMH) is designated as National Center for EANET. DMH have carried out its responsibility by wet deposition monitoring and then the following are some relevant activities and program that are currently implemented:

- Developed National Monitoring Plan for EANET
- Developed Standard Operating Procedures (SOPs)
- Upgrading of the laboratory is on-progress
- Capacity building of staffs in Myanmar on acid deposition
- Participation in the inter-laboratory comparison on wet deposition
- Carrying out public awareness activities in Myanmar in coordination with the Secretariat and the Network Center (NC) for EANET
- Fully equip the urban site to provide all the required data for wet deposition monitoring by the use of Ion chromatography

8.1.2 Monitoring program in 2005-2009

After Myanmar become one of EANET member countries, DMH, the national center of EANET is carrying out its responsibility by wet deposition monitoring at the chosen urban site, Yangon (Kaba-Aye). According to the capacity of the Myanmar, wet deposition monitoring was conducted with measuring pH, EC and amount of precipitation. The systematic rain water collection by wet sampler was started in June 2007. The measurement of pH and EC of the collected rain water have been done by Horiba pH/Cond meter. Result of pH and EC data could be sent to ADORC (Acid Deposition and Oxidant Research Center) from 2007 up to now. In July 2009, JICA had provided two instruments, Ion Chromatograph and Ultra pure water production system. During August 2009, Ion Chromatograph and Ultra pure water production system were installed at the laboratory of DMH. After installing, DMH has started to analyze the ion contents such as Cation NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+} and Anion SO_4^{2-}, NO_3^-, Cl^- by Ion Chromatograph.

8.1.3 Monitoring stations

In Myanmar, one monitoring site, Yangon (Kaba-Aye) was chosen for wet deposition monitoring site for EANET. It was classified into urban site following the technical manual of EANET as shown in Table 8.1.1. At that chosen site wet only sampler was installed on the roof of hydrology building in June 2007. The geographical location and picture of the station were shown in Figure 8.1.1 and Figure 8.1.2.

Table 8.1.1. The characteristics and location of monitoring site in Myanmar.

Name of site	Site classification	Latitude	Longitude	site category
Yangon (Kaba-Aye)	Urban	16.5˚ N	96.11˚ E	Wet Deposition

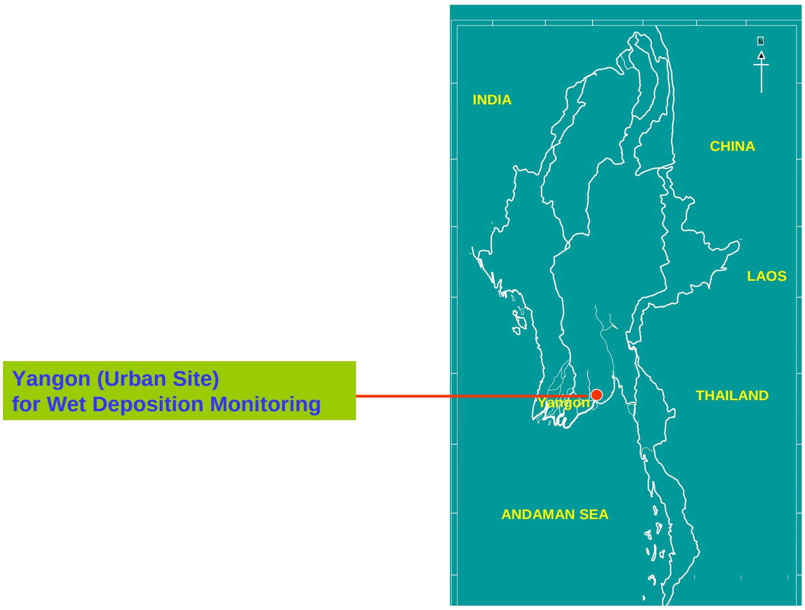

Figure 8.1.1. The geographical location of EANET site in Myanmar.

Figure 8.1.2. Picture of wet deposition monitoring site at Yangon (Kaba-Aye) in Myanmar.

8.1.4 Sampling and measurements

Rainwater samples for wet deposition monitoring were collected daily by the wet only sampler installed on site during 2007 and DMH follow daily sample collection and weekly composite analysis since 2008. We measured amount of precipitation, pH and EC by pH meter (pH/Cond meter Horiba) and analyzed ion contents by Ion Chromatograph following the technical manual for wet deposition monitoring analysis adopted by EANET as shown in Table 8.1.2.

Table 8.1.2. Monitoring parameters and method for wet deposition.

Monitoring parameters	Method
Electric conductivity(EC)	Conductivity cell method
pH	Glass electrode method
Cl^-, $NO_3^{\ -}$, SO_4^{2-}	Ion chromatography (preferably with suppressor)
NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography

8.2. State of acid deposition in Myanmar

8.2.1 Atmospheric deposition

8.2.1.1 State of wet deposition

Acid deposition monitoring in Myanmar has been carried out according to the common methologies specified in the "Technical documents for wet deposition monitoring in East Asia". Precipitation samples are collected by wet only sampler on daily basis at Yangon (Kaba-Aye). Collected samples are carried to laboratory and stored in the refrigerator at 4˚C to preserve the sample composition. And then measurement and analysis of the rain water sample have been done according to the technical manual. Annual mean of pH and EC data were shown in Table 8.2.1 and ion analysis data was shown in Table 8.2.2. Also meteorological parameters such as Temperature, Relative humidity, wind speed, wind direction, precipitation amount and sunshine hours were observed at Yangon (Kaba-Aye) station, and it was shown in Table 8.2.3.

Table 8.2.1. Annual means of pH and EC on wet deposition at Yangon (Kaba-Aye).

Station	**Year**	**pH**			**EC $mS.m^{-1}$**			**Precipitation amount (mm)**		
		Min	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Yangon (Kaba-Aye)	2007	4.44	7.53	6.06	0.13	2.79	0.85	1	225	36
	2008	5.64	7.27	6.46	0.12	4.65	0.83	2	210	50
	2009	5.90	6.67	6.52	0.39	7.72	1.90	4	312	104

Table 8.2.2. Annual mean ion concentration for wet deposition at Yangon (Kaba-Aye) in 2009.

NH_4^+ $\mu mol.l^{-1}$	**Na^+** $\mu mol.l^{-1}$	**K^+** $\mu mol.l^{-1}$	**Ca^{2+}** $\mu mol.l^{-1}$	**Mg^{2+}** $\mu mol.l^{-1}$	**Cl^-** $\mu mol.l^{-1}$	**$NO_3^{\ -}$** $\mu mol.l^{-1}$	**SO_4^{2-}** $\mu mol.l^{-1}$	**Precipitation amount** (mm)
24.5	18.0	4.2	9.7	3.0	21.7	9.9	9.4	103.8

Table 8.2.3. Monthly mean Meteorological Data at Yangon (Kaba-Aye) in 2007 -2009.

Year	Month	Temp (˚C)	Relative humidity (%)	Wind speed (m.s^{-1})	Wind direction	Precipitation amount(mm)	Sunshine (hours)
2007	Jan	25.85	72.00	1.56	NW	0	8.0
	Feb	27.25	64.50	1.86	W	0	8.5
	Mar	29.20	64.00	2.10	SW	0	8.9
	Apr	31.90	64.00	3.06	SW	0	8.6
	May	28.10	89.00	2.94	SW	837	5.3
	June	27.65	91.00	2.65	SW	559	2.0
	July	26.60	92.00	2.46	SW	700	1.6
	Aug	26.65	92.00	2.40	SW	446	1.4
	Sep	26.05	94.00	1.98	SW	774	1.8
	Oct	27.05	87.50	1.86	E	260	4.1
	Nov	27.15	80.50	1.98	NE	16	8.3
	Dec	24.95	75.00	1.68	NW	0	7.8
Year	Month	Temp (˚C)	Relative humidity (%)	Wind speed (m.s^{-1})	Wind direction	Precipitation amount (mm)	Sunshine (hours)
2008	Jan	25.48	74.00	1.74	NW	5	7.4
	Feb	26.05	65.10	1.56	SE	7	8.1
	Mar	29.15	64.50	1.92	SW	25	7.9
	Apr	29.70	74.00	1.92	SW	169	6.7
	May	27.10	87.50	4.14	SW	656	2.6
	June	26.60	89.50	2.70	SW	431	2.1
	July	26.00	92.00	2.82	SW	541	1.9
	Aug	25.80	93.00	2.28	SW	474	2.5
	Sep	26.10	92.00	2.04	SW	448	3.2
	Oct	27.00	86.00	1.80	SW	301	4.9
	Nov	26.40	76.00	2.23	NE	6	7.9
	Dec	24.50	71.00	2.04	NE	0	8.6
Year	Month	Temp (˚C)	Relative humidity (%)	Wind speed (m.s^{-1})	Wind direction	Precipitation amount (mm)	Sunshine (hours)
2009	Jan	24.10	66.00	2.04	NE	0	8.7
	Feb	26.60	67.50	1.98	N	0	8.2
	Mar	28.70	69.00	2.46	SW	5	7.7
	Apr	29.20	69.00	2.22	SW	46	7.3
	May	27.00	81.50	1.74	SW	457	5.3
	June	26.30	90.50	1.92	SW	561	1.6
	July	25.20	93.50	2.16	SW	914	1.6
	Aug	26.20	90.00	1.86	SW	485	3.0
	Sep	26.30	89.50	1.8	SW	508	2.8
	Oct	27.00	85.00	1.62	S	125	5.2
	Nov	26.80	72.50	1.74	NE	0	8.5
	Dec	24.00	69.50	1.74	NE	0	8.6

In the year 2007, it was recorded minimum of pH =4.4 (lowest acidic value), EC= 0.13 mS.m^{-1} and the maximum of pH =7.53, EC= 2.8 mS.m^{-1} as shown in Figures 8.2.1 and 8.2.2

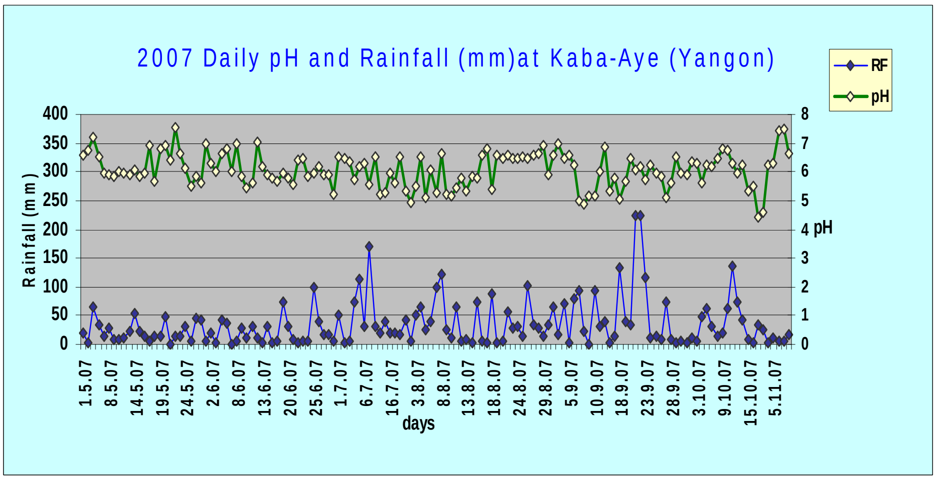

Figure 8.2.1. Daily pH and rainfall (mm) at Yangon (Kaba-Aye) in 2007.

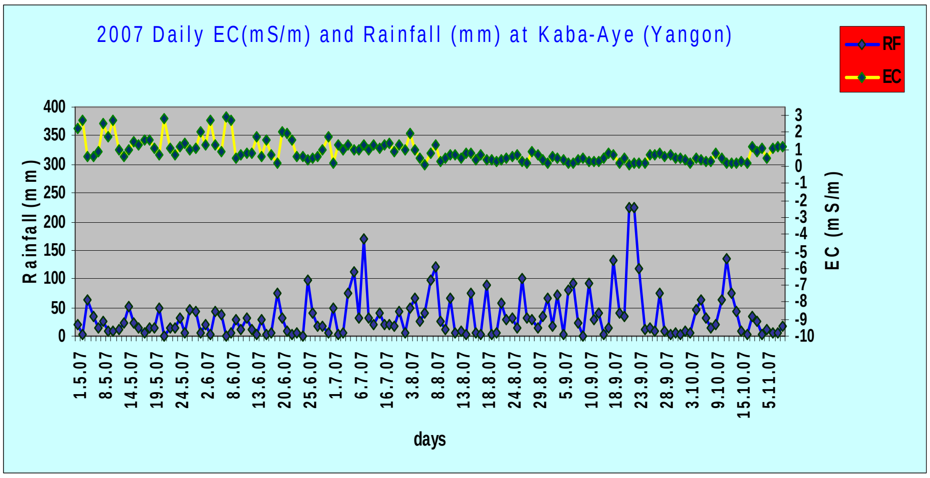

Figure 8.2.2. Daily EC (mS.m^{-1}) and rainfall (mm) at Yangon (Kaba-Aye) in 2007.

In the year 2008, it was recorded minimum of pH =5.6 (lowest acidic value), EC= 0.12 mS.m^{-1} and the maximum of pH =7.3, EC= 4.7 mS.m^{-1} as shown in Figures 8.2.3 and 8.2.4.

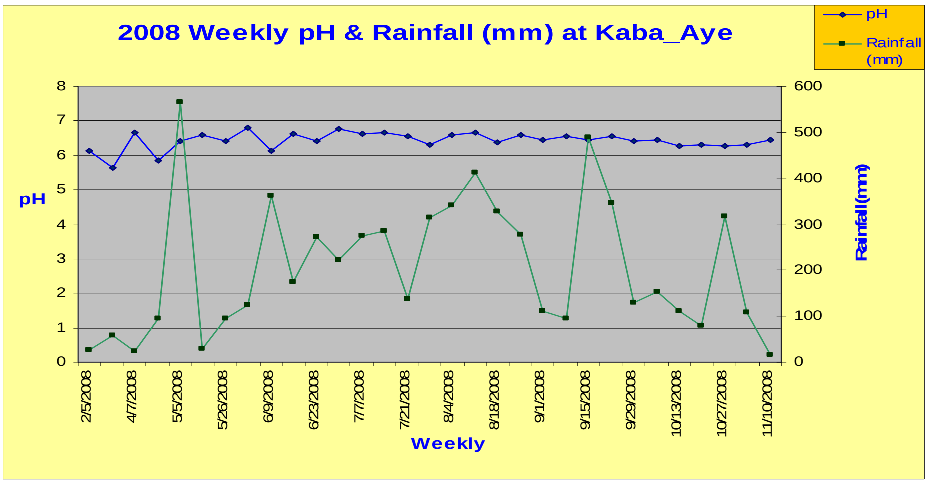

Figure 8.2.3. Weekly pH and rainfall (mm) at Yangon (Kaba-Aye) in 2008.

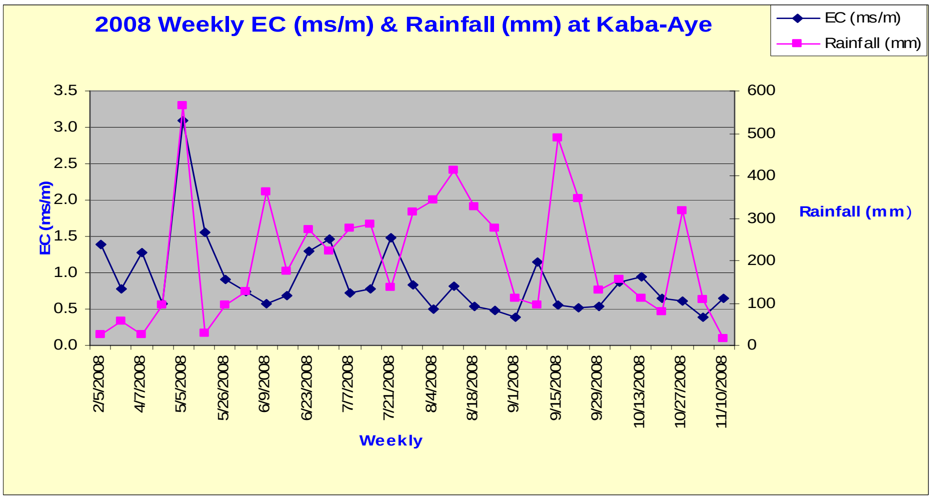

Figure 8.2.4. Weekly EC (mS.m^{-1}) and rainfall (mm) at Yangon (Kaba-Aye) in 2008.

In the year 2009, it was recorded minimum of pH =5.9 (lowest acidic value), EC = 0.4 mS.m^{-1} and the maximum of pH = 6.67, EC = 7.72 mS.m^{-1} as shown in Figures 8.2.5 and 8.2.6

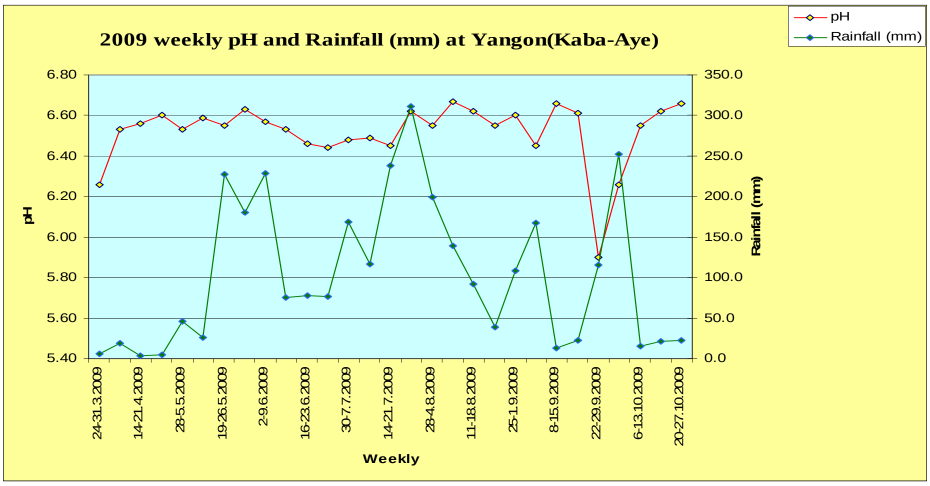

Figure 8.2.5. Weekly pH and rainfall (mm) at Yangon (Kaba-Aye) in 2009.

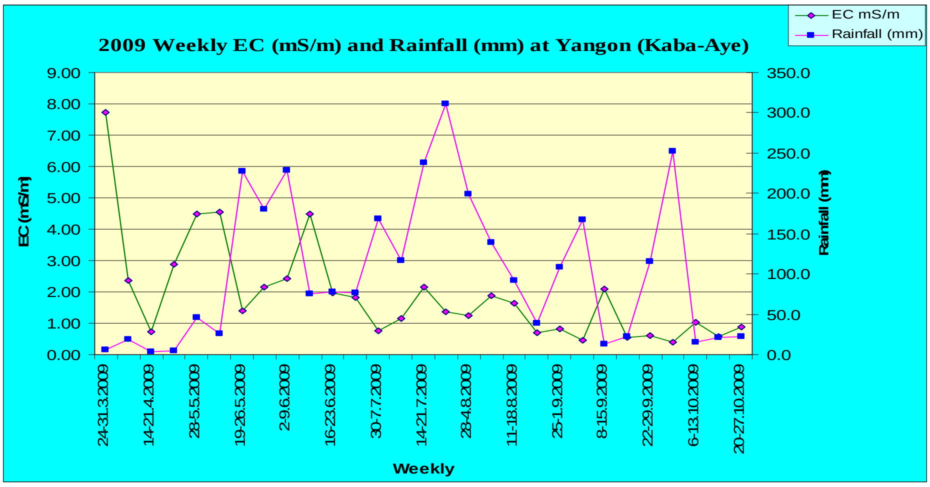

Figure 8.2.6. Weekly EC (mS.m^{-1}) and rainfall (mm) at Yangon (Kaba-Aye) in 2009.

In the year 2009, it was recorded minimum of Anion Cl^- = 2.3 μmol.$l^{-1,}$ NO_3^-= 2.9 μmol.l^{-1} and SO_4^{2-}=3.1 μmol.l^{-1}, the minimum of cation NH_4^+ = 10.0 μmol.l^{-1}, Na^+ = 2.5 μmol.l^{-1}, K^+= 0.4μmol.l^{-1}, Ca2$^+$, = 2.6 μmol.l^{-1} and Mg^{2+} = 0.9 μmol.l^{-1} as shown in Figure 8.2.7

In the year 2009, it was recorded maximum of anion Cl^- = 64.7 μmol.l^{-1}, NO_3^-= 27.2 μmol.l^{-1} and SO_4^{2-}=27.0 μmol.l^{-1}, the maximum of cation NH_4^+ = 98.1 μmol.l^{-1}, Na^+= 58.6 μmol.l^{-1}, K^+= 19.5 μmol.l^{-1}, Ca^{2+},= 24.5 μmol.l^{-1} and Mg^{2+} = 8.4 μmol.l^{-1} as shown in Figure 8.2.8

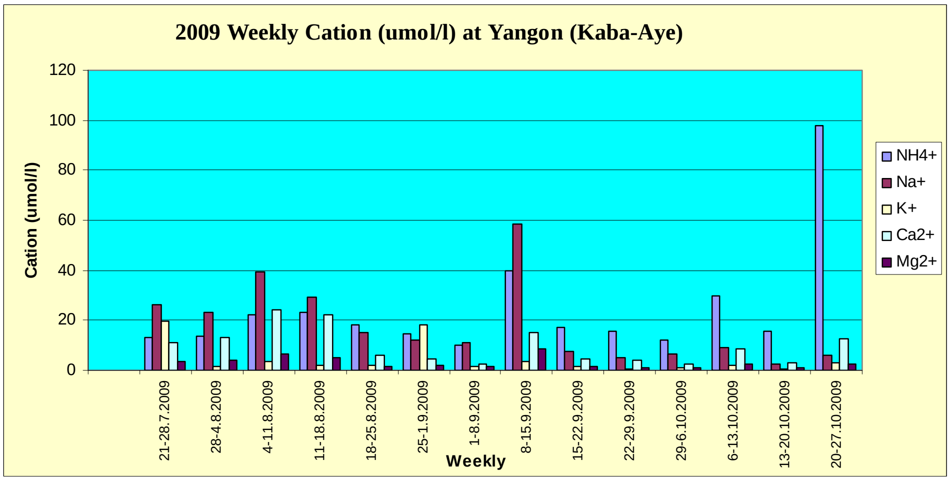

Figure 8.2.7. Weekly analysis of cation at Yangon (Kaba-Aye) in 2009.

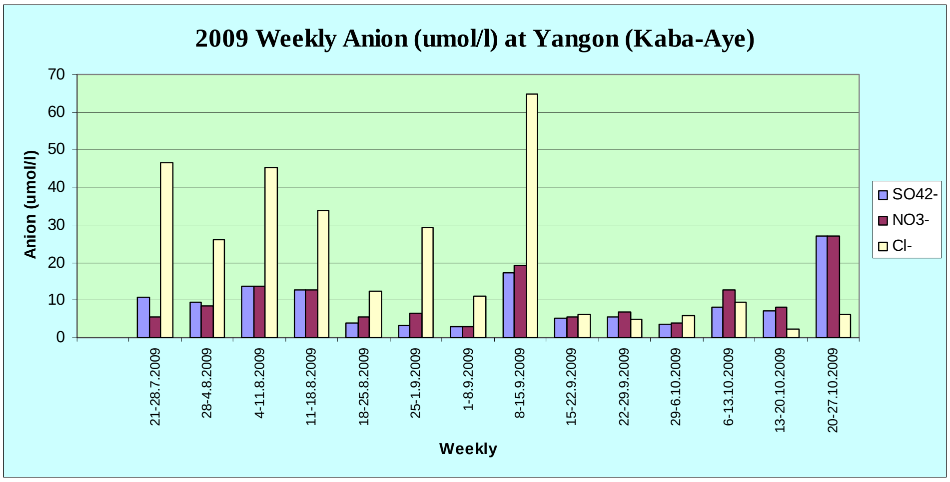

Figure 8.2.8. Weekly analysis of anion at Yangon (Kaba-Aye) in 2009.

8.2.1.2. State of dry deposition

Myanmar will initiate the monitoring of dry deposition in the near future in order to fulfill the requirements of EANET activities.

8.2.2. State of inland and aquatic environment

Myanmar will initiate the monitoring of inland and aquatic environment in the near future in order to fulfill the requirements of EANET activities.

8.2.3 State of soil and vegetation

The activities for soil and vegetation monitoring are not yet decided now in Myanmar due to constraints for instrument supply and capacity building. However, the national center will make plan to conduct soil and vegetation monitoring in the future.

8.2.4. Overall analysis

Wet deposition monitoring is the only activity for EANET in Myanmar. Among the observed data from Yangon (Kaba-Aye) urban site, minimum pH value for 2007, 2008 and 2009 were 4.4, 5.6 and 5.9 respectively; most of the measured pH values throughout the year were between 6 and 7. Hence, it can be generally concluded that acid deposition is not significant in Yangon area. Regarding the value of EC, the maximum of 7.72 $mS.m^{-1}$ was recorded on 24 March 2009. It was early rain in 2009, and there could be some contaminants in that rain water sample. So, the value of EC is very high on 24 March 2009 while the minimum of 0.39 $mS.m^{-1}$ was recorded on 29 September 2009. From the data recorded in 2007 and 2009, the overall analysis describes the average concentrations of pH and EC receptivity, which are still within the acceptable level. Meteorological data such as wind direction, wind speed, temperature, humidity and sunshine hours are also observed together with precipitation at the site. The monitoring results much depend on sampling, instruments and experience of staffs responsible for sampling and analytical performance. Analysis of parameters related to wet deposition is carrying out with great effort because chemical reagents are expensive and it also requires technical expert and funds for machine maintenance.

8.3. Review of National Measure Against Acid Deposition

Based on monitoring result of Acid deposition from 2007 to 2009, the status of Yangon rain is not acidic and its negative impacts has not identified yet in Myanmar. As the National Monitoring Center for EANET, the Department of Meteorology and Hydrology will continue the relevant environmental monitoring activities. Apart from DMH, there are some governmental agencies such as: Yangon/Mandalay city Development Committee, Department of Health, Department of Atomic Energy, Irrigation Department, Water Resources Utilization Department etc., which monitor water and air qualities. Regarding acid deposition monitoring, only wet deposition have been monitored due to limitation of funds, equipments, reagents and skilled staff. The National Center will seek the possible opportunities to extend dry deposition and inland aquatic monitoring to follow the examples of other participating countries of EANET.

8.4. References

EANET. 2000. Technical Documents for Acid Deposition Monitoring in East Asia. Niigata, Japan.
EANET. 2002. Data Reporting, Data Quality Assessment, and Data Treatment of Wet Deposition Monitoring for EANET Textbook. Niigata, Japan.
EANET. 2006. Periodic Report on the State of Acid Deposition in East Asia. Niigata, Japan.
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National Assessment on Acid Deposition
Philippines

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9.1 Basic Information on National Monitoring Activities

9.1.1 Outline of the activities on acid deposition and national monitoring plan

The Philippines participated in the preparatory phase of the Acid Deposition Monitoring in East Asia (EANET) in 1998 to 2000 and has affirmed its continued participation in the Network. The country’s national monitoring plan is based on the guidelines for acid deposition monitoring developed by the Environment Agency, Government of Japan, and adopted by the Experts Meetings on EANET in March 1997. The National Monitoring Plan was developed in 1999 after the basic monitoring infrastructure was set up with the assistance of the Government of Japan.

Acid deposition activities in the Philippines include the following:
1) Implementation of the National Monitoring Plan through the conduct of monitoring of wet deposition, dry deposition, soil, vegetation, and inland aquatic;
(2) Participation in inter-laboratory comparison exercises for wet deposition, soil, and inland aquatic environment; and
(3) National training capacities for enforcers and inspectors of emission sources relative to emission inventories, sulphur oxides stack testing and ambient sulphur dioxide sampling.
(4) Conduct of public awareness activities through the preparation of the acid deposition brochures, conduct of seminar-workshops for stakeholders, and initiation of a "Rain Watch" project involving elementary schools in Metro Manila.

At the regional level, the Philippines also participates in sessions of the (1) Senior Technical Managers that discuss the results of monitoring and quality assurance/quality control (QA/QC) activities; (b) Scientific Advisory Committee that provides advice from the scientific and technical viewpoints; and (3) Intergovernmental Meeting that sets the policy and makes decisions relative to EANET budget and operations.

9.1.2 Monitoring program from 2005 to 2009

The national monitoring plan covers the generation of the relevant data, operation and maintenance of field and laboratory facilities and equipment, and conduct of QA/QC activities.

For wet deposition monitoring, weekly monitoring was conducted in the Metro Manila, Los Baños and Mt. Sto. Tomas stations. Measurements were done on ten (10) parameters as follows: pH, electrical conductivity, sulphate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

For dry deposition monitoring, weekly monitoring was conducted in the Metro Manila, Los Baños and Mt. Sto. Tomas stations. Measurements were done for four (4) gases, i.e., sulphur dioxide (SO_2), nitric acid (HNO_3), hydrogen chloride (HCl), and ammonia (NH_3), and for eight (8) parameters in aerosol, i.e., sulphate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}). For remote site, sampling in Sto. Tomas started on 2009.

For soil monitoring, soil samples were collected and analyzed for pH (H_2O), pH (KCl), exchangeable base cations (Ca, Mg, K, Na), and exchangeable acid cations (Al, H). Exchangeable acidity and ECEC were calculated. Study sites for soil vegetation are the Mt. Makiling forest reserve at the University of the Philippines at Los Baños in Laguna and the U.P. Quezon Land Grant in Quezon (Figure 9.1.1). The prescribed monitoring frequency for soil monitoring is 3-5 years. For the period 2005-2009, there were two (2) sampling events.

For vegetation monitoring, investigations were made on the trees in the sampling plots (species, diameter at breast height/DBH, height) and understorey vegetation in terms of species. Indicators of tree damage were also noted. Study sites for vegetation monitoring are the Mt. Makiling forest reserve at the University of the Philippines in Laguna and the U.P. Quezon Land Grant located in Quezon. The prescribed monitoring frequency for vegetation monitoring is 3-5 years. The results of two (2) sampling events are presented in this report.

For inland aquatic monitoring, quarterly monitoring was conducted in Pandin lake in Laguna and Ambulalakao lake in Itogon, Benguet for the period 2005-2009. Measurements were done on twelve (12) parameters as follows: temperature, pH, electrical conductivity, alkalinity, sulphate (SO_4^{2-}), chloride (Cl^-), phosphate (PO_4^{3-}), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

9.1.3 Monitoring stations

Figure 9.1.1. Monitoring sites of wet and dry deposition, inland aquatic, soil and vegetation.

Table 9.1.1. List of monitoring stations.

Site category	Site classification	Location
Wet deposition/ Dry deposition	Urban	Metro Manila (Ateneo de Manila University Campus, Quezon city)
	Rural	Los Banos (University of the Philippines Campus, Los Banos)
	Remote	Mt. Sto. Tomas

Ecological survey site Soil and Vegetation	Rural	Makiling forest reserve Los Banos, Laguna
		UP Quezon-Laguna Land Grant Laguna
	Urban	La Mesa watershed Quezon city
	Remote	Environmental Research and Development Sector, DENR Itogon, Benguet
Inland Aquatic	Rural	Pandin lake San Pablo city
	Remote	Ambulalakao lake Itogon, Benguet

9.1.4 Sampling and measurements

Rainwater samples for wet deposition monitoring were collected by the "wet-only" samplers installed on site. Gas and aerosol samples for dry deposition monitoring were collected by the filter pack. Soil samples were collected by soil augers. Lake water samples were scooped directly into the sample containers.

Analytical methods for the measurement of specific parameters are the methods recommended in EANET manuals.

9.2 State of Acid Deposition in the Philippines

9.2.1 Atmospheric deposition

9.2.1.1 State of wet deposition

1) Ion concentrations and composition of precipitation

The pH of rainwater in urban site was in the range from 3.34 to 8.33 for the monitoring year of 2005-2009. In rural site , pH ranged from 4.55 to 6.46. The histogram shows the frequency distribution of monthly pH wherein the occurrence of less than 4.5 was at 4% and 46% of less than 5.5 in urban site (Figure 9.2.1). In Figure 9.2.2, pH at less than 5.5 shows 43% at rural site.

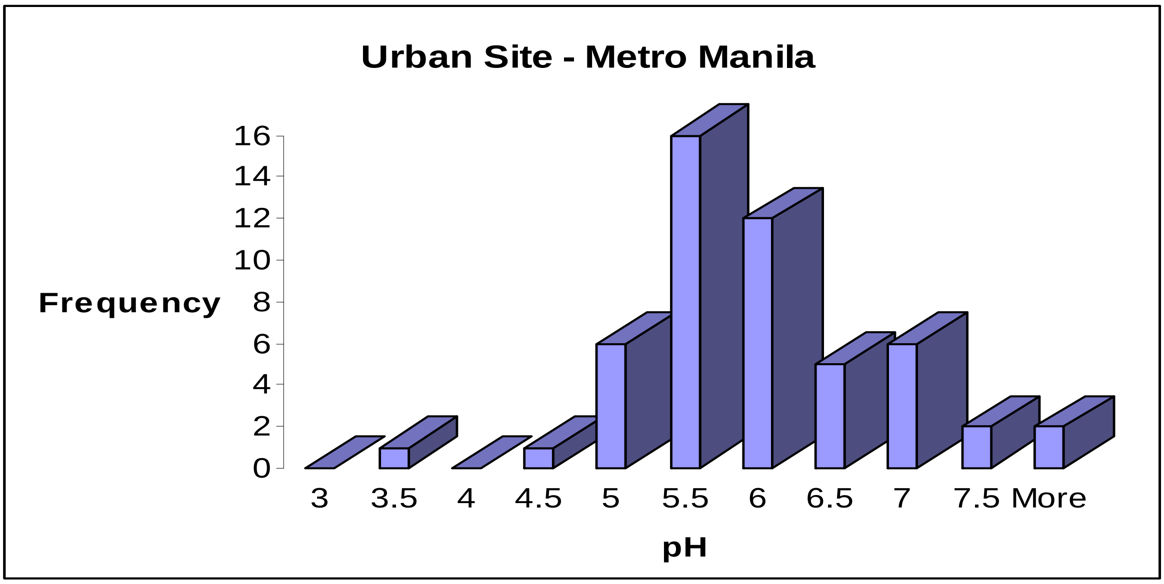


Figure 9.2.1. Frequency distribution of pH 2005-2009 (n = 50).

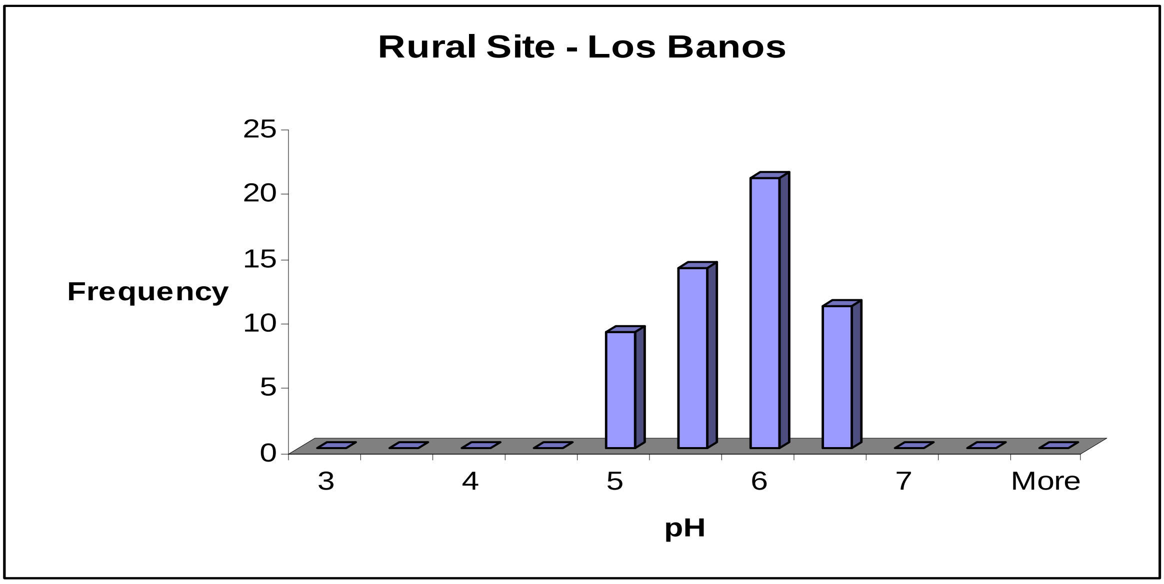


Figure 9.2.2. Frequency distribution of pH 2005-2009 (n= 54).

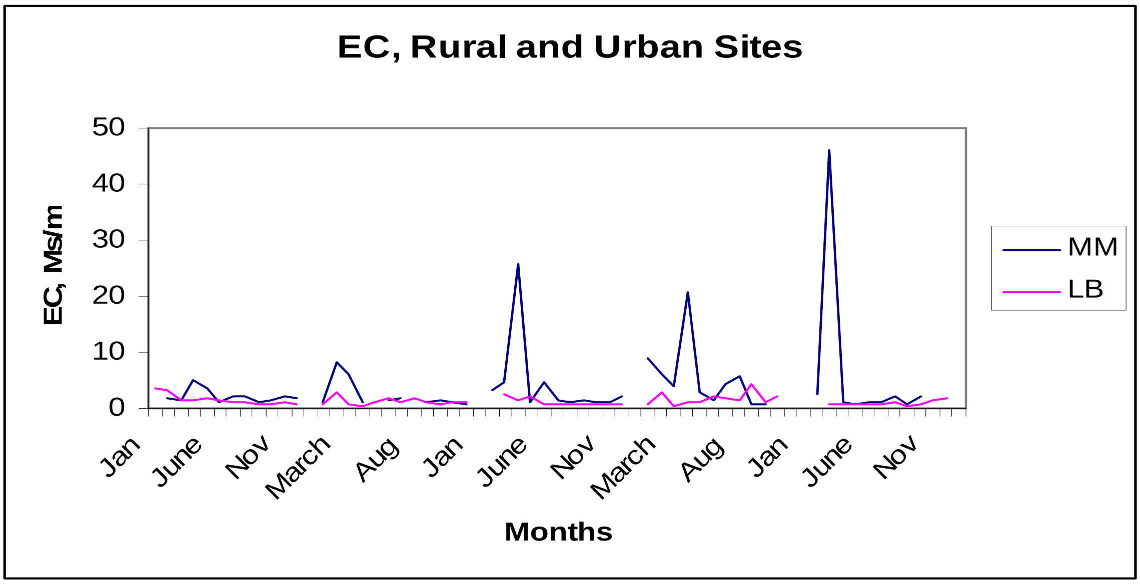


Figure 9.2.3. Electric conductivity in Metro Manila (urban) and Los Banos (rural) for 2005-2009.

Electric conductivity (EC) was high in Metro Manila compared to Los Banos. The highest EC was 45.9 mS/m at the start of wet season in year 2009. From the years 2005-2009, it was noted that an increased EC in Metro Manila were at the period between the start months of dry and wet seasons.

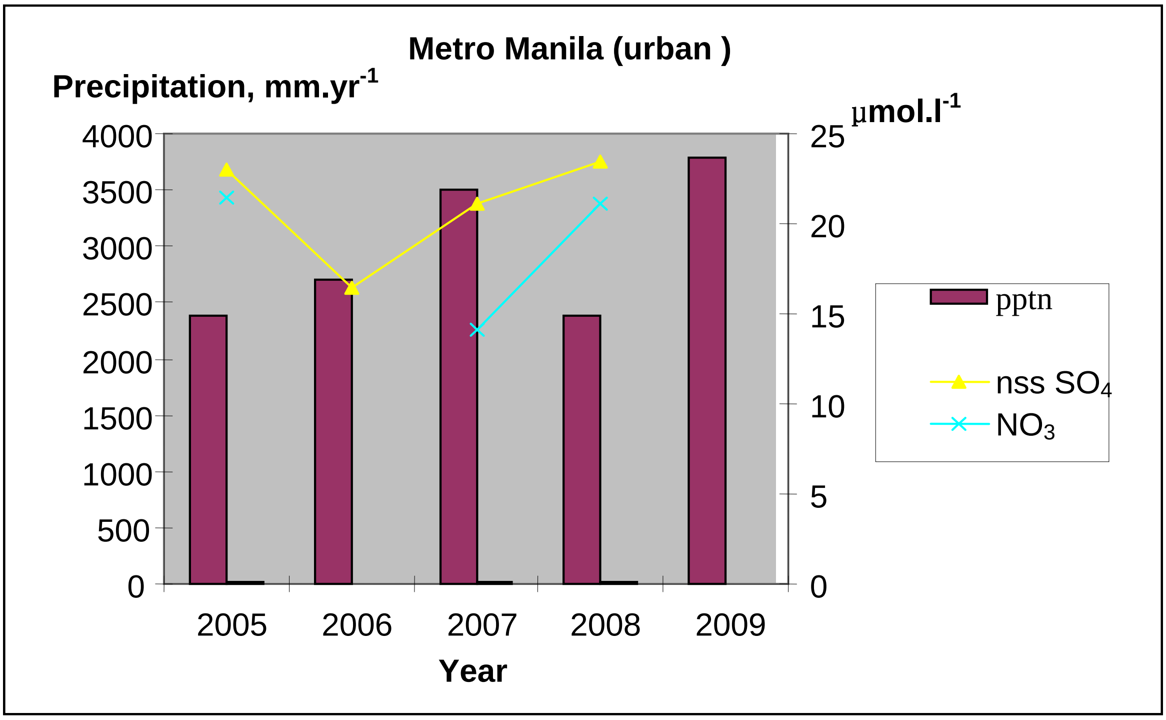


Figure 9.2.4. Precipitation and annual mean concentration (umol.l^{-1}).

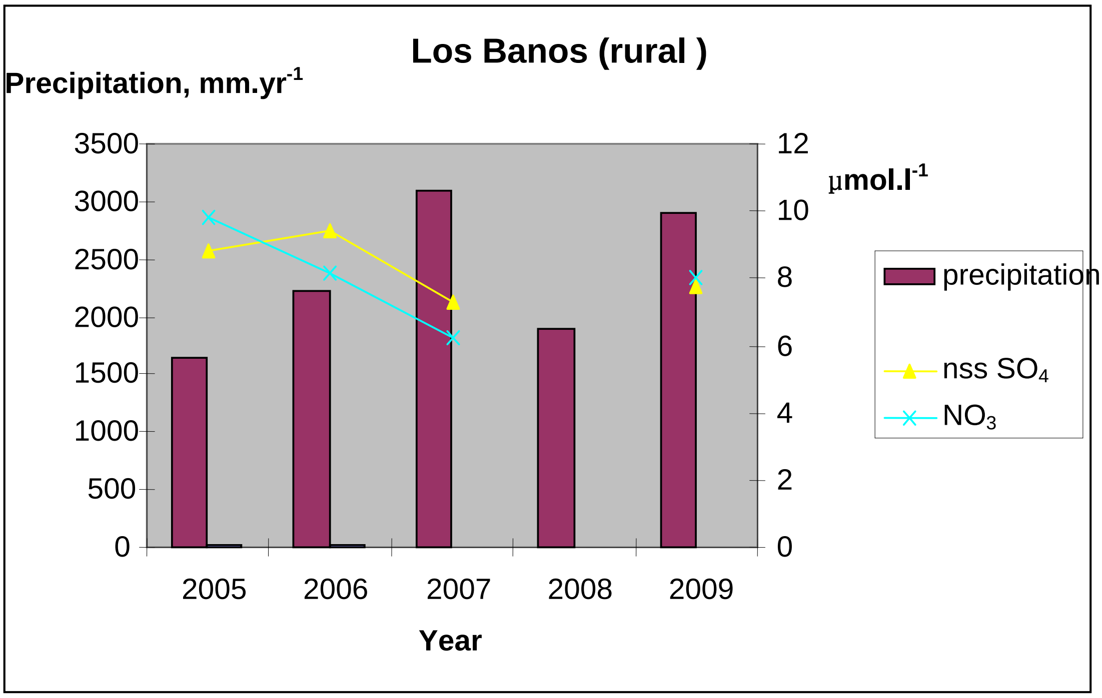


Figure 9.2.5. Precipitation and annual mean concentration (µmol.l^{-1}).

Figures 9.2.4 and 9.2.5 show the annual precipitation and annual mean concentrations of nss SO_4 and NO_3. The annual non sea salt sulphate (nss-sulphate) concentration of the rainfall ranged from 16.7 to 23.4 µmol.l^{-1}. The annual sulphate concentration, although not shown in the graph exhibited the same variations of nss sulphate and ranged from 22.3 to 24.9. The annual nitrate concentration of the rainfall ranged from 14.1 to 21.5 µmol.l^{-1}.

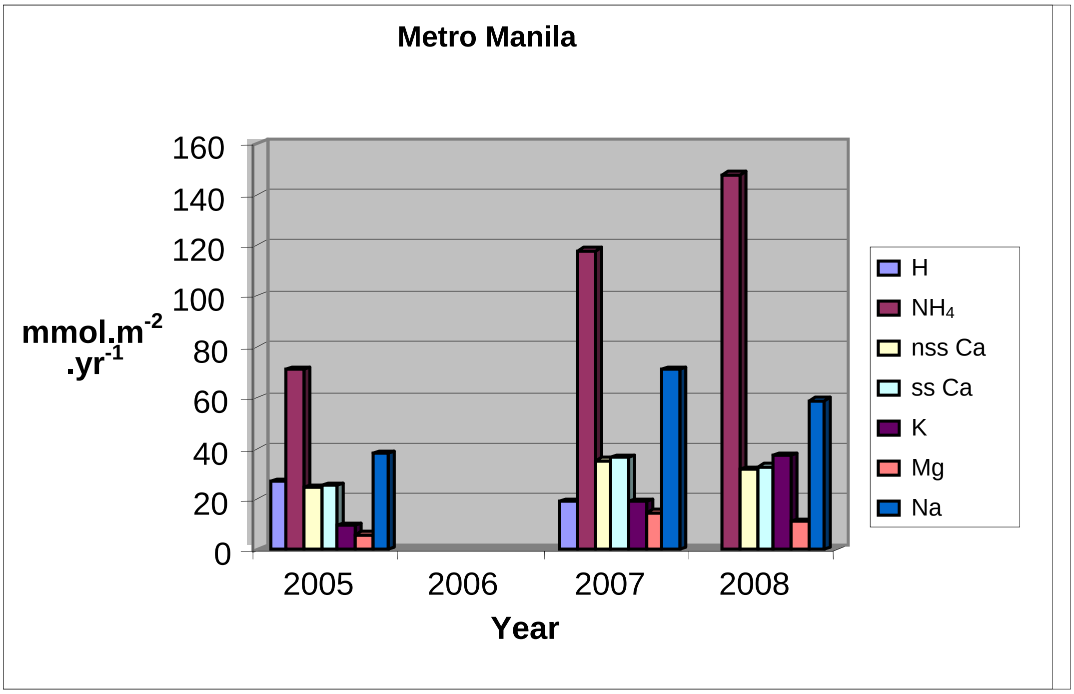


Figure 9.2.6. Annual deposition of components for urban site.

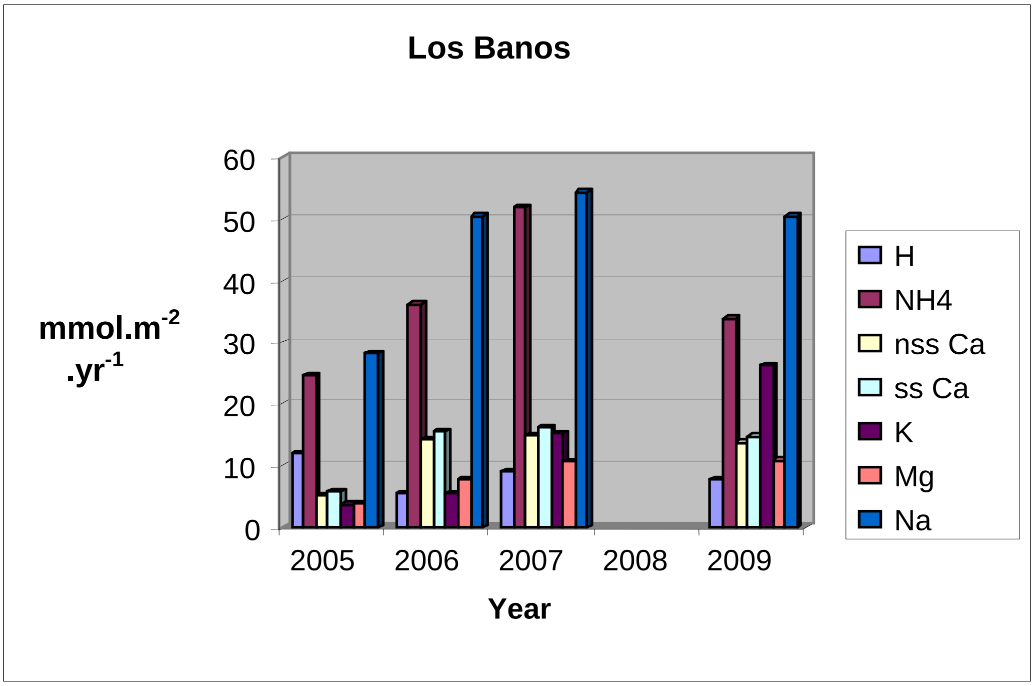


Figure 9.2.7. Annual depositions of components for rural site.

9.2.1.2. State of dry deposition

Dry deposition monitoring results are shown for Metro Manila and Los Banos in Figures 9.2.8 – 9.2.9. Annual trends for sulphur dioxide and ammonia show higher concentrations in Metro Manila than in Los Banos. Figures 9.2.10 to 9.2.12 show the annual trends in sulphate, nitrate and calcium in particulate matter concentrations. Sulphate shows lower concentration in remote site compared to urban and rural sites. Nitrate and calcium concentrations exhibited similar trends for urban and rural sites that is, higher concentrations in urban than in rural. There was an increased trend in nitrate and calcium concentrations at Mt. Sto. Tomas.

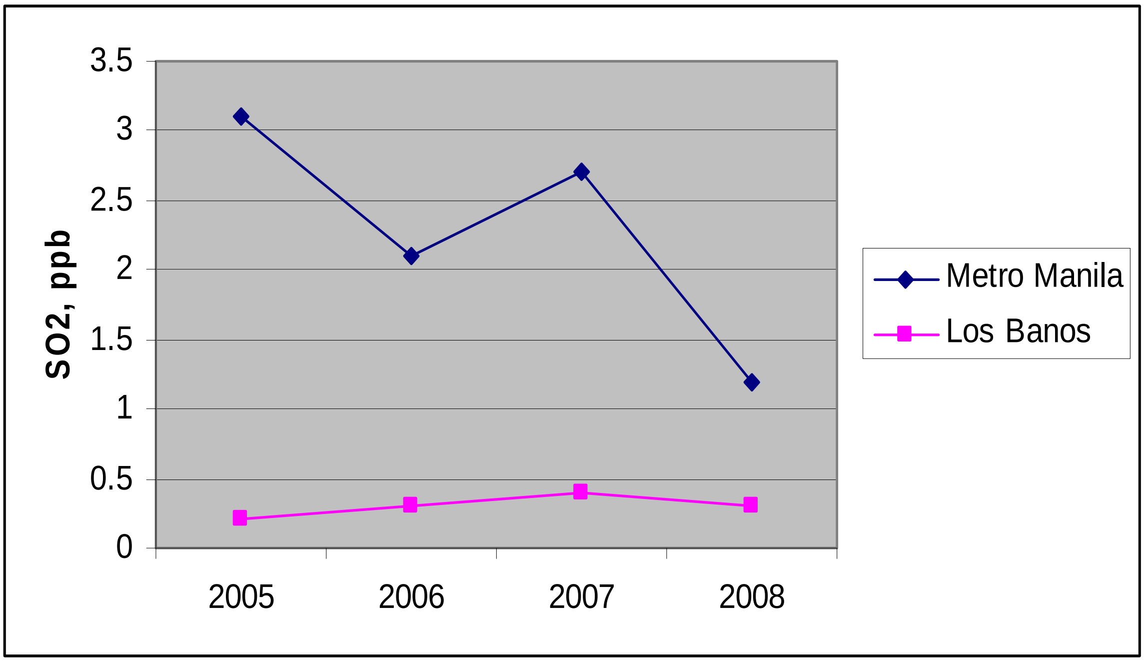


Figure 9.2.8. Annual SO_2 concentrations.

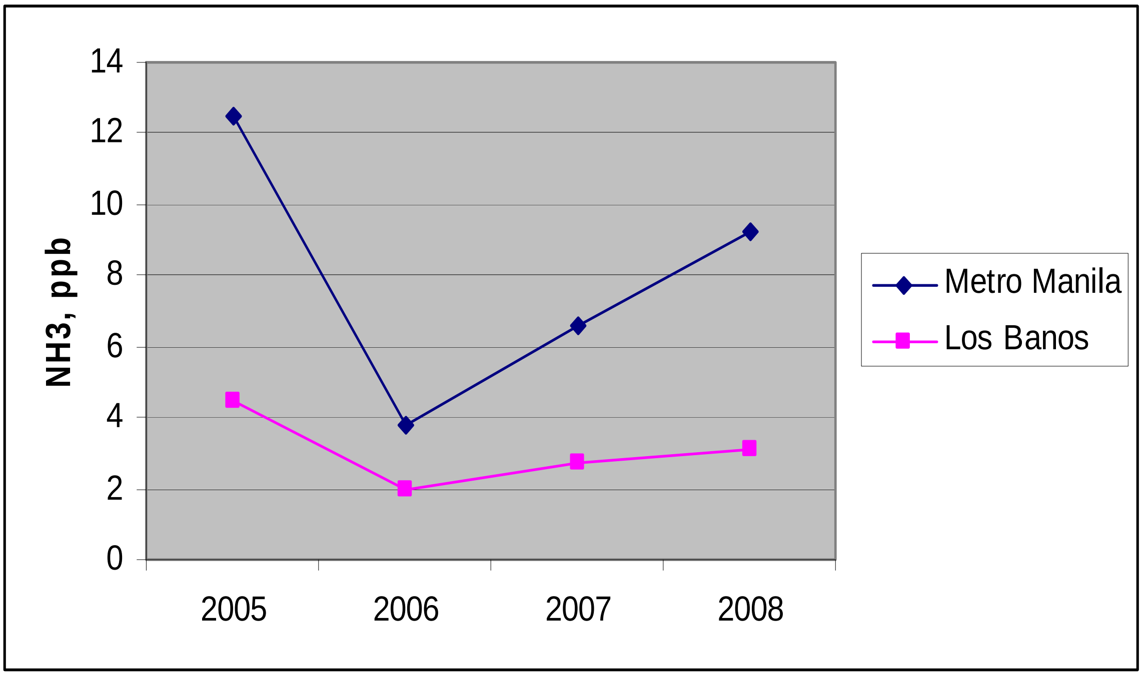


Figure 9.2.9. Annual NH_3 concentration.

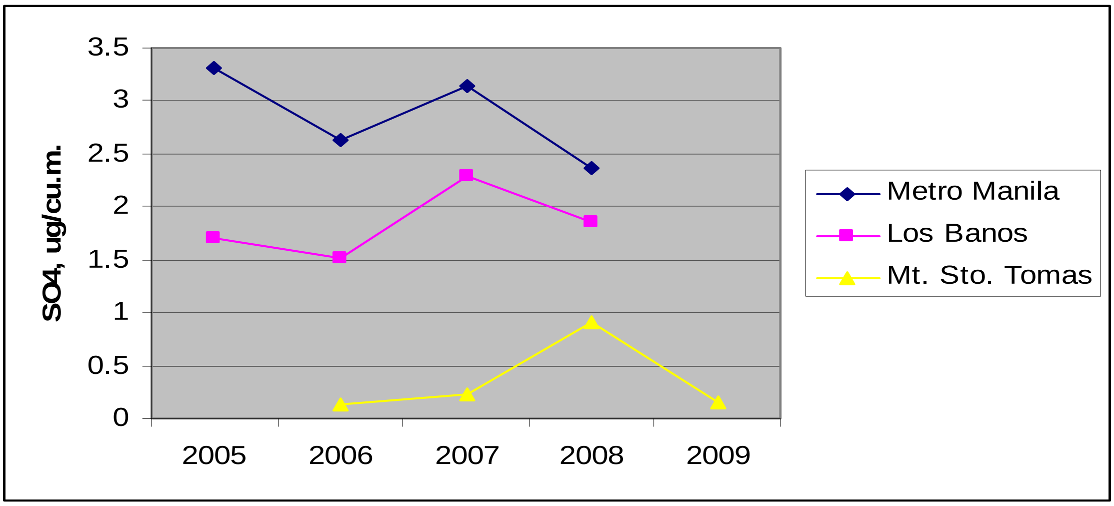


Figure 9.2.10. Annual SO_4 in PM concentration.

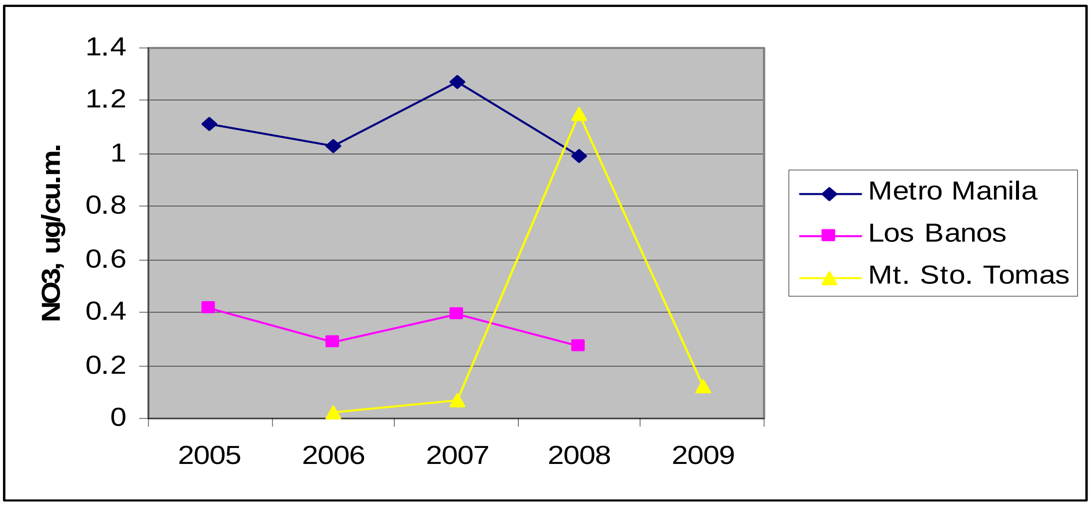


Figure 9.2.11. Annual NO_3 in PM concentration.

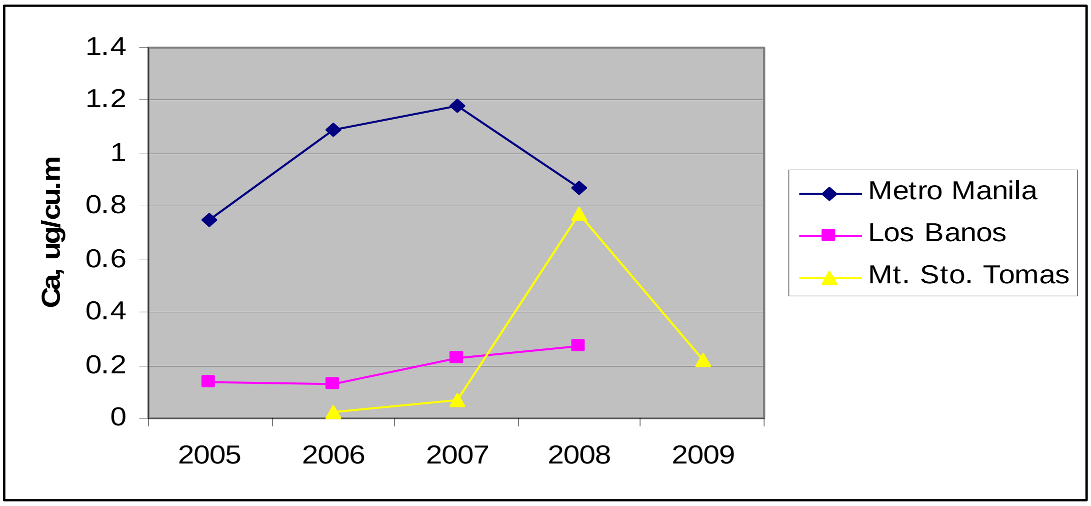


Figure 9.2.12 Annual Ca in PM concentration.

9.2.1.3. State of inland aquatic environment

Monitoring results in Pandin lake and Ambulalakao lake are presented in Figures for pH, EC and ionic concentration. Pandin lake monitoring started in 2004 and conducted four times a year while in Ambulalakao, categorized a remote site, monitoring started on 2005 and conducted two times a year. Other parameters monitored include ammonium, nitrate, chloride, sodium, potassium, calcium, magnesium, phosphate, nitrate and transparency.

Figure 9.2.13 shows the annual pH for Pandin and Ambulalakao lake. Ambulalakao lake is the site for remote and exhibited lower pH than Pandin lake. Electric conductivity data were observed to be lower in Ambulalakao than in Pandin (Figure 9.2.14). Ionic concentrations for Ambulalakao lake exhibited lower trends compared with Pandin lake, although, in the year 2009 data for Ambulalakao lake were considerably high for some parameters.

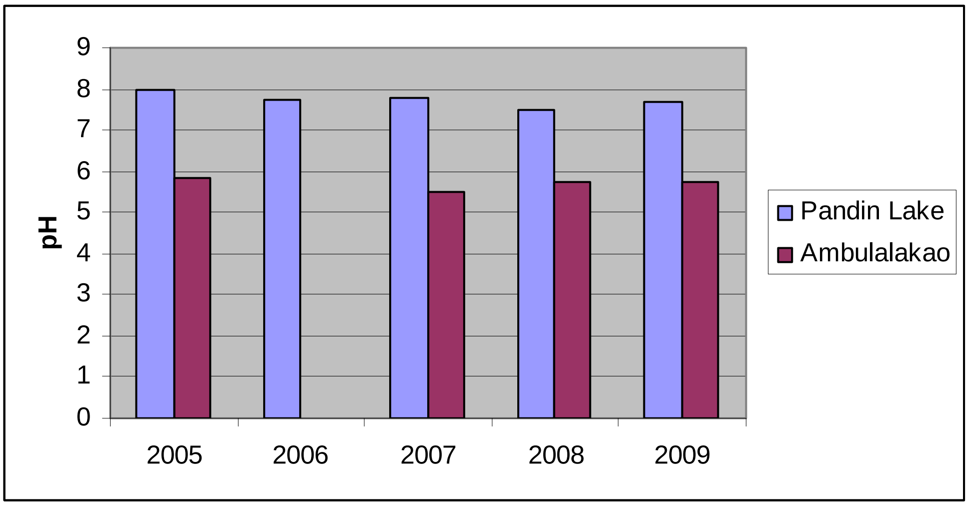


Figure 9.2.13. Annual pH for rural (Pandin) and remote (Ambulalakao) sites.

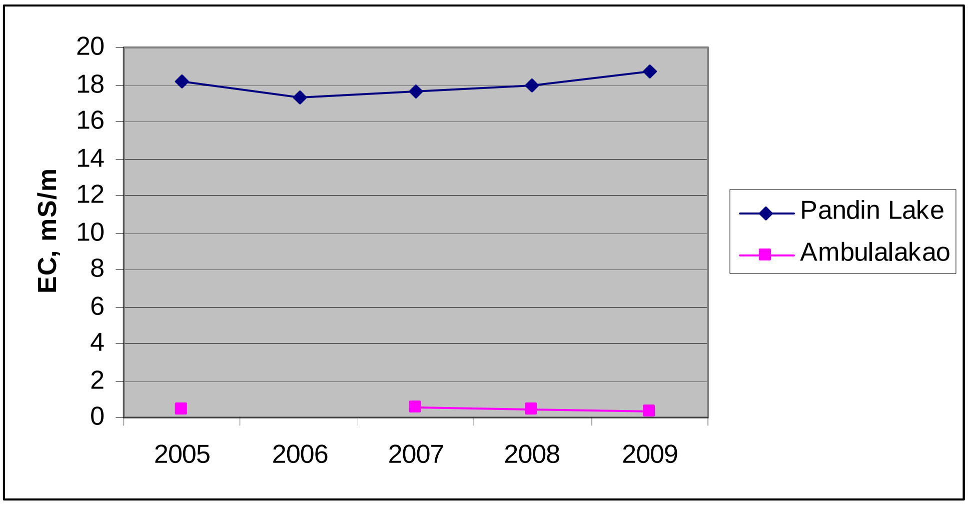


Figure 9.2.14. Annual EC for Pandin lake and Ambulalakao lake.

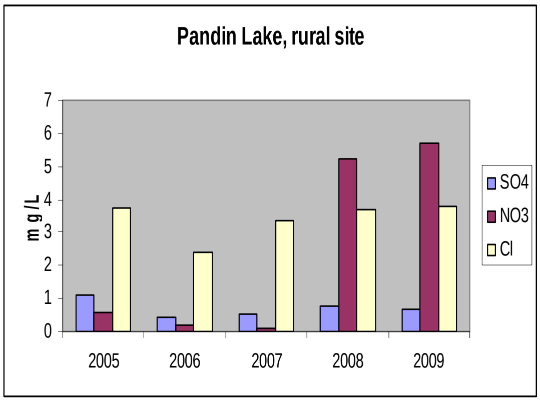


Figure 9.2.15. Ionic concentration.

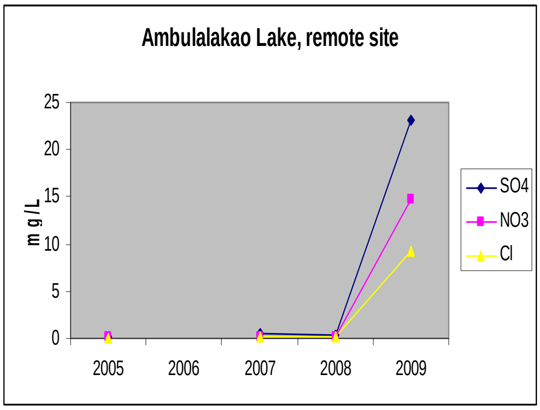


Figure 9.2.16. Ionic concentration.

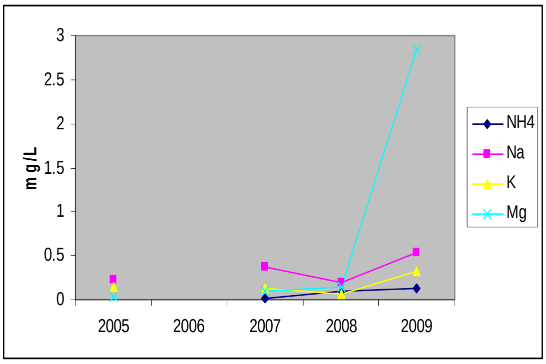


Figure 9.2.17. Ionic Concentration.

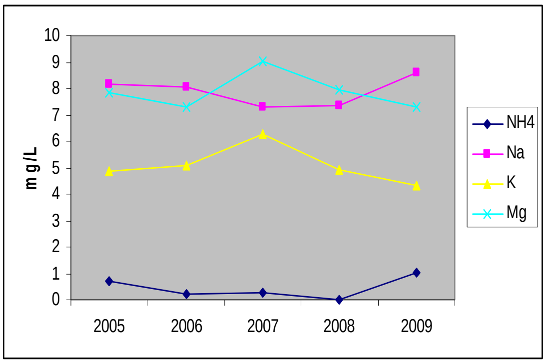


Figure 9.2.18. Ionic Concentration.

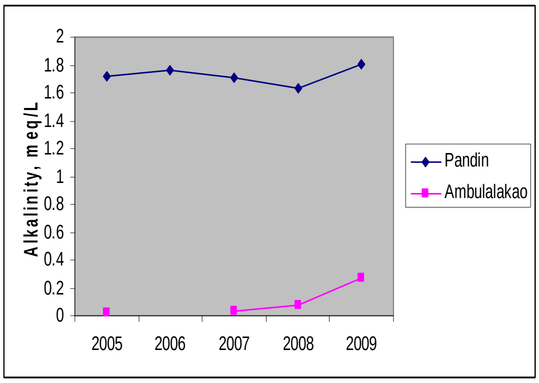


Figure 9.2.19. Calcium concentration.

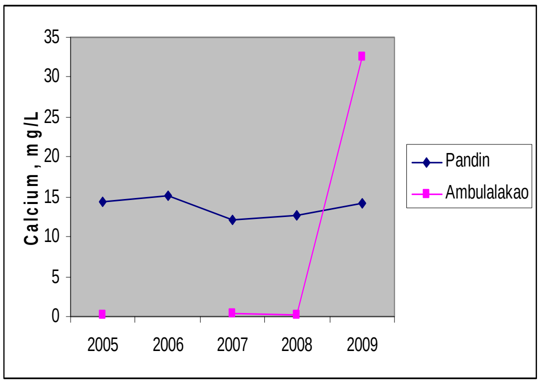


Figure 9.2.20. Alkalinity.

9.2.2 State of soil and vegetation

9.2.2.1. State of soil

The staggering increase in fuel consumption in East Asia is the result of increasing population and industrialization. This has translated into increased air pollution resulting in acid deposition that could cause damage to the environment. The effects of acid rain have alerted scientists and society especially in the USA and Europe where measures are being undertaken to address the problem. The continuation of this occurrence might result to significant adverse effects on the ecological systems of this region. This similar situation is also happening in our country, the Philippines.

Acidification of the soil, nutrient imbalance and direct damage to the plant caused by acid deposition could lead to a forest decline. However, due to the fact that this process is relatively slow, it becomes increasingly important to obtain accurate, precise and comparable data on a long term basis on acid deposition through soil and vegetation monitoring.

1) Methodology

The methodology used in soil monitoring was in accordance with the Soil and Vegetation Monitoring in East Asia (2000). The 2004-2009 data generated in the Philippines' monitoring sites were analyzed although the data from 1999-2004 were also used to determine if there were any changes that occurred during the 2nd five-year monitoring period.

2) Basic Survey of Soil

Figure 9.2.21 presents the basic scheme followed in the surveys conducted in the EANET participating countries. If some changes in the parameters are detected which possibly may have been due to acid deposition, a more intensive survey should be undertaken to fully assess the impacts and implications of the same changes. Figure 9.2.22 shows an image map that depicts the location of the acid deposition monitoring sites. Two forest sites with soils having different sensitivities to acid deposition, and within a radius of approximately 50 km of acid from the monitoring sites were selected. Sampling plots for soil and vegetation monitoring were established in each forest. At least two plots occupying areas from 5 m x 5 m to 10 m x 10 m, were selected randomly at each soil type. Five subplots for soil sampling, each occupying 1 m x 1 m, were chosen at the center and on the diagonal lines of the plot. The locations of the acid deposition monitoring sites are shown in Figure 9.2.23.

The different parameters measured from soil and forests are presented in Table 9.2.1. Some parameters are common among the sampling sites, although there are also distinct measurements that are unique to each location. Soils were sampled for elements and ions, and their physical characteristics.

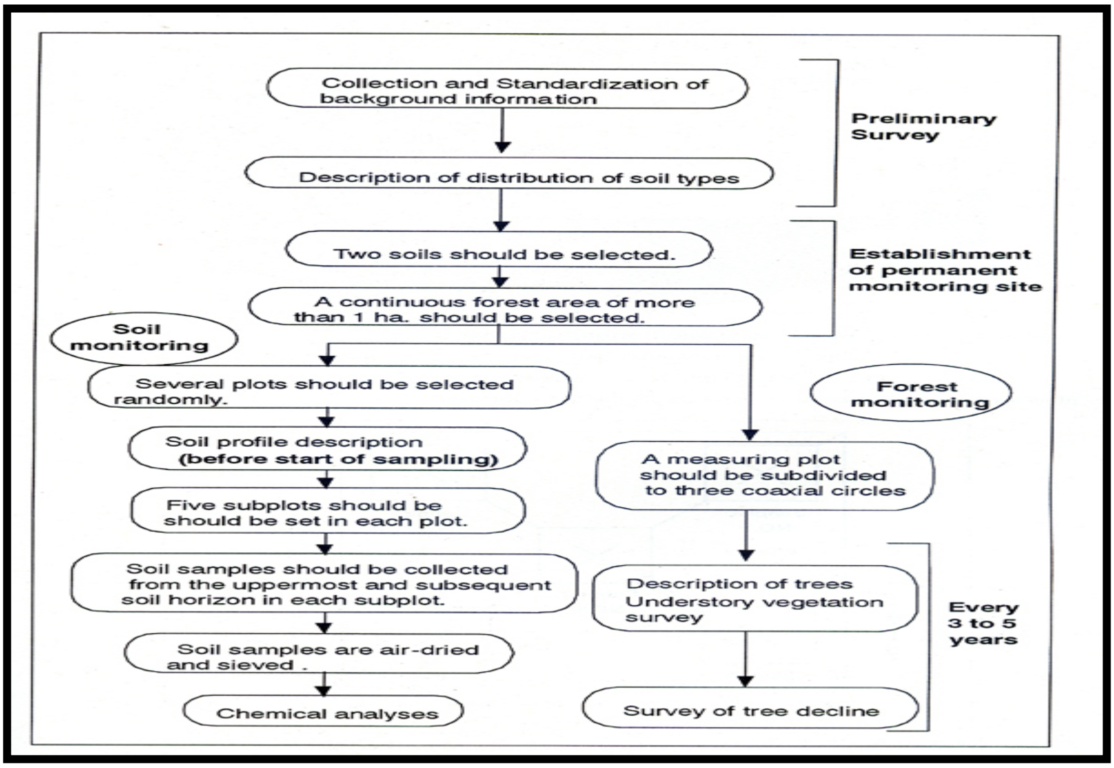


Figure 9.2.21. Overall process of basic survey of soil and forest.

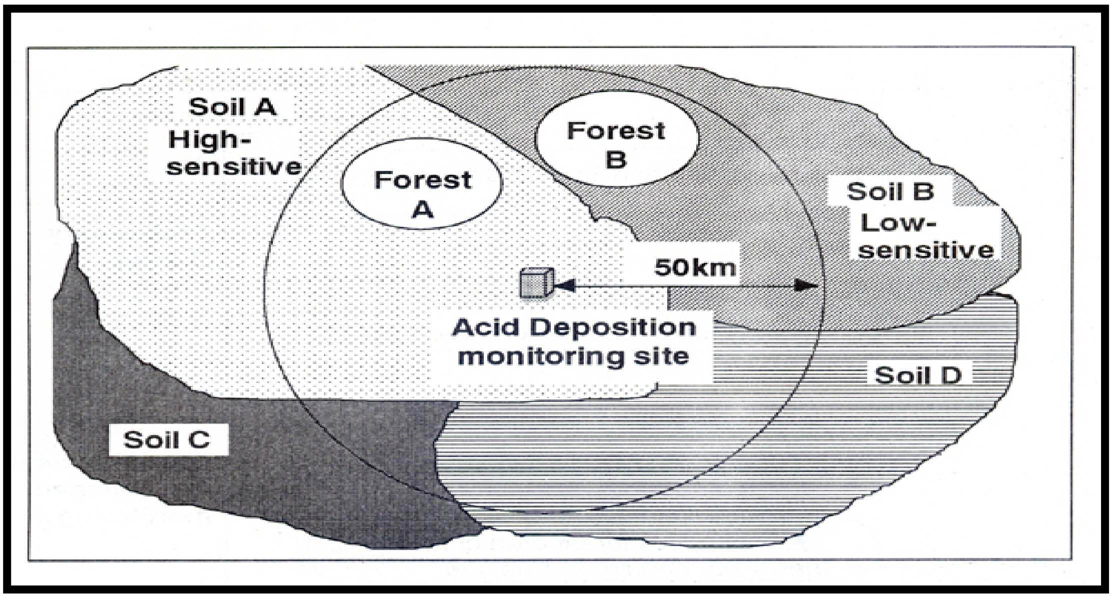


Figure 9.2.22. Image map of the permanent acid deposition monitoring sites.

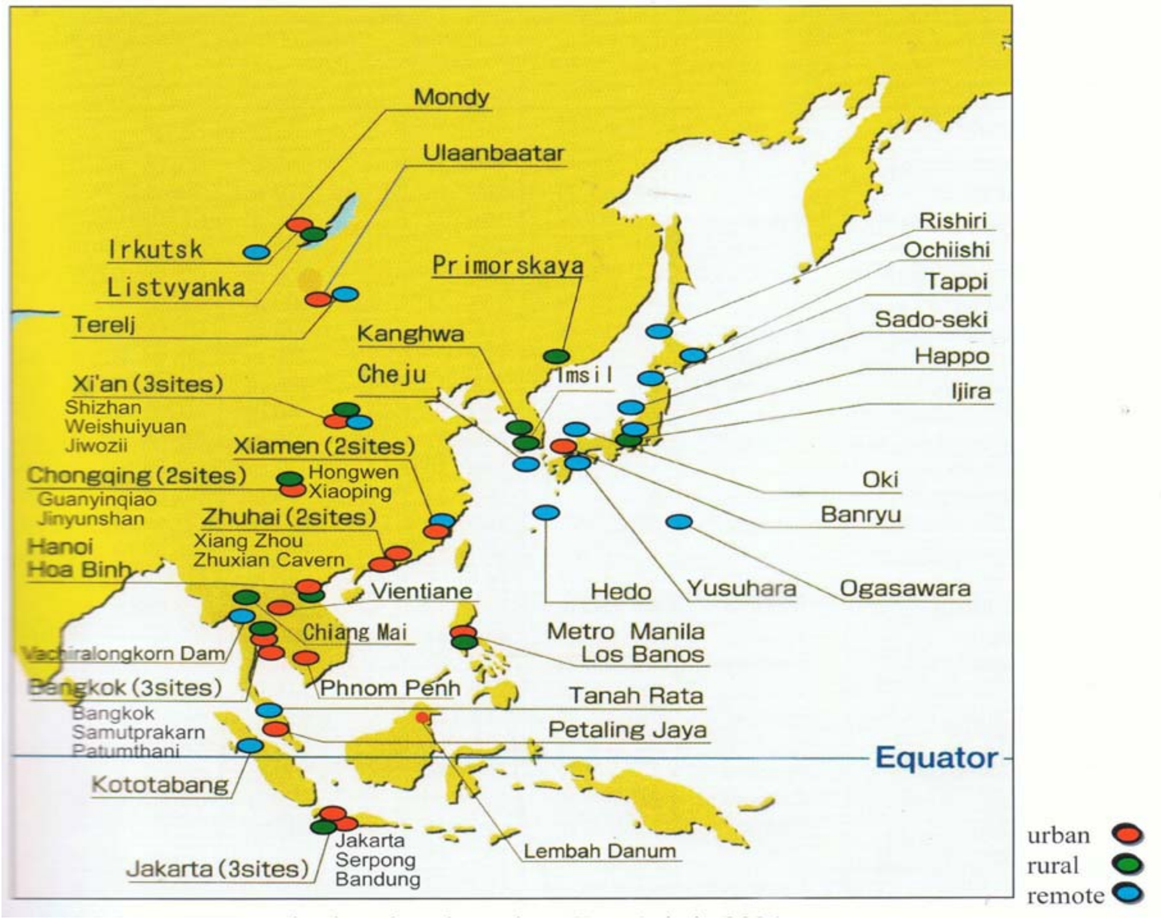


Figure 9.2.23. EANET monitoring sites throughout East Asia.

Table 9.2.1. Basic survey for soil and forest.

Item	**Parameters**
Soil	- pH (H_2O), pH (KCl), Exchangeable base cations (Na, K, Ca, and Mg), Exchangeable acidity, Effective cation exchange capacity (ECEC), Carbonate content (if pH > 7) - Exchangeable Al and H, Total C content, Total N content (optional) - Available P, Sulphate (voluntary) - Physical properties (Fine earth bulk density, and Penetration resistance)(optional)

Forest	- General description of the forest
	    - description of trees
	    - understory vegetation
	- Observation of tree decline
	- Photographic record of tree decline
	- Estimation of decline causes (optional)

3) Description of data on soil

Soil pH. Analyses of soil samples collected from different monitoring sites at Mt. Makiling, Los Banos, Laguna, UP Quezon Land Grant, La Mesa Dam Watershed, Payatas, Quezon city and Binga, Itogon, Benguet from 2005-2008 are presented in Figures 9.2.24-9.2.30 and Tables 9.2.2a, 9.2.2b, 9.2.3a and 9.2.3b, respectively. In general, the pH_w of the surface soil at UP Quezon Land Grant which is described as extremely acidic to very strongly acidic, based on corresponding terms in Table 9.2.4, is very much lower when compared to the soil pH_w values at Mt. Makiling which is described as strongly acidic to moderately acidic (Figure 9.2.24). It was also observed that the lower layer of the soil (10 –20 cm depth) showed lower pH values than the upper layer (0 – 10 cm). The pH_{KCl} was also noted to give lower pH values than the pH_w (Figure 9.2.24). It was also noted that for the 2nd five year monitoring period, the pH at Mt. Makiling decreased slightly (pH 6.2 – 5.8) while a slight increase in pH value was observed in UP Quezon Land Grant although the pH is still very strongly acidic (pH 4.2-4.7). On the other hand, the pH_w of the new sites at La Mesa Dam in Quezon city and Itogon in Benguet were characterized as strongly acidic or pH ranging from 5.1 to 5.5, however, the pH_{KCL} from La mesa Dam was noted to be extremely acidic.

Exchangeable Aluminum. In connection with exchangeable aluminum, it was observed to be present when the pH_w falls below 5.20 as shown by the data from Mt. Makiling, however, the observed values were very low during the period in review. Although there is a slight increase in the value during the last monitoring period, still this is not enough to affect the growth of the plants. UP Quezon Land Grant exhibited highly toxic level of Al in the sites sampled. Aluminum was also observed to have higher values in the lower layer where pH is also lower. With time (2000-2008), the amount of exchangeable aluminum increases in UP Quezon Land Grant on both layers sampled. Initial findings from the new monitoring sites at La Mesa Dam, Quezon city and Itogon, Benguet reveals that Benguet has high amount of exchangeable aluminum while the value at Quezon city is almost nil and will not cause any damage to plant growth.

Exchangeable Base cations. The soil test values for Ca, Mg and K for Mt. Makiling were all above the critical levels as cited by Haby *et al.*, 1990, wherein they mentioned critical values of 1.25 – 2.5, 0.13 – 0.25 and 0.28 – 0.51 cmol (+)/kg soil for Ca, Mg and K, respectively, however, it was observed that there is a large decrease in values of all the cations tested (K, Ca, Mg, Na) and effective CEC from 2005 to 2008 sampling (Figures 9.2.26-9.2.30). This does not hold true for the exchangeable cations and effective CEC for UP Quezon Land Grant where the soil test values obtained showed slight increase although these values were below the critical levels. For La Mesa Dam, Quezon city and Itogon, Benguet, except for potassium which is below the critical level all the cations and effective CEC were high or above the critical level.

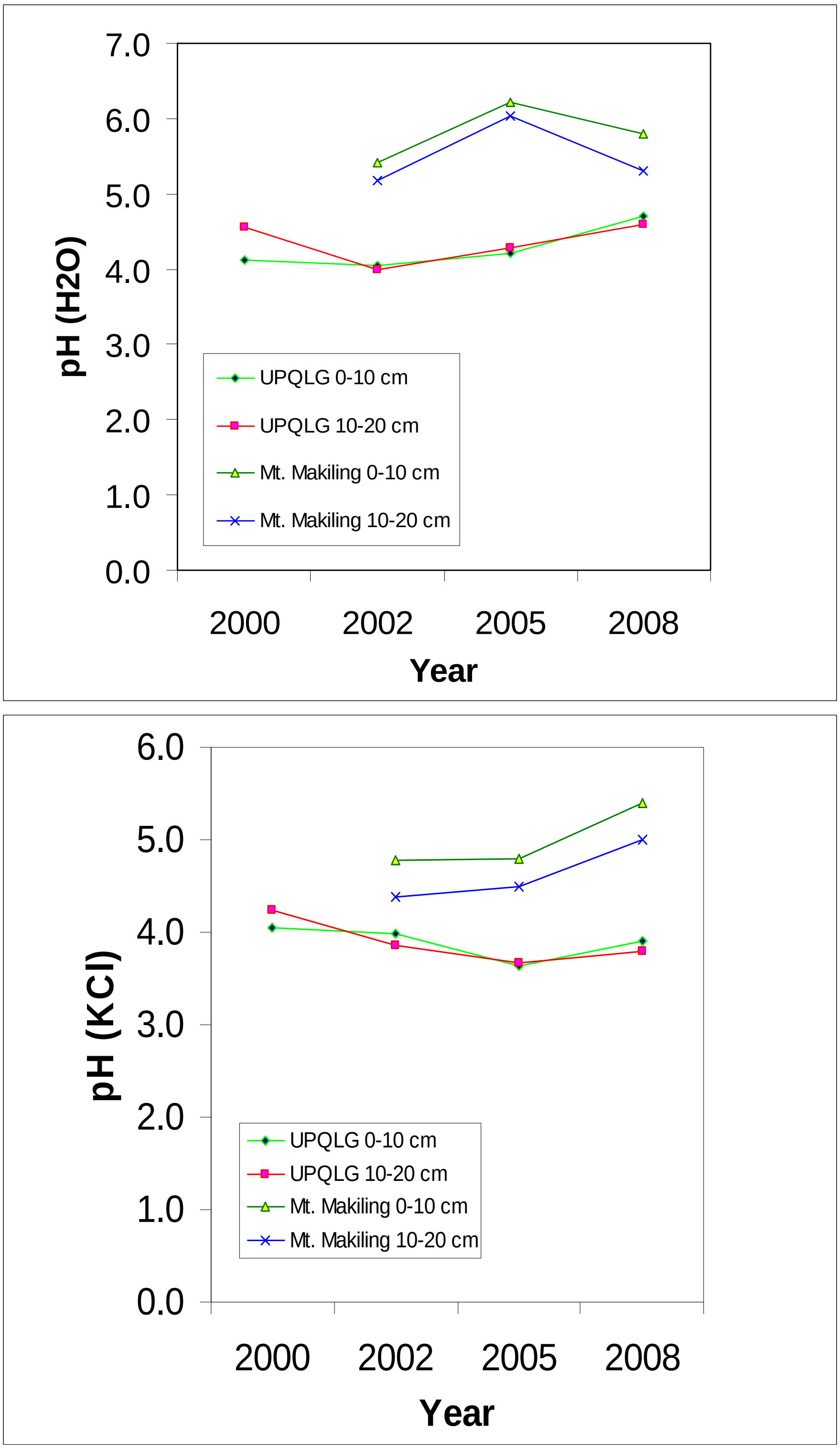


Figure 9.2.24. Changes in soil pH from 2000-2008 at two sampling sites in the Philippines.

Table 9.2.2a. Soil Chemical analysis: La Mesa dam watershed, Payatas, Quezon city, Philippines.

Sampling period: November 9, 2007

Name of analysis laboratory: Department of Soil Science, UPLB

Sample No.	Location	Plot No.	Subplot No.	Layer analyzed (cm)	Moisture content (wt %)	pH		Exchangeable base cations (B)				Ex-acidity (A)	Ex-acid cations		ECEC (A)+(B)	Base saturation %
						H_2O	KCl	Ca	Mg	K	Na		Al	H		
								(cmol[+]kg^{-1})								
1	La Mesa dam, Payatas, Quezon city	1	1	0 - 10	1.1	5.7	4.6	14.48	8.94	0.30	3.95	0.13	0.00	0.13	27.80	99.53
			2		1.1	6.0	4.6	10.15	6.00	0.22	3.59	0.22	0.00	0.22	20.18	98.91
			3		1.1	5.9	4.6	9.54	4.98	0.29	2.39	0.21	0.00	0.21	17.41	98.79
			4		1.1	5.8	4.4	9.88	5.55	0.29	2.87	0.21	0.00	0.21	18.80	98.88
			5		1.1	5.7	4.3	10.57	4.64	0.32	4.78	0.40	0.05	0.35	20.71	98.07
2			1	10 - 20	1.1	4.5	4.2	9.33	5.32	0.23	2.15	0.44	0.11	0.33	17.47	97.48
			2		1.1	6.0	4.5	13.24	5.43	0.39	4.18	0.26	0.00	0.26	23.50	98.89
			3		1.1	5.6	4.2	8.92	4.75	0.25	4.3	0.35	0.05	0.30	18.57	98.12
			4		1.1	5.7	4.3	9.40	7.13	0.25	2.75	0.28	0.00	0.28	19.81	98.59
			5		1.1	6.0	4.7	12.49	4.19	0.34	2.81	0.21	0.00	0.21	20.04	98.95
3		2	1	0 - 10	1.1	5.6	4.0	12.56	9.62	0.27	4.36	0.73	0.47	0.26	27.54	97.35
			2		1.1	5.7	4.6	8.10	4.30	0.33	3.11	0.20	0.00	0.20	16.04	98.75
			3		1.0	5.1	4.0	10.17	6.48	0.28	1.85	0.74	0.36	0.38	19.52	96.21
			4		1.1	5.6	4.3	11.87	7.02	0.28	2.27	0.35	0.05	0.30	21.79	98.39
			5		1.1	5.5	4.5	9.47	4.98	0.25	3.23	0.19	0.00	0.19	18.12	98.95
4			1	10 - 20	1.0	5.6	4.2	8.98	5.86	0.20	2.34	0.31	0.05	0.26	17.69	98.25
			2		1.1	5.6	4.2	8.30	5.32	0.24	1.02	0.34	0.08	0.26	15.22	97.77
			3		1.1	5.2	4.1	11.60	7.58	0.24	2.51	0.42	0.12	0.30	22.35	98.12
			4		1.1	5.6	4.4	11.60	6.45	0.23	2.51	0.18	0.00	0.18	20.97	99.14
			5		1.1	5.7	4.2	10.84	6.90	0.23	2.69	0.27	0.00	0.27	20.93	98.71

Table 9.2.2b. Soil chemical analysis: La Mesa dam watershed, Payatas, Quezon city, Philippines (repeat analysis).

Sampling period: November 9, 2007

Name of analysis laboratory: Department of Soil Science, UPLB

Sample No.	Location	Plot No.	Subplot No.	Layer analyzed (cm)	Moisture content (wt %)	pH		Exchangeable base cations (B)				Ex-acidity (A)	Ex-acid cations		ECEC (A)+(B)	Base saturation %
						H_2O	KCl	Ca	Mg	K	Na		Al	H		
								(cmol[+]kg^{-1})								
1	La Mesa dam, Payatas, Quezon city	1	1	0 - 10	1.1	5.6	4.3	10.70	7.13	0.31	3.83	0.26	0.00	0.26	22.23	98.83
			2		1.1	5.6	4.5	10.22	6.34	0.20	2.63	0.33	0.00	0.33	19.72	98.33
			3		1.1	5.6	4.4	8.30	3.96	0.31	2.99	0.33	0.00	0.33	15.89	97.92
			4		1.1	5.5	4.3	8.99	5.21	0.27	2.21	0.33	0.00	0.33	17.01	98.06
			5		1.1	5.4	4.2	9.67	4.19	0.33	5.74	0.37	0.00	0.37	20.30	98.18
2			1	10 - 20	1.1	5.4	4.2	8.50	5.77	0.23	2.45	0.43	0.04	0.40	17.38	97.53
			2		1.1	5.6	4.3	11.80	4.98	0.33	3.77	0.33	0.00	0.33	21.21	98.44
			3		1.1	5.4	4.1	8.51	4.53	0.23	3.05	0.43	0.04	0.40	16.75	97.43
			4		1.1	5.5	4.2	8.71	6.11	0.24	3.47	0.33	0.00	0.33	18.86	98.25
			5		1.1	5.8	4.5	12.28	3.96	0.35	3.65	0.25	0.00	0.25	20.49	98.78
3		2	1	0 - 10	1.1	4.9	3.8	10.50	7.70	0.26	3.23	1.02	0.39	0.63	22.71	95.51
			2		1.1	5.5	4.4	8.37	4.41	0.31	3.47	0.29	0.00	0.29	16.85	98.28
			3		1.0	5.0	3.8	11.10	5.45	0.26	2.55	0.75	0.25	0.50	20.11	96.27
			4		1.1	5.3	4.1	11.80	7.81	0.27	3.11	0.50	0.04	0.46	23.49	97.87
			5		1.1	5.4	4.3	8.10	4.41	0.26	3.89	0.33	0.00	0.33	16.99	98.06
4			1	10 - 20	1.0	5.3	4.1	8.05	6.28	0.19	2.39	0.39	0.02	0.37	17.30	97.75
			2		1.1	5.2	3.9	8.1	5.09	0.26	1.97	0.49	0.09	0.40	15.91	96.92
			3		1.1	5.3	4.0	9.47	7.81	0.24	1.85	0.54	0.18	0.36	19.91	97.29
			4		1.1	5.6	4.2	9.74	5.77	0.24	3.17	0.33	0.00	0.33	19.25	98.29
			5		1.1	5.3	4.0	10.09	6.22	0.24	3.29	0.37	0.00	0.37	20.21	98.17

Table 9.2.3a. Soil chemical analysis: Binga, Itogon, Benguet, Philippines.

Sampling period: April 17, 2008

Name of analysis laboratory: Department of Soil Science, UPLB

Sample No.	Location	Plot No.	Subplot No.	Layer analyzed (cm)	Repeat* analysis	Moisture content (wt %)	pH		Exchangeable basecations (B)				Ex-acidity (A)	Ex-acid cations		ECEC (A)+(B)	Base saturation
							H_2O	KCl	Ca	Mg	K	Na		Al	H		
									(cmol[+]kg^{-1})								%
1	Binga, Itogon, Benguet, Philippines	1	1	0 - 10	1st	1.0	5.3	5.1	8.58	0.95	0.25	0.43	2.02	1.72	0.30	12.22	83.50
			2			1.0	5.5	5.0	8.74	1.02	0.26	0.41	1.79	1.60	0.19	12.22	85.36
			3			1.0	5.2	5.0	8.49	0.88	0.24	0.40	1.61	1.35	0.26	11.63	86.12
			4			1.0	5.6	5.1	8.13	1.18	0.27	0.54	1.32	1.06	0.25	11.43	88.47
			5			1.0	5.1	5.0	8.23	1.11	0.22	0.49	1.48	1.17	0.31	11.53	87.17
2			1	10 - 20	1st	1.0	5.1	4.9	6.24	0.77	0.20	0.37	2.02	1.60	0.42	9.59	78.96
			2			1.0	5.1	4.8	6.48	0.76	0.16	0.33	2.02	1.40	0.62	9.75	79.28
			3			1.0	4.9	4.7	5.87	0.85	0.21	0.39	1.88	1.49	0.40	9.20	79.53
			4			1.0	5.4	5.1	5.86	0.73	0.24	0.50	1.64	1.34	0.30	8.97	81.72
			5			1.0	5.1	4.8	5.74	0.78	0.20	0.40	1.86	1.53	0.32	8.98	79.33
3		2	1	0 - 10	1st	1.0	5.3	5.1	7.04	1.09	0.25	0.45	1.86	1.30	0.56	10.68	82.59
			2			1.0	5.5	5.1	7.24	0.84	0.24	0.36	2.27	1.94	0.33	10.95	79.27
			3			1.0	5.5	5.2	7.64	1.01	0.21	0.41	2.10	1.86	0.24	11.37	81.55
			4			1.0	5.5	5.1	7.76	0.72	0.22	0.32	2.29	2.04	0.25	11.30	79.77
			5			1.0	5.1	4.9	7.37	0.62	0.22	0.31	2.76	2.37	0.39	11.28	75.55
4			1	10 - 20	1st	1.0	5.1	4.9	4.99	0.88	0.20	0.41	1.86	1.49	0.37	8.33	77.73
			2			1.0	5.2	4.9	5.36	0.73	0.24	0.38	2.77	2.43	0.34	9.48	70.79
			3			1.0	5.3	4.9	5.13	0.94	0.16	0.40	2.22	1.81	0.41	8.85	74.92
			4			1.0	5.1	4.9	5.12	0.55	0.16	0.26	2.53	2.16	0.37	8.62	70.67
			5			1.0	5.1	4.9	4.85	0.48	0.16	0.28	2.77	2.27	0.50	8.53	67.53

Table 9.2.3b. Soil chemical analysis: Binga, Itogon, Benguet, Philippines.
Sampling period: April 17, 2008
Name of analysis laboratory: Department of Soil Science, UPLB

Sample No.	Location	Plot No.	Subplot No.	Layer analyzed (cm)	Repeat* analysis	Moisture content (wt %)	pH		Exchangeable basecations (B)				Ex-acidity	Ex-acid cations		ECEC (A)+(B)	Base saturation
							H_2O	KCl	Ca	Mg	K	Na	(A)	Al	H		
									(cmol[+]kg^{-1})								%
1	Binga, Itogon, Benguet, Philippines	1	1	0 - 10	2nd	1.0	5.3	5.1	8.10	0.97	0.24	0.44	1.78	1.48	0.30	11.53	84.56
			2			1.0	5.5	5.0	8.36	1.02	0.25	0.40	1.67	1.25	0.42	11.70	85.73
			3			1.0	5.2	5.0	8.72	0.97	0.24	0.42	1.61	1.35	0.26	11.96	86.50
			4			1.0	5.6	5.1	8.71	1.09	0.27	0.48	1.52	1.27	0.25	12.07	87.41
			5			1.0	5.1	5.0	8.61	1.12	0.22	0.50	1.56	1.25	0.31	12.00	87.01
2			1	10 - 20	2nd	1.0	5.1	4.9	7.70	0.77	0.20	0.38	2.00	1.58	0.42	11.05	81.90
			2			1.0	5.1	4.8	7.98	0.72	0.16	0.34	2.00	1.61	0.39	11.20	82.14
			3			1.0	4.9	4.7	7.35	0.86	0.21	0.39	1.88	1.49	0.40	10.69	82.39
			4			1.0	5.4	5.1	7.76	0.75	0.24	0.47	1.64	1.34	0.30	10.85	84.88
			5			1.0	5.1	4.8	7.86	0.78	0.20	0.39	1.84	1.52	0.32	11.07	83.38
3		2	1	0 - 10	2nd	1.0	5.3	5.1	7.60	0.95	0.25	0.46	1.86	1.60	0.26	11.12	83.27
			2			1.0	5.5	5.1	7.48	0.85	0.24	0.36	2.27	1.94	0.33	11.20	79.73
			3			1.0	5.5	5.2	7.48	0.93	0.20	0.43	2.20	1.96	0.24	11.25	80.44
			4			1.0	5.5	5.1	7.78	0.82	0.22	0.34	2.19	1.94	0.25	11.35	80.71
			5			1.0	5.1	4.9	7.49	0.73	0.22	0.32	2.36	1.97	0.39	11.12	78.78
4			1	10 - 20	2nd	1.0	5.1	4.9	6.09	0.79	0.20	0.38	2.06	1.69	0.37	9.52	78.36
			2			1.0	5.2	4.9	6.17	0.75	0.24	0.35	2.47	2.13	0.34	9.97	75.24
			3			1.0	5.3	4.9	6.11	0.74	0.17	0.37	2.32	1.91	0.41	9.71	76.12
			4			1.0	5.1	4.9	6.16	0.64	0.16	0.29	2.43	2.06	0.37	9.68	74.89
			5			1.0	5.1	4.9	5.99	0.67	0.16	0.31	2.57	2.07	0.50	9.70	73.51

Table 9.2.4. Corresponding terms to use for ranges in pH.

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral[1]	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 and higher

[1] Strict neutrality is pH 7.0 but in field work those soils between pH 6.6 and 7.3 are called neutral. In rare cases, the terms very slightly acid and very mildly alkaline may be used for soils of pH 6.6 to 6.9 and 7.1 to 7.3 respectively.

Source: Soil Science 1 Laboratory Manual (2005)

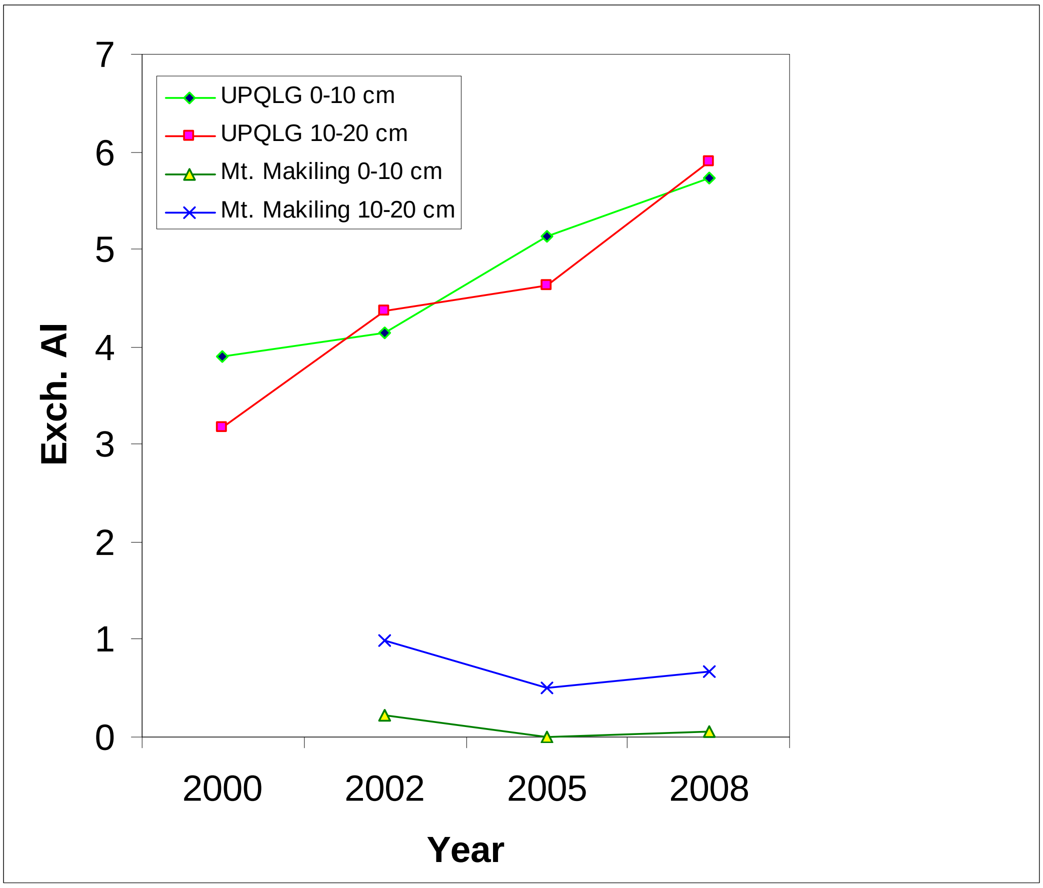


Figure 9.2.25. Exchangeable aluminum at two sampling sites in the Philippines.

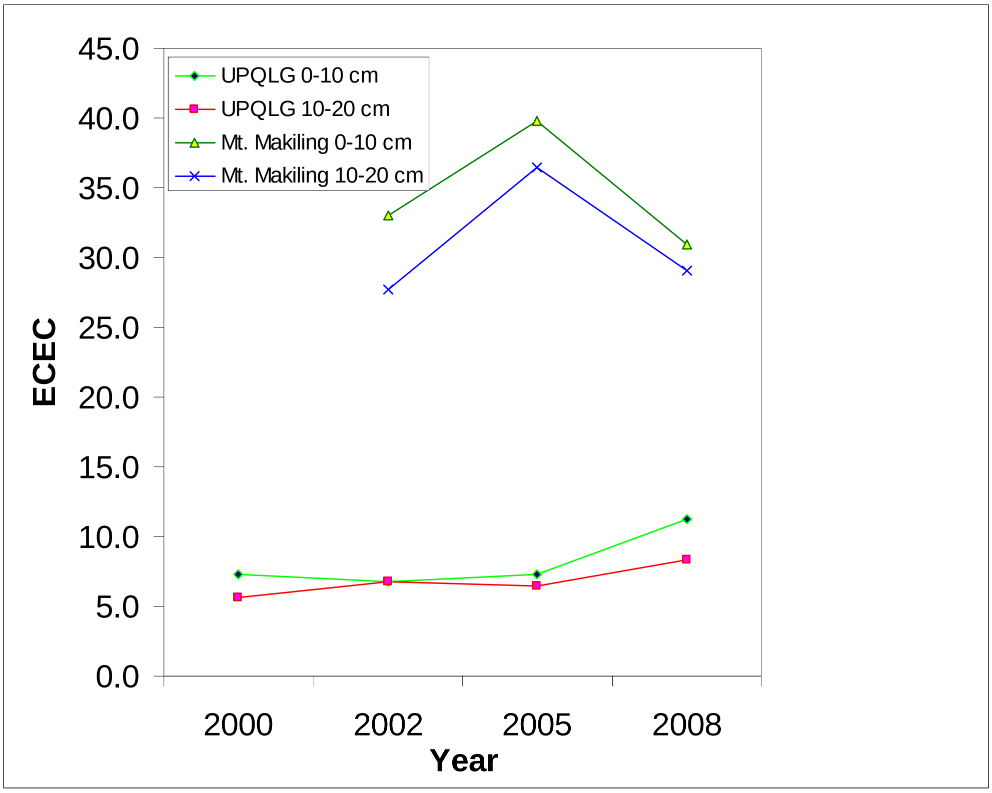


Figure 9.2.26. Effective CEC at two sampling sites in the Philippines.

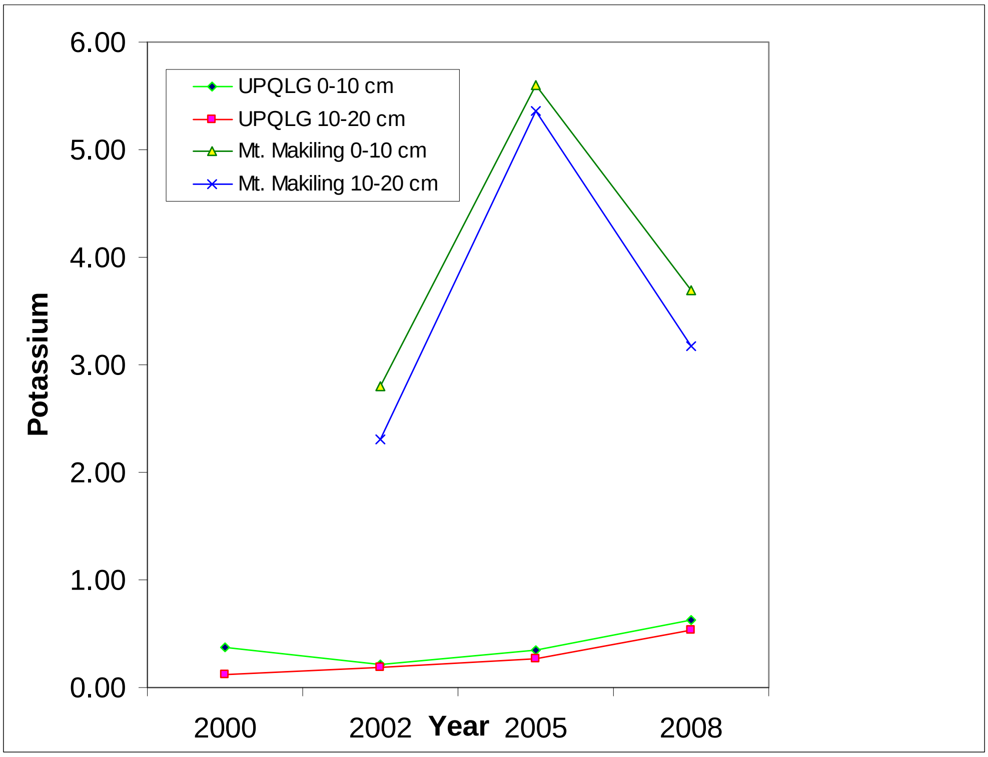


Figure 9.2.27. Exchangeable potassium at two sampling sites in the Philippines.

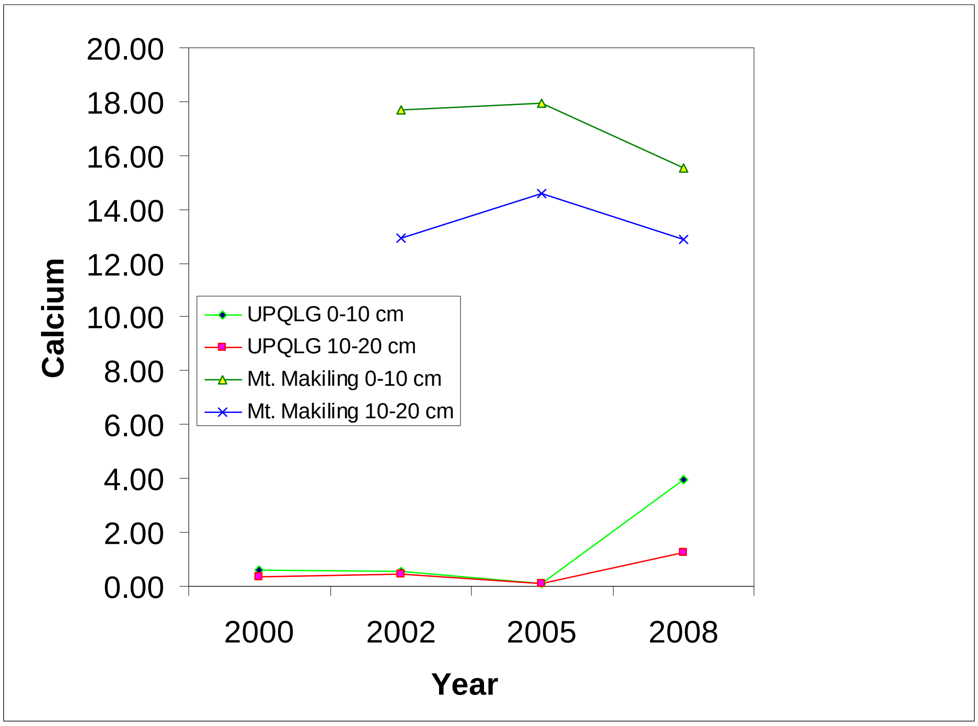


Figure 9.2.28. Exchangeable calcium at two sampling sites in the Philippines.

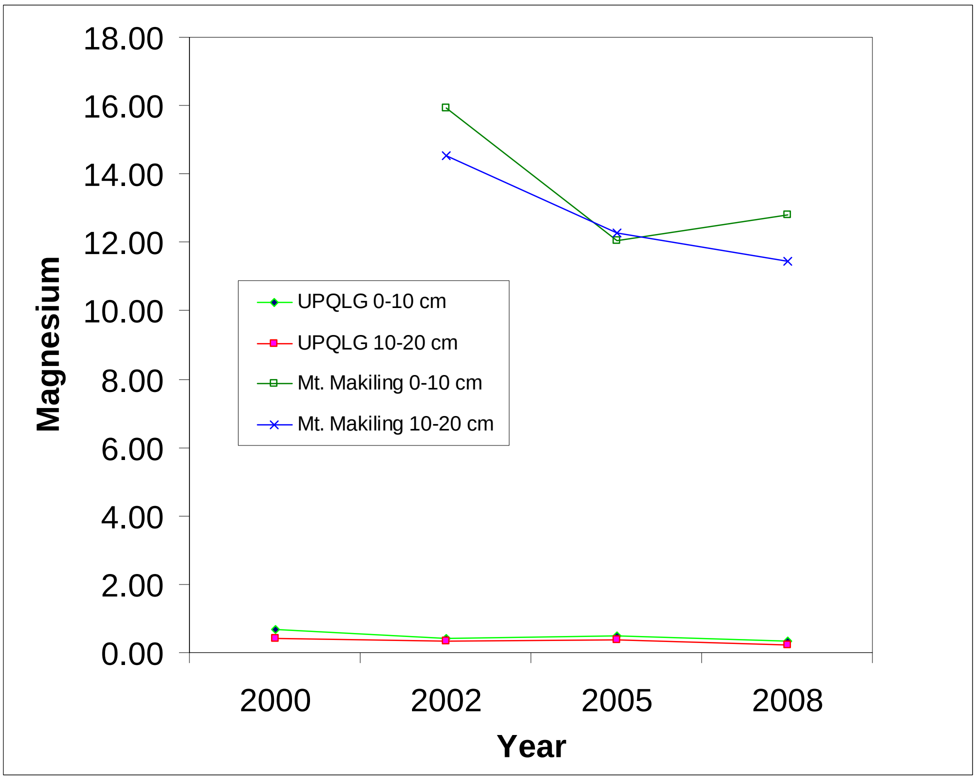


Figure 9.2.29. Exchangeable magnesium at two sampling sites in the Philippines.

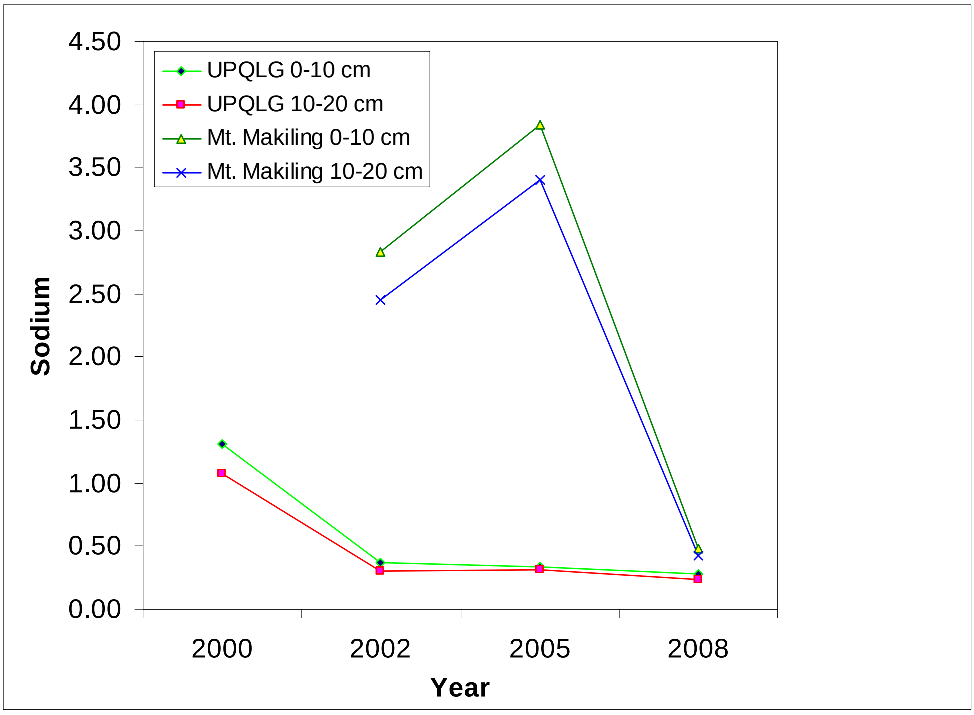


Figure 9.2.30. Exchangeable sodium at two sampling sites in the Philippines.

9.2.2.2. State of vegetation

In the Philippines, there are four EANET ecological monitoring sites. These are located in the Mt. Makiling forest reserve and the UP Quezon-Laguna Land Grant in the Province of Laguna for the rural monitoring site, the La Mesa watershed in Quezon city, Metro Manila for the urban monitoring site, and the ERDS Experimental Forest in Itogon, Province of Benguet for the remote monitoring site (Figure 9.2.31). Monitoring started in 2001 for the first two sites, while the first monitoring was conducted in the last two sites in 2008. Thus far, three measurements (2001, 2005, and 2008) have been made in both the Mt. Makiling and UP Quezon-Laguna Land Grant sites.

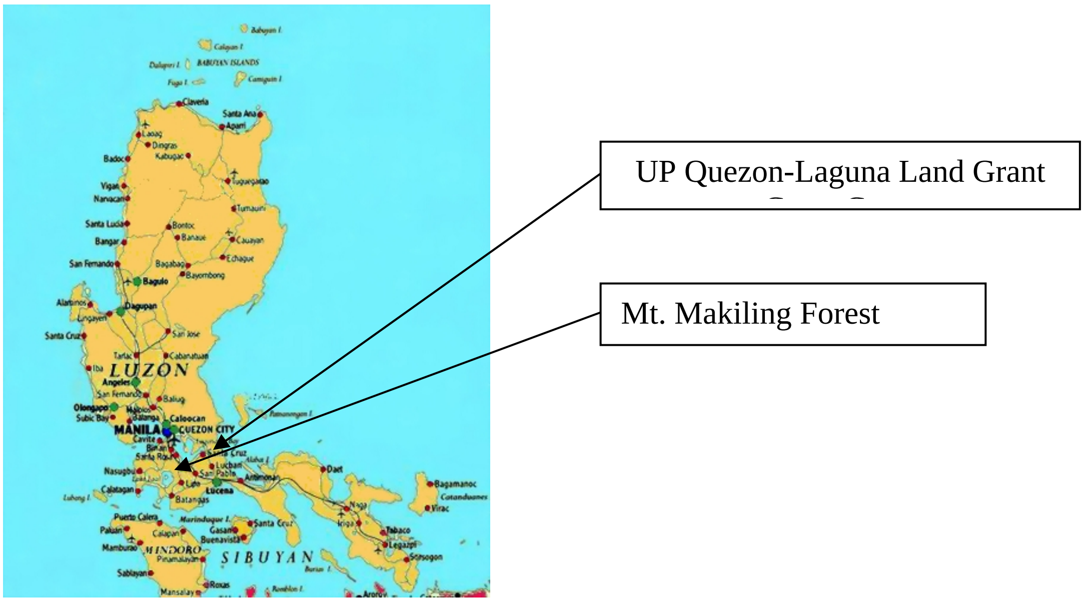


Figure 9.2.31. Location of the EANET ecological monitoring.
Sites in the Province of Laguna, Philippines.

1) Tree measurements

There was a continuing decline in the number of trees sampled in the Mt. Makiling forest reserve ecological monitoring site (Table 9.2.5 and Figures 9.2.32-9.2.35). A typhoon crossed the Laguna area in September 2004 which toppled down a number of observation trees in the area. Another strong typhoon again passed through the area in September 2006 which destroyed more observation trees reducing the number to 60 from a high of 130 in 2001. In the Makiling forest, the trees of *Celtis luzonica* were able to withstand the force of the strong winds. The species remained to be dominant in the area. The trees of this species exhibited growth through the years from 2001 to 2008. The destruction of a number of the observation trees in the Mt. Makiling forest reserve reduced the total basal area by half. The same reduction was also observed in the total volume on a per hectare basis in this monitoring site.

Table 9.2.5. Changes in the biometric characteristics of sample trees in the Mt. Makiling forest reserve from 2001 to 2008.

Parameters	**Measurements**		
	2001	**2005**	**2008**
Number of trees sampled	130	121	60
Maximum height	26.58 m	39.27 m	29.32 m
Maximum diameter	110 cm	110 cm	67.2 cm
Mean height of dominant trees (*Celtis luzonica* Warb.)	5.53 m	7.46 m	10.0 cm
Mean DBH of dominant trees (*Celtis luzonica* Warb.)	8.48 cm	10.13 cm	15.83 cm
Basal area	5.61 m^2 in a hectare	5.73 m^2 for all trees sampled; 35m^2 in a hectare	2.49 m^2 for all trees sampled;15.56 m^2 in a hectare
Total volume	90.44 m^3 for all trees	111.55 m^3 for all trees sampled; 697 m^3 in a hectare	50.70 m^3 for all trees sampled; 316.88 m^3 in a hectare
Density	812 trees/ha	756 trees/ha	375 trees/ha

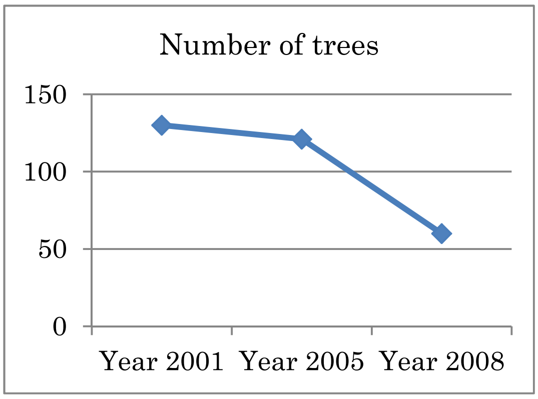


Figure 9.2.32. Decrease in the number of trees in the reserve observation Mt. Makiling forest ecological monitoring site from 2001 to 2008.

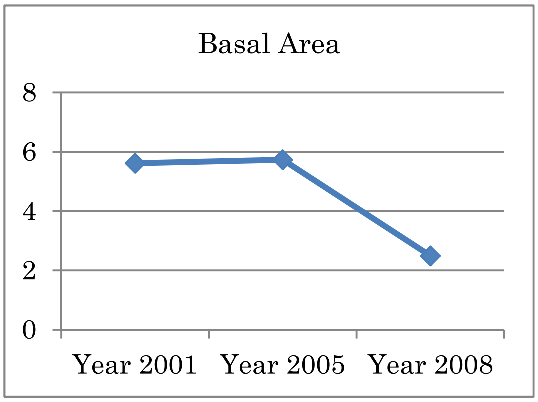


Figure 9.2.33. Basal area (m^2) of reserve trees in the Mt. Makiling forest ecological monitoring site from 2001 to 2008.

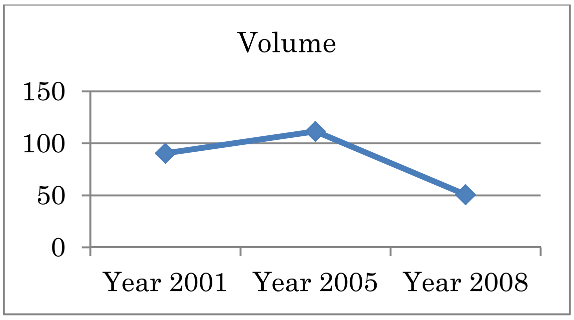


Figure 9.2.34. Volume (m^3) of observation trees in the Mt. Makiling forest reserve monitoring site from 2001 to 2008.

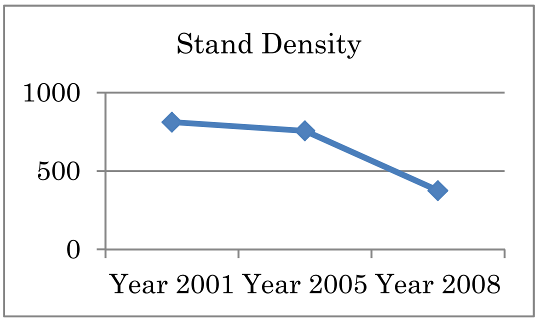


Figure 9.2.35. Stand density (trees/ha) in the Mt. Makiling forest reserve ecological monitoring site from 2001 to 2008.

The number of observation trees in the UP Quezon-Laguna Land Grant ecological monitoring site was likewise reduced due to the same typhoons earlier mentioned (Table 9.2.6 and Figures 9.2.36-9.2.39). However, the destruction wrought by the typhoons was not as severe as compared with the damages in the Mt. Makiling forest reserve. The number of trees destroyed did not result to a decrease in basal area as well as total volume of the standing trees in this monitoring site. In fact there were slight increases in both stand parameters through the years.

Table 9.2.6. Changes in the biometric characteristics of sample trees in the UP Quezon-Laguna Land Grant from 2001 to 2008.

Parameters	**Measurements**		
	2001	**2005**	**2008**
Number of trees sampled	92	69	52
Maximum height	12.45 m	13.49 m	13.49 m
Maximum diameter	28.0 cm	28.40 cm	28.40 cm
Mean height of dominant trees			
Pterocarpus indicus	6.35 m	7.09 m	8.34m
Ficus callosa	5.02 m	5.99 m	7.61m
Dipterocarps (*Hopea foxworthyii* and *Dipterocarpus philippinensis)*	5.40 m	5.70 m	6.91m
Macaranga bicolor	5.49 m	5.52 m	
Baccaurea philippinensis.	4.1 m	6.42 m	
Mean DBH of dominant trees			
Pterocarpus indicus	8.13 cm	10.4 cm	
Ficus callosa	5.92 cm	7.3 cm	
Dipterocarps (*Hopea foxworthyii* and *Dipterocarpus philippinensis)*	5.96 cm	6.66 cm	
Macaranga bicolor	7.04 cm	9.60 cm	
Baccaurea philippinensis.	4.38 cm	9.73 cm	
Basal area	0.50 m^2	0.55 m^2 for the trees sampled; 3.44 m^2 in a hectare	0.65m^2 for the trees sampled; 4.06 m^2 in a hectare
Total volume	4.01 m^3	4.77 m^3 for the trees sampled; 29.81 m^3 in a hectare	5.75 m^3 for the trees sampled; 35.94 m^3 in a hectare
Density	575 trees/ha	456 trees/ha	581 trees/ha

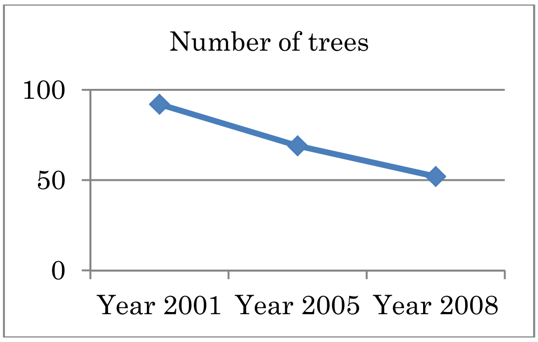


Figure 9.2.36. Decrease in the number of trees in the UP Quezon-Laguna Land Grant ecological monitoring site from 2001 to 2008.

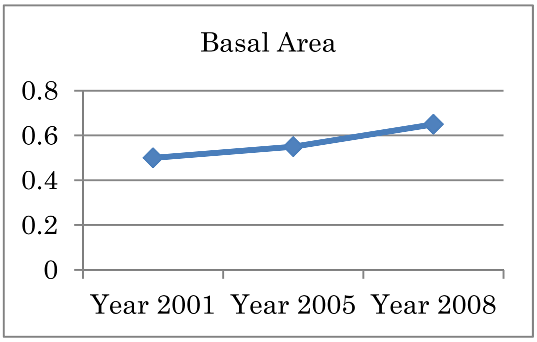


Figure 9.2.37. Basal area (m^2) of observation trees in the UP Quezon-Laguna Land Grant ecological monitoring site from 2001 to 2008.

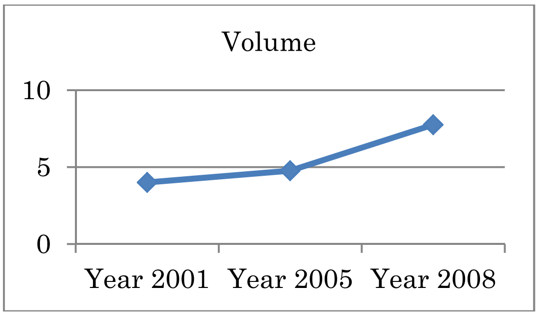


Figure 9.2.38. Volume (m^3) of observation trees in the UP Quezon-Laguna Land ecological monitoring site from 2001 2008.

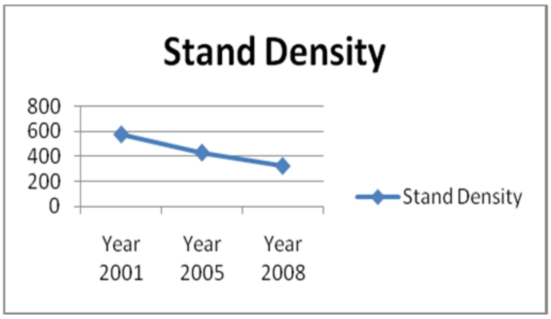


Figure 9.2.39. Stand density (trees/ha) in UP Quezon-Laguna Land Grant ecological monitoring site from to 2001 to 2008.

2) Understory vegetation

An increase in the number of species found in the understory of the monitoring plot in the Mt. Makiling forest reserve ecological monitoring site was observed. Sixteen (16) regenerations of new species were enumerated in 2008 (Table 9.2.7). From 2001-2005, there were 4 new species observed and two species lost in the regenerations. The increase can be attributed to the signficant opening up of the forest that resulted from the strong typhoons that passed through the area in 2004 and 2006. Such apparently gave opportunity to pioneer tree species to start colonizing the gap created in the forest. However, three species whose regenerations were observed in 2005 could no longer be seen in the monitoring plot in 2008. These were those of *Diospyrus diepenhorstii, Canarium luzonicum* (Blume) A. Gray and S*wietenia macrophylla* King.

In the UP Quezon-Laguna Land Grant ecological monitoring station, one species, *Neonauclea puberola*, was no longer accounted for among the regenerations observed in 2008 (Table 9.2.8). In 2005, there were five new species of regenerations observed namely, *Antidesma angustifoium, Elaeocarpus candollei, Dimocarpus longan* ssp. *malesianus* var. *echinatus, Ardisia clementis*, and *Wikstroemia lancelolata*. Regenerations of the species *Cratoxylum formosum* and *Anaxagorea luzoniensis* which were observed in 2001 were no longer found in 2005.

Table 9.2.7. Understory vegetation in the Mt. Makiling forest reserve sampled in 2008.

Number of species	43
Name of dominant species	*Celtis luzonica* Warb.
Newcomer species	*Macaranga bicolor* *Palaquium montanum* *Turpinia ovalifolia* Elmer *Aglaia edulis* (Roxb.) Wall. *Chisocheton pentandrus* (Blanco) Merr. *spp. pentandrus* *Evodia confuse* *Melanolepis multiglandulosa* *Dysoxylum arborescens* (Blume) Miq *Artocarpus blancoi* *Gomphandra luzoniensis* *Pouteria macrantha* *Securinega flexuosa* *Leea guineensis* *Ahernia glandulosa* *Artocarpus rubrovenius* *Claoxylon albicans*
Lost Species	*Diospyrus diepenhorstii* *Canarium luzonicum* (Blume) A. Gray S*wietenia macrophylla* King

Table 9.2.8. Understory vegetation in UP Quezon-Laguna Land Grant enumerated in 2008.

Species name	**Abundance**
1. *Diospyrus phylosanthera var. philosanthera*	1
2. *Neonauclea puberola*	Lost
3. *Gnetum gnemon* var. *gnemon*	+
4. *Calophyllum blancoi*	+
5. *Nauclea undulate*	+
6. *Syzygium subcaudatum*	+
7. *Cryptocaria glauca*	+
8. *Xanthophyllum flavescens*	+
9. *Dimocarpus longan malesianus* var. *echinatus*	+
10. *Elaeocarpus calomala*	+
11. *Microcos stylocarpa*	+
12. *Ardisia clementis*	+
13. *Elaeocarpus candollei*	+
14. *Lithocarpus budii*	+
15. *Antidesma angustifolium*	+
16. *Symplocos acuminatissima*	+
17. *Glochidion album*	+
18. *Wikstroemia lanceolata*	+

3) Tree decline

The survey of tree decline in both the Mt. Makiling forest reserve and UP Quezon-Laguna Land Grant ecological monitoring sites did not show any indication of problems due to acid deposition. While there were very few trees that showed decline symptoms, such were largely noted to be due to causal factors other than acid deposition.

4) Research work on acid deposition impacts in the Philippines

A study was done to establish the sensitivity of three species found in the Makiling forest reserve, in the Province of Laguna, Philippines, to simulated acid rain by Carandang *et al*. (2010). The species included (*Madhuca betis* (Blanco) MacBride), *Artocarpus blancoi* (Elmer) Merr.), and (*Toona calantas* Merr. & Rolfe). Simulated acid rain with the following pH levels were used in watering the seeds and seedlings: 2.5, 3.5, 4.5, 5.5, and distilled water serving as the control with a pH of 7.0.

The sensitivities were established by examining the response of the said species to the aforementioned pH levels of simulated rain in terms of seed germination and early growth of their seedlings. Germination value and root length were not significantly affected by acidity treatment. However, height and diameter growth, shoot and root biomass and shoot root ratio were found significantly affected by rainfall acidity. These parameters were then considered as most useful indicators of sensitivity to acid treatment in the study area. Root length and sturdiness quotient were both affected by rainfall pH and soil type and were regarded as less useful parameters in the study of the sensitivity of plants to acid treatment.

Of the three species studied, *T. calantas* was observed to be the most sensitive to changes in the acidity treatment levels. With *M. betis*, the differences in the seedling responses to the various pH levels of simulated acid rain were found to be insignificant. *A. blancoi* was intermediate between *T. calantas* and *M. betis*.

9.3 Review of National Measures Against Acid Deposition

9.3.1. Air quality

The Clean Air Act or Republic Act 8749 is the guiding framework in the effective implementation of air quality management, interventions and programs.

Under the Clean Air Act, publication of Air Quality Status Report is required to report the extent of air pollution, per type of pollutant and per type of source. In includes an analysis of the current situation and identifies trends in air pollution. It identifies critical areas, activities or projects, which need closer monitoring or regulation.

Measures for mitigating air pollution include strategies for:

a) Enforcement on motor vehicles;
b) Enforcement on stationary/industrial sources;
c) Enforcement on open burning;
d) Shift to cleaner fuels
e) Public awareness

9.3.1.1. Mobile sources

Emission testing is required to all in-use vehicles prior to annual registration. The in-use emission standards for gasoline-fed are hydrocarbons and carbon monoxide. For diesel-fed, the standard is light absorption coefficient, k)

Private Emission Testing Centers are authorized and accredited by the government to conduct compliance emission testing prior to registration. The Land Transportation Office conducts emission testing for public utility vehicles in a Motor Vehicle Inspection Center.

Certificate of Conformity is issued by the DENR, through the EMB, to a motor vehicle manufacturer, assembler or importer certifying that a new motor vehicle type complies with the emission limits adopted under EURO 2 regulations.

Issuance of Certificate of Compliance to Emission Standards (CCES): For rebuilt or second hand-CBU imported into the country or pre-registered vehicles retrofitted with second hand engines shall not be allowed registration or renewal without a valid Certificate of Compliance to Emission Standard (CCES) issued by the DOTC-LTO. (No data from LTO)

9.3.1.2. Stationary sources

Industries or firms that emit air pollutants are required to submit to EMB a self-monitoring reports (SMR) that demonstrates their compliance with environmental regulations. The SMR which is submitted on a quarterly basis, contains monitoring of effluents/discharges, emissions and solid waste disposal.

Major industrial plants such as power plants, cement, refineries among others are required to install continuous emission monitoring system. The regulated pollutants are sulphur oxides, oxides of nitrogen, particulate matter, carbon monoxide, metals etc.

Accreditation for Third-Party stationary source emission testing firms: In order to augment the limited resources of EMB in stack emissions monitoring and to strengthen private participation, DENR has issued **DAO 03-2006** in 2006 and was recently revised by **DAO 2007-25** in July 2007, for EMB-DENR to accredit third party emission /stack testers who shall conduct emissions measurement in their behalf. To date, there are 17 accredited stack testing firms.

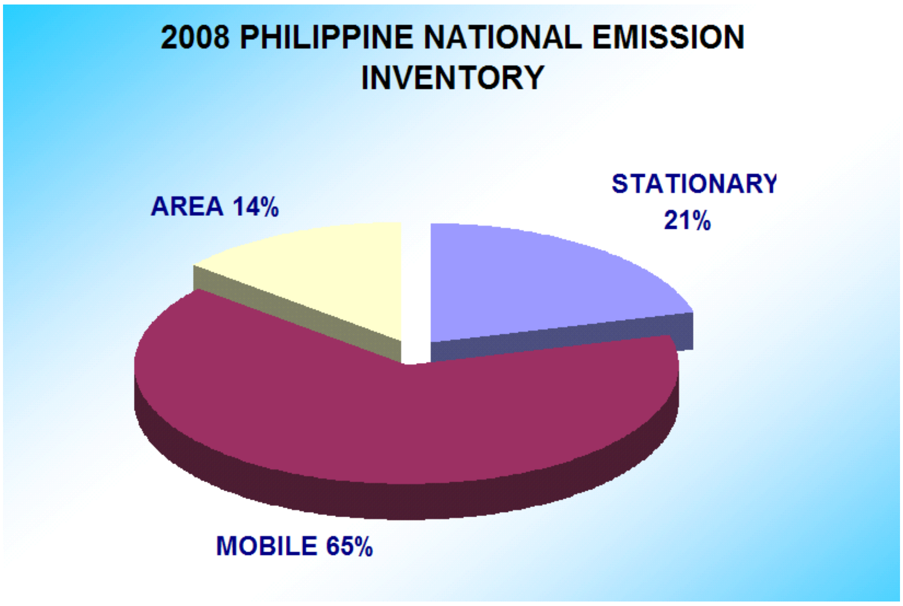
9.3.1.3. Ambient air quality monitoring

The EMB Regional Offices are regularly monitoring Total Suspended Particulate (TSP) within their area of jurisdiction using manual samplers. The EMB has a total of thirty six (36) manually operated ambient air monitoring stations located nationwide, of which 10 stations are located in Metro Manila. Most of these stations are roadside monitoring which could only measure Total Suspended Particulates (TSP).

Aside from the manual stations, EMB has a total of thirteen (13) state-of-the-art technology monitoring stations (continuous and automatic) which measures all criteria pollutants (SO_2, NOx, O_3, CO, PM) including meteorological parameters (i.e. wind speed, wind direction, temperature, etc.). Ten of these stations are located within the Metro Manila Airshed (MMAS) (NCR, Regions 3 and 4A) while the other 3 are located in the metro cities outside Metro Manila (Cebu, Cagayan de Oro and Baguio).

9.3.2. Emission inventory:

It was estimated that 21% of the pollutants came from stationary sources, 65% from mobile sources, and the remaining 14% from area sources.



9.3.2.1. Cleaner fuels

1) Fuel quality specifications

Sulphur content of automotive diesel is 0.05% while phase out of leaded gasoline had been effected since early 2000. The TCPPA has set fuel quality specifications for conventional fuels (diesel and unleaded gasoline) and bio-fuels (Fatty Acid Methyl Ester (FAME) and Ethanol, E100).

2) Use of alternative fuels

The overall objective of the program is to promote the use of CNG as indigenous clean alternative fuel to diesel and improve air quality. 22 CNG commercial buses are already plying on regular basis.

Enactment of RA 9367 also known as the “Biofuels Act of 2006”. This board sets the National Program on the Use of Biofuels. At present, automotive diesel is available at 1% blend biodiesel in all gas stations and shall be further increased to 5% two years after (2009). Likewise, E_{10} (10% gasoline blend) is available.

9.3.3. Water quality

Republic Act 9275 or Philippine Clean Water Act of 2004 provides for a comprehensive water quality management program. It also provides the framework for sustainable development to achieve a policy of economic growth in a manner consistent with the protection, preservation and revival of the quality of fresh, brackish and marine water.

9.3.4. Public awareness

With the help of different agencies and sectors, raised public awareness about air quality and air pollution thru different campaigns such as:

Development, production and dissemination of information, education and promotional materials for cleaner air, cleaner water etc;

Conduct of fora on the following: (i) Anti-Smoke Belching Campaign Action Plan and Communication Strategies for LGU Enforcement Teams; (ii) Clean Air for Public Transport Companies; and (iii) EDSA Bus Operators' Forum on Environment-friendly; and Cost-Effective Vehicle Handling and Maintenance;

9.4. Reference:

EANET. 2000. Technical Documents for Soil and Vegetation Monitoring in East Asia. Adopted at the Second Interim Scientific Advisory Group Meeting of the Acid Deposition Monitoring Network in East Asia (EANET). Niigata, Japan.

Haby, V.A., Russelle, M.P. and Skogley, E.O. 1990. Testing soils for potassium, calcium and magnesium. pp. 181-227. In: R.L. Westerman (ed.). Soil testing and plant analysis. 3rd Ed. Soil Science Society of America, Madison,WI.

Laboratory Manual in Soil Science 1. 2005. Revised by R.B. Badayos, R.L. Castillo, W.C. Cosico and P.B. Sanchez. Agricultural Systems Cluster, College of Agriculture, UPLB, College, Laguna, Philippines.

Vida, Q. Carandang, Enrique L. Tolentino, Jr., Rex Victor O. Cruz, Arturo SA Castillo, Roberto G. Visco, and Wilfredo M. Carandang. 2011. Effect of simulated acid rain on the germination and early seedling growth of Betis (*Madhuca betis* (Blanco) MacBride), Antipolo (*Artocarpus blancoi* (Elmer) Merr.) and Kalantas (*Toona calantas* Merr. & Rolfe) in two soil types in Laguna, Philippines. Asia Life Sciences 20(1):243-262.

Second Periodic Report on the State of Acid Deposition in Korea

National Institute of Environmental Research

10.1 Introduction

Korean government has taken comprehensive measures to reduce air pollutant emissions for the last three decades or so as it recognized the seriousness of air pollution caused by industrialization since the 1960's. That is why the country initiated a national air monitoring program in the middle of the 1970's. Then, photochemical assessment stations and hazardous air monitoring stations were added to the network in early 2000. As of 2004, there are 213 urban sites, 11 rural sites, 5 remote sites, 22 traffic sites under the national monitoring network and 31 monitoring sites for acid deposition shows that Korea is deeply aware of its importance.

Adverse effects of long range transport of air pollutants have a long history in Korea. Since its first record over six hundred years ago, the occurrence of Asian dusts and its harmful effects have been constantly reported. More importantly, North East Asia, one of the most populated regions in the world, has been experiencing extensive industrialization for the last half century and, consequently, a long range transport of air pollutants became a great public concern along with natural air pollutants and Asian dusts. As a result, rural sites and remote sites were established to evaluate the effect of long range transport on the air quality with the implementation of the acid deposition monitoring network.

Recognizing that international collaboration is required to effectively cope with trans-boundary air pollutants, Korea has actively promoted to and, if allowed, participated in regional endeavors such as LTP (Long range Transport Project), NEASPEC (North East Asian Sub-regional Program of Environmental Cooperation), EANET (Acid Monitoring Network in East Asia), NOWAP (Northwest Pacific Action Plan), and ACE-ASIA (Asian Pacific Regional Aerosol Characterization Experiment). Each of these has its own objectives and methods in addressing long range transport of air pollutants and other regional air quality problems.

EANET has become a leading acid deposition monitoring network in East Asia region since it was launched in 2001. As a founding member of EANET, Korea has been actively involved in various efforts of EANET; preparation of technical manuals; participation of QA/QC program; and regular monitoring of wet deposition, dry deposition, soil and vegetation. Monitoring data has been submitted to Network Center of EANET helping and used as the scientific information for the evaluation of both acid depositions and its impacts on ecosystems in East Asia. This year's national report covers characteristics of monitoring stations for EANET as well as preliminary analysis of monitoring data.

10.2 Monitoring Network in Korea

Korea selected Ganghwa, Imsil, and Jeju as the acid deposition monitoring sites for EANET. Ganghwa and Jeju were classified into “rural site”, and Imsil, “remote site” according to the Technical Manual of EANET as summarized in Table 10.2.1. The locations and pictures of the stations are shown in Figure 10.2.1 and Figure 10.2.2, respectively. Ganghwa and Jeju sites are located near the coast to minimize anthropogenic emissions. Meanwhile, Imsil site is located near the mountain, which is subjected to soil and vegetation monitoring.

With the exception for those measured by automatic instruments, as noted in Table 10.2.2, NO_x, SO_2, O_3 and PM_{10} mass were monitored using air monitoring devices, and $PM_{2.5}$ compositions and the gaseous species, with filter pack. Together with chemical species, meteorological parameters such as wind speed, wind direction, air temperature, relative humidity, and solar radiation were observed at automatic weather stations in each site or nearby meteorological observatories.

Table 10.2.1. The characteristics and location of monitoring sites in Korea

Name of sites	Site classification	Latitude	Longitude	Height above the sea level
Ganghwa	Rural	37° 42' N	126° 17' N	102 m
Imsil	Remote	33° 18' N	126° 10' N	50 m
Jeju	Rural	35° 36' N	126° 11' N	-

Table 10.2.2. The selected monitoring parameters and methods in Korea

Name of sites	Wet dep.	Dry dep.			
		Automatic			Filter pack
		SO_2, NOx	O_3	PM	
Ganghwa	O	O	O	O	O
Imsil	O	O	O	O	O
Jeju	O	O	O	O	O

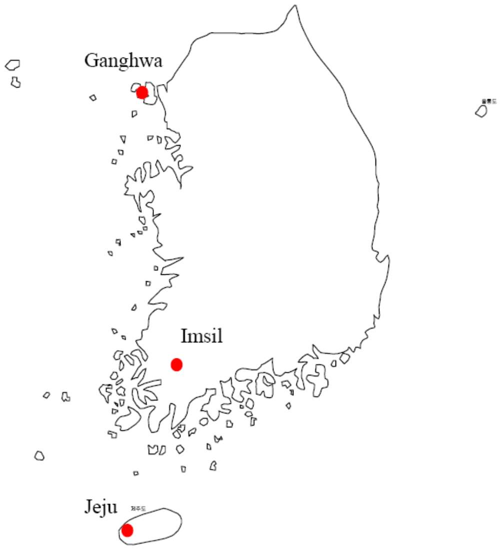


Figure 10.2.1. The geographical location of EANET sites in Korea.

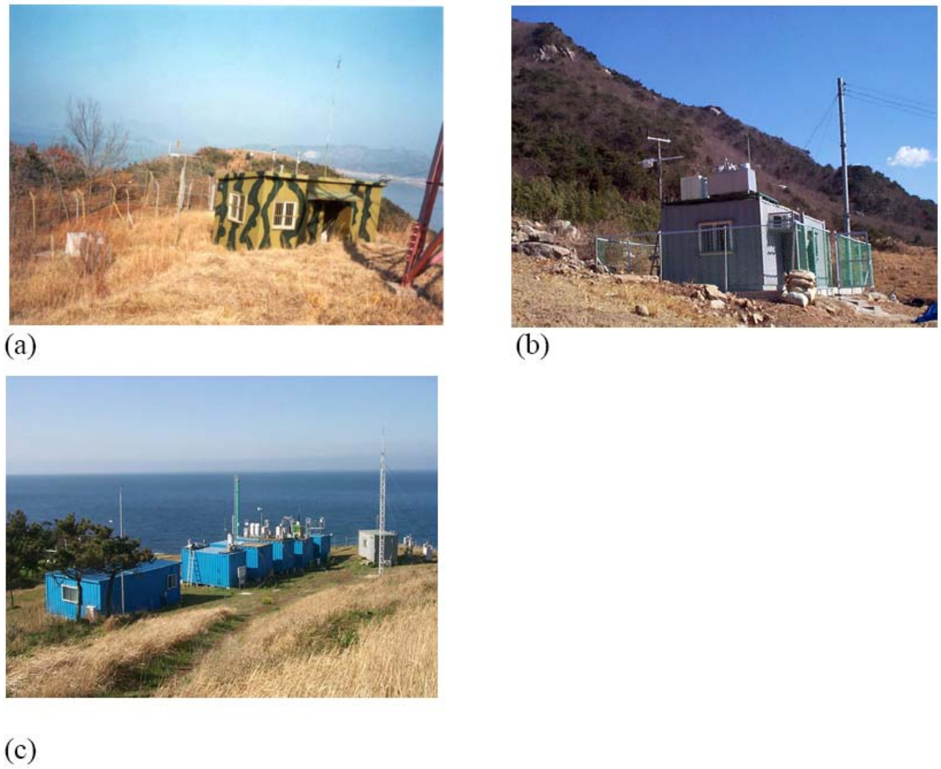


Figure 10.2.2. Pictures of monitoring sites in Korea ((a) Ganghwa, (b) Imsil, (c) Jeju).

10.3 Wet Deposition Monitoring

10.3.1 Method

Acid deposition monitoring in Korea has been carried out according to the common methodologies specified in the “Technical Documents for Wet deposition Monitoring in East Asia” (hereafter denoted as Manual) in order to obtain the equivalent quality of monitoring data. Figure 10.3.1 shows wet-only samplers used for monitoring work. Precipitation samples were collected on a daily basis at 3 sites as listed in Table 10.3.1 Collected samples without biocides were shipped to laboratories and stored in a cooling box to preserve the sample composition.

Rainwater major constituent were analyzed in line with the Manual as shown in Table 10.3.2. Ion Chromatography is a major analytical method for chemical analysis of anions and Atomic Absorption Spectrometry for Na^-, K^+, Ca^{2+}, and Mg^{2+}, and Spectro-photometric method for NH_4^+.


AQUA (RM8300, Japan)


APM KOREA (ARS101)

Figure 10.3.1 Wet deposition monitoring samplers.

Table 10.3.1 Sampling method for wet deposition monitoring in Korea.

Name of sites	Site classification	Sampling frequency	Starting month
Ganghwa	Rural	Daily	March '99
Imsil	Remote	Daily	April '99
Jeju	Rural	Daily	January '99

Table 10.3.2 Analytical method for wet deposition monitoring in Korea.

Name of sites	Site classification	Anion analysis	Cation analysis	
			NH_4^+	Other cations
Ganghwa	Rural	IC	SP	AAS
Imsil	Remote	IC	SP	AAS
Jeju	Rural	IC	SP	AAS

(Note) AAS: Atomic Absorption Spectrometry, IC: Ion Chromatography, SP: Spectrophotometry

The reliability of data was assessed based on the consistency between the measured electrical conductivity of precipitation and calculated one. If the balance of between cation and anion is not good, it means that there are errors in sampling or conducting chemical analysis or that there is one or more missed compositions in the precipitation. As presented in Figure 10.3.2., both regression and correlation analysis showed that the slope of the regression line is 0.9550, the coefficient of determination is 0.9699, and the balance between cation and anion was relatively good.

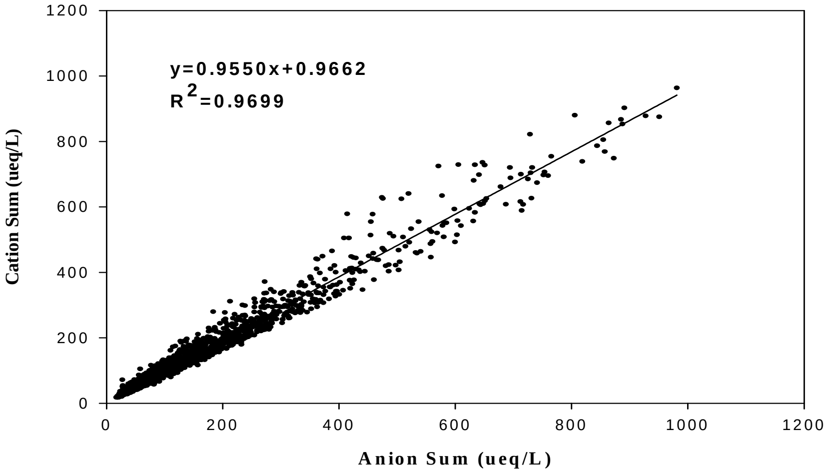


Figure 10.3.2. Relationship between total cation and anion in precipitation.

The EC of weak solution can be calculated using the equivalent conductance, and the result should be consistent with the EC value of samples, which can be calculated using the following equation.

$$EC_{calc}\,(\mu S.cm^{-1}) =$$

$$\{349.7\times10^{(6-pH)} + 80.0\times2[SO_4^{2-}] + 71.5[NO_3^-] + 76.3[Cl^-] + 73.5[NH_4^+] + 50.1[Na^+] + 73.5[K^+] + 59.8\times2[Ca^{2+}] + 53.3\times2[Mg^{2+}]\} / 1000$$

According to regression and correlation analyses of calculated conductivity and measured conductivity, as presented in Figure 10.3.3., the slope of the regression line is 0.9294 and the coefficient of determination is 0.9284.

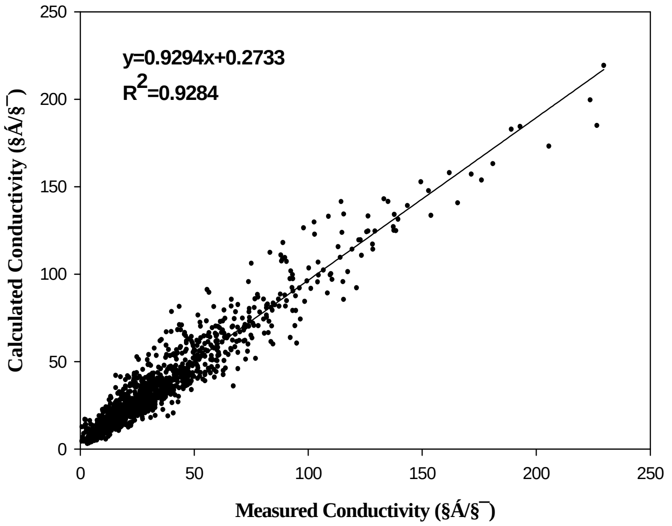
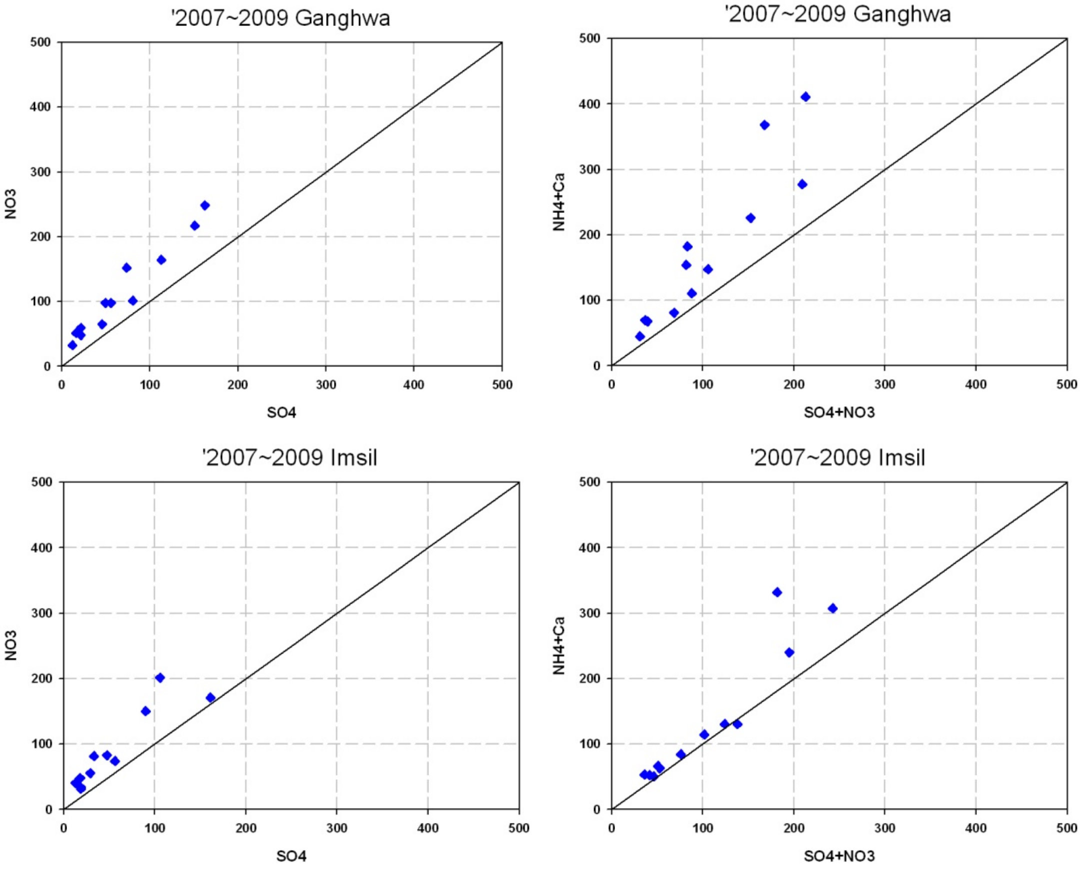


Figure 10.3.3. Relationship between the EC_{meas} and $EC_{cal.}$

Figure 10.3.4 presents the sum of major anion and cation ratio and SO_4^{2-} and NO_3^- ratio (2006-2009). NH_4^+ and Ca^{2+} were selected as major cations, and SO_4^{2-} and NO_3^- were selected as major anions. The sum of SO_4^{2-} and NO_3^- concentrations appeared to be slightly larger than the sum of NH_3^+ and Ca^{2+}. The ratios of major anions and cations were constantly checked as a key parameter for the ion balance and for rain water characteristics of sulfur and nitrogen containing species and checked together with major anion and cation ratios.



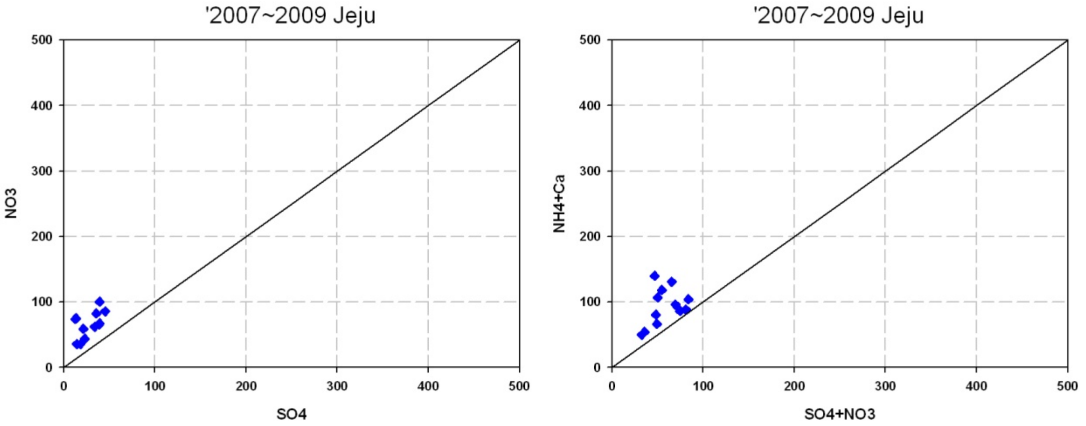


Figure 10.3.4. Ion balance check in Ganghwa, Imsil and Jeju (Unit: µeq.l^{-1}).

10.3.2 Results of wet deposition monitoring

pH is regarded as a major parameter characterizing acid rain mainly because it determines the acidity of rain waters. The annual mean pH was 4.8 in 2007, 4.9 in 2008 and 4.8 in 2009 while the average annual precipitation was 1,318 mm, 1,052 mm, and 1,267mm, respectively. This indicates pH levels may decrease despite heavy precipitation. Figure 10.3.5 shows the frequency and volume of precipitation in the three EANET sites in Korea from 2007 to 2009.

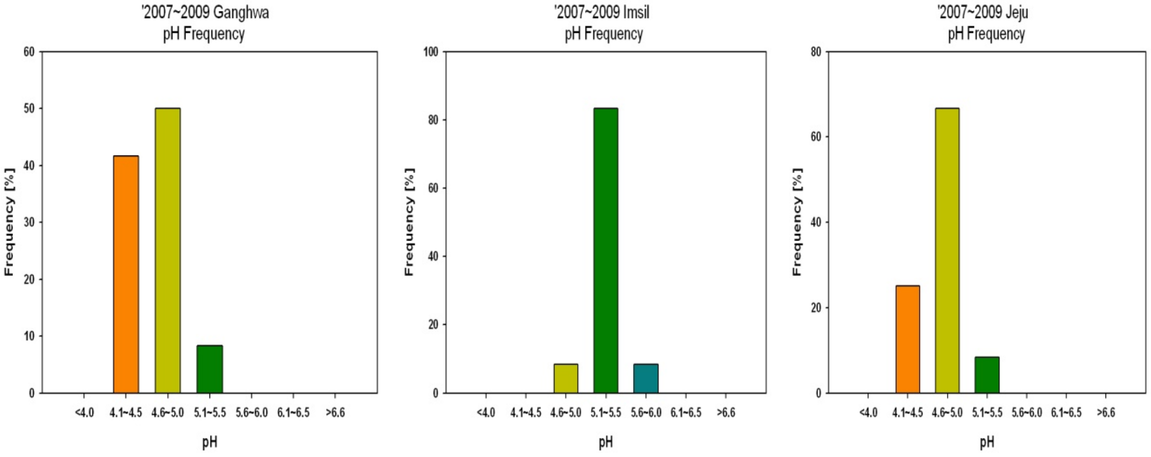


Figure 10.3.5. pH frequency and the amount in each site (2007- 2009).

Seasonal variations of precipitation, EC, and pH are shown in Figures 10.3.6 and 10.3.7. Precipitation concentrates on summer, rainy season in Korea. As we can see in the three-year results, the summer is not always the season with highest pH and lowest EC. The pHs in Ganghwa and Imsil had the maximum value in spring instead of summer probably because of calcium carbonate contained in Asia dusts, which mainly occur in spring in North East Asia.

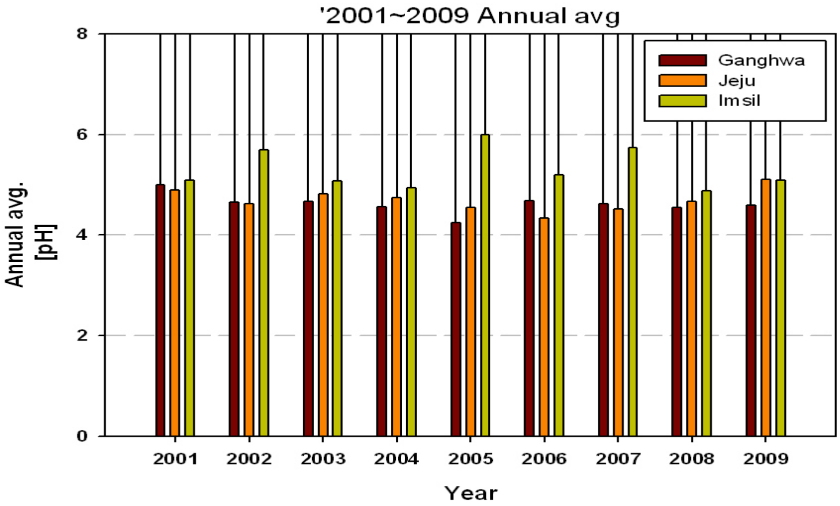


Figure 10.3.6. The average annual pH in each site (2001-2009).

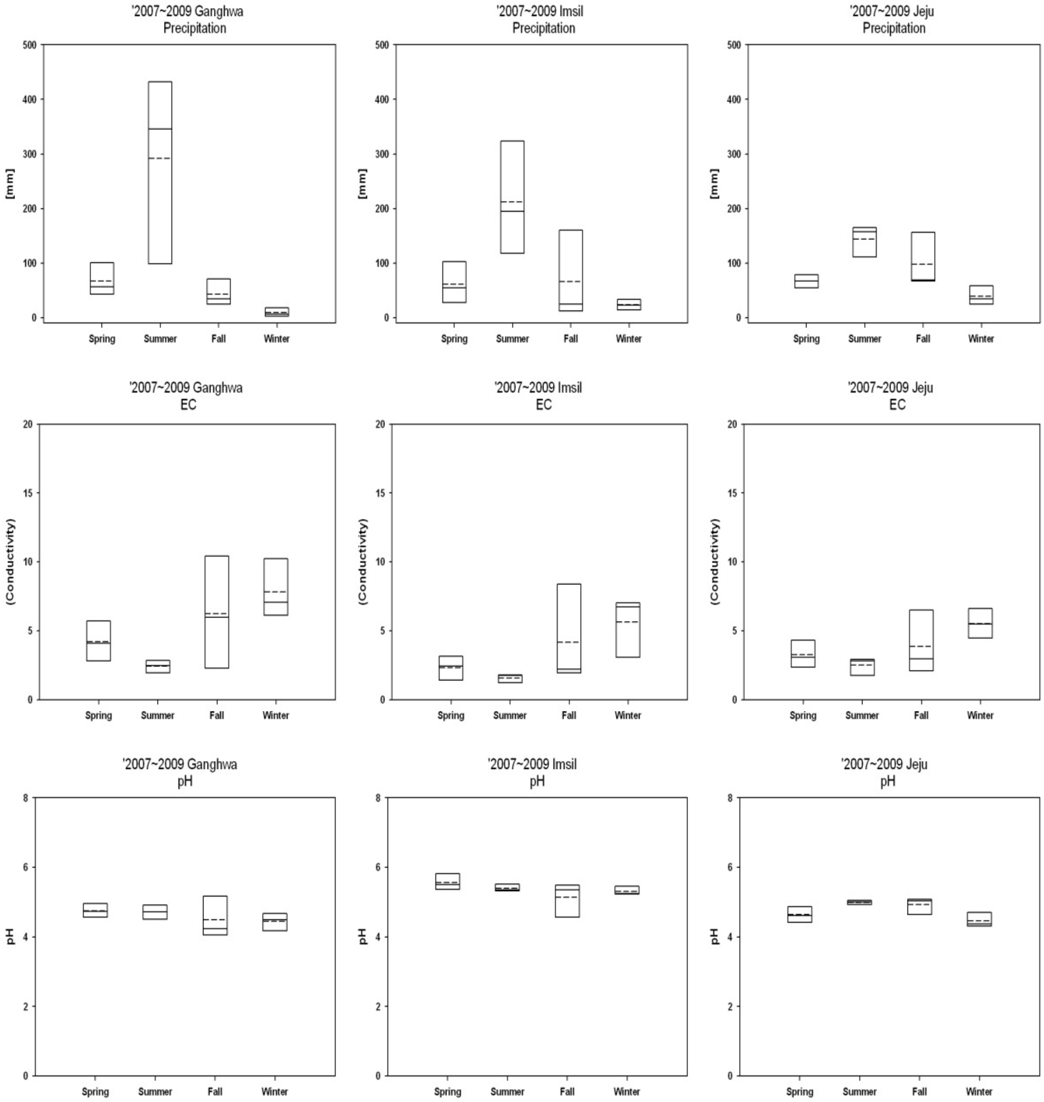


Figure 10.3.7. Seasonal variations of precipitation, electronic conductivity and pH.

Figures 10.3.8, 10.3.9, and 10.3.10 show seasonal variations of major ionic species concentrations and the amount of wet depositions at each site. The heavy precipitation during summer as discussed above diluted ionic species concentrations for rain waters, leading to the lowest concentration in summer. Despite the lowest ionic concentrations, the volume of wet depositions was still the largest in summer thanks to the heavy precipitation. The SO_4^{2-} concentration was high in fall at Ganghwa and Jeju while it was high in winter in Imsil because of increasing demand for heating fuel. The same held for the concentration of NO_3^-.

Ganghwa

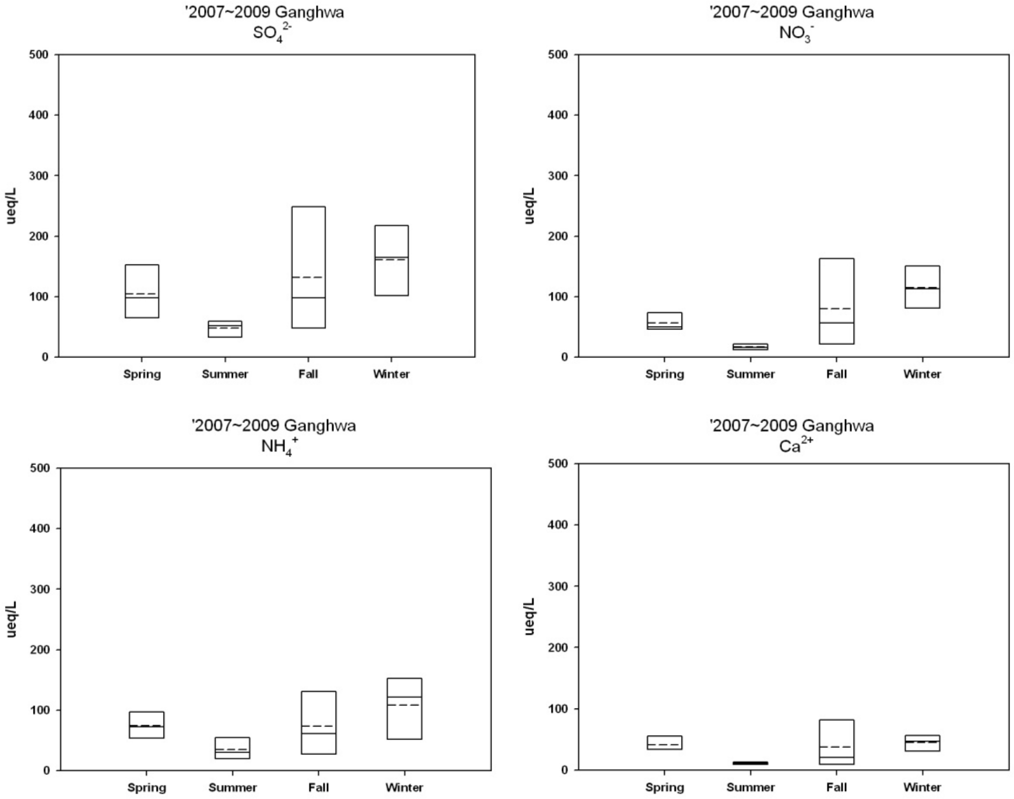


Figure 10.3.8. Seasonal variation of wet deposition (equivalent concentration), Ganghwa.

Imsil

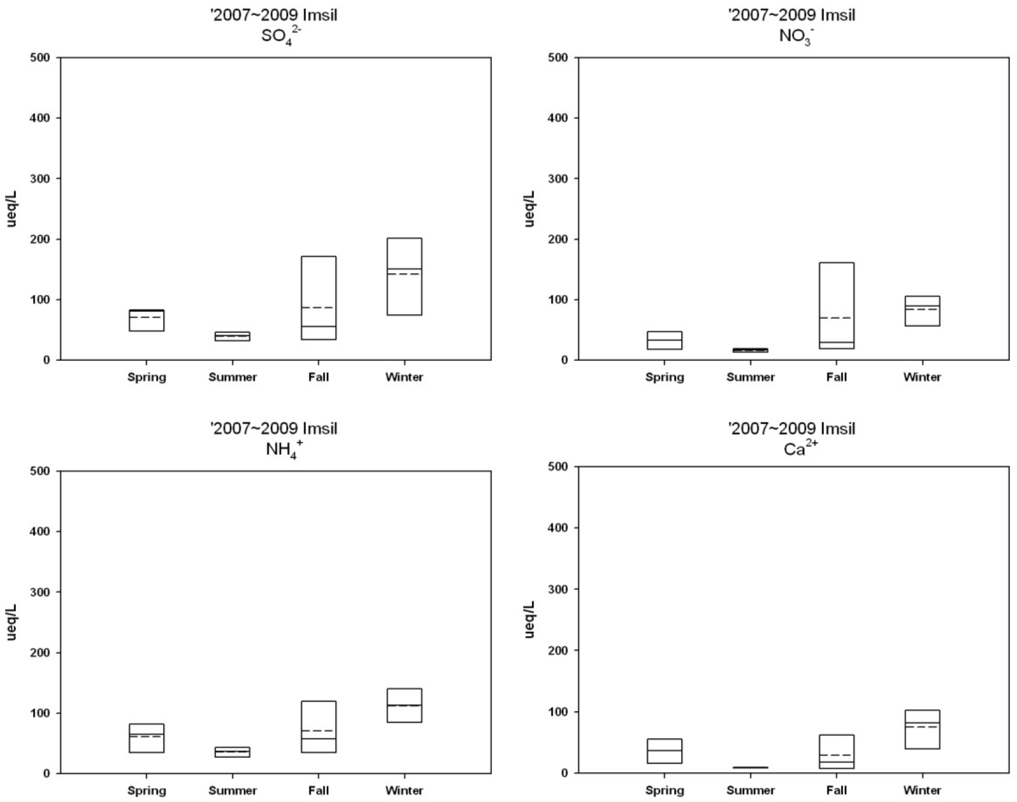


Figure 10.3.9. Seasonal variation of wet deposition (equivalent concentration), Imsil.

Jeju

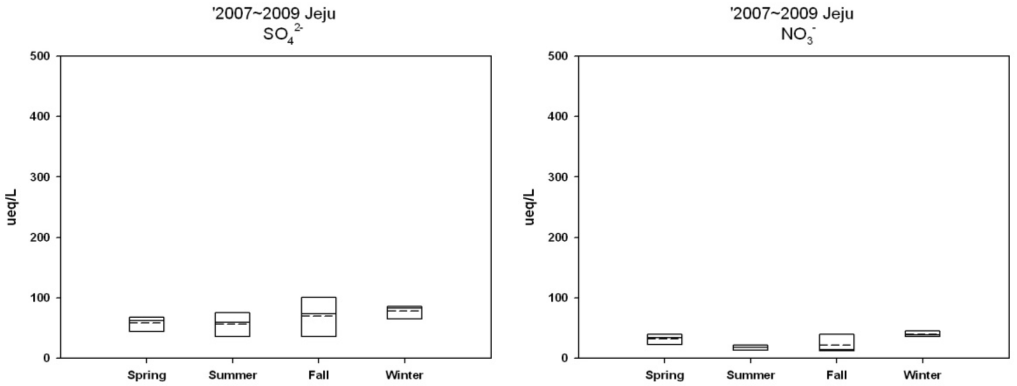


Figure 10.3.10. Seasonal variation of wet deposition (equivalent concentration), Jeju.

10.4 Dry Deposition Monitoring

10.4.1 Method

SO_2, NO_2, O_3 - based-on the priority of the chemical species - and PM10 mass were monitored by automatic instruments as directed by "QA/QC Program for the Air Concentration Monitoring in East Asia (2001)." Three-stage $PM_{2.5}$ filter pack sampler, shown in Figure 10.4.1, was used to monitor gaseous acids and bases, HNO_3, HCl, NH_3, and particulate components (SO_4^{2-}, NO_3^-, Cl^-,

Na^+, K^+, NH_4^+, Ca^{2+} and Mg^{2+}).

The equivalent conductance, as shown in Figure 10.4.2, was calculated using the same method for wet deposition monitoring results. The result shows that the balance between cation and anion is relatively good with 0.9475 of the coefficient of determination. In this case, based-on the review of the ion balance, samples with reliability problem were reanalyzed or excluded from data analysis.

URG (3 state $PM_{2.5}$ Sequential Sampler, USA)

Figure 10.4.1. Instruments used for dry deposition monitoring.

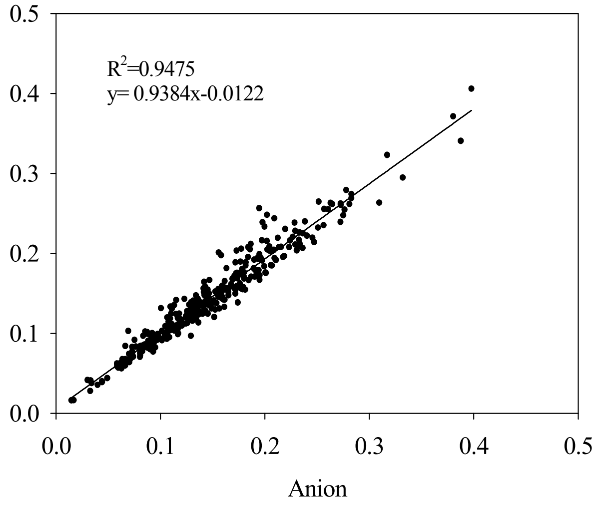


Figure 10.4.2. Relationship between total anion and cation.

10.4.2 Results of dry deposition monitoring

Figures 10.4.3, 10.4.4, and 10.4.5 present the average monthly concentrations of SO_2, NO_2, O_3, and PM_{10} mass from 2007 to 2009. The average concentration of PM_{10} ranges from 32 $\mu g.m^{-3}$ to 65 $\mu g.m^{-3}$. PM_{10} concentrations were observed to be high mainly in March or May, a period of Asian dust. The average monthly concentration of O_3 measured to be high in April and May. SO_2 and NO_2 levels were less than 4 ppbv and 10 ppbv in Jeju, one of the most remote sites, with one exception of February.

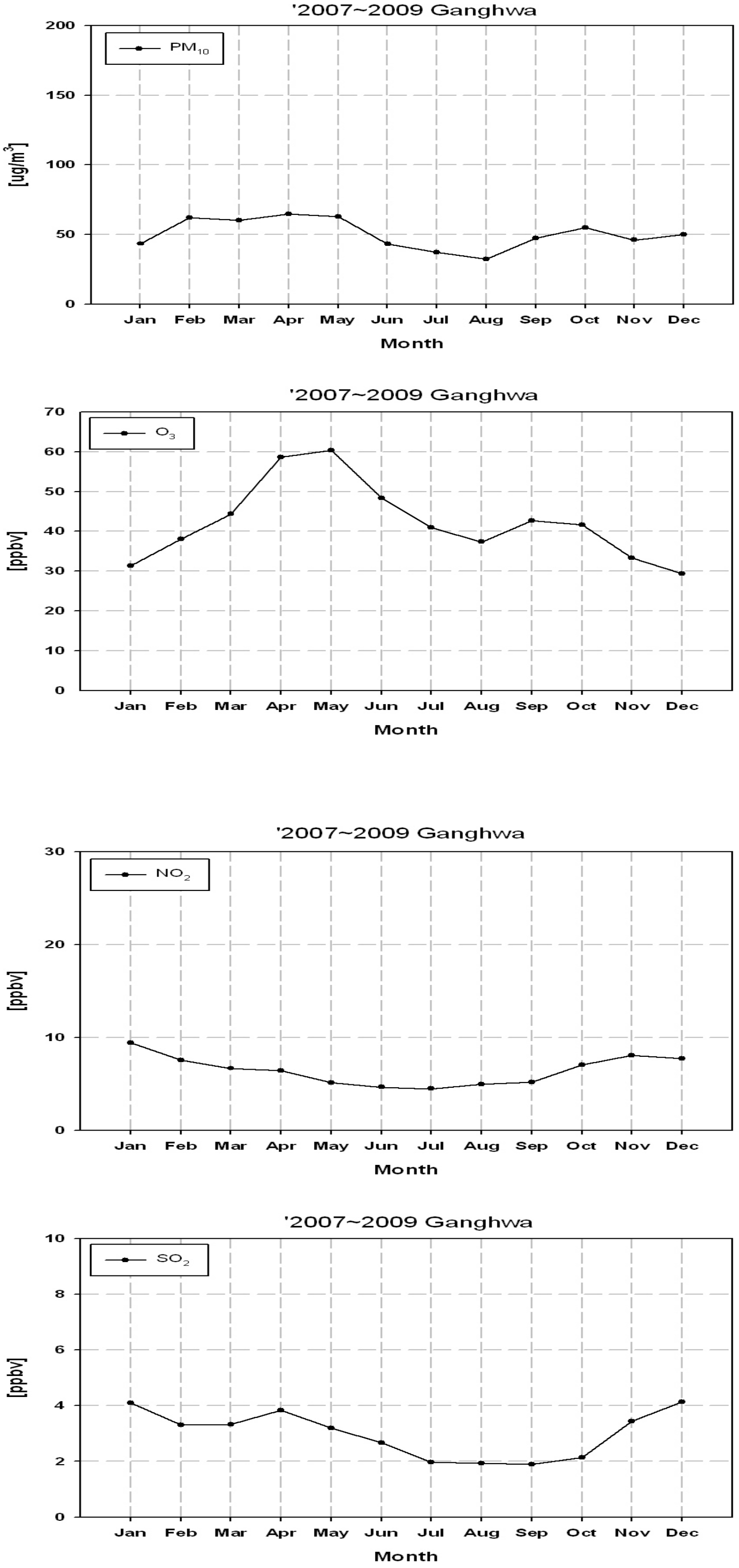


Figure 10.4.3. Average monthly concentrations of SO_2, NO_2, O_3 and PM_{10} at Ganghwa.

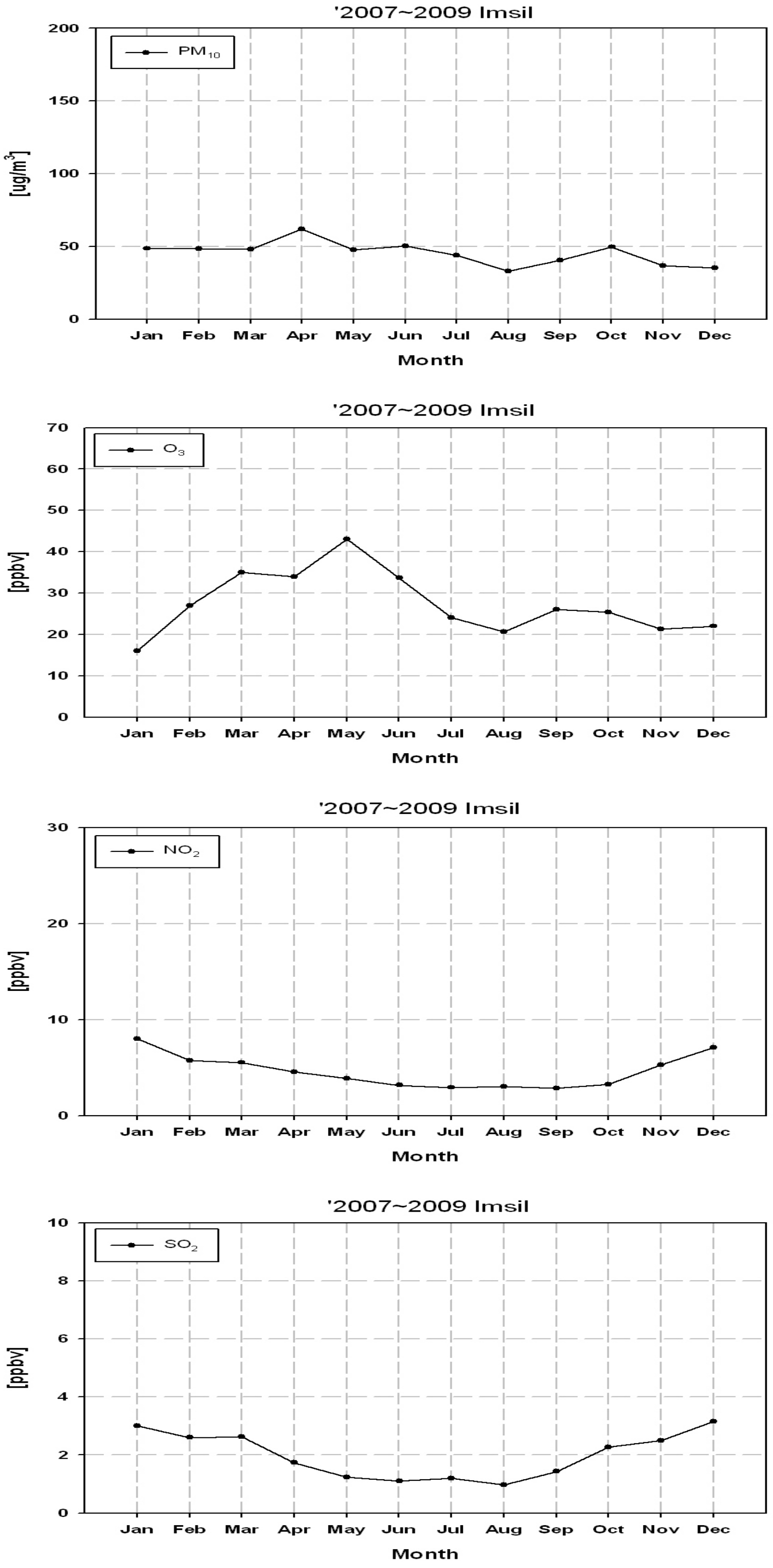


Figure 10.4.4. Average monthly concentrations of SO_2, NO_2, O_3 and PM_{10} at Imsil.

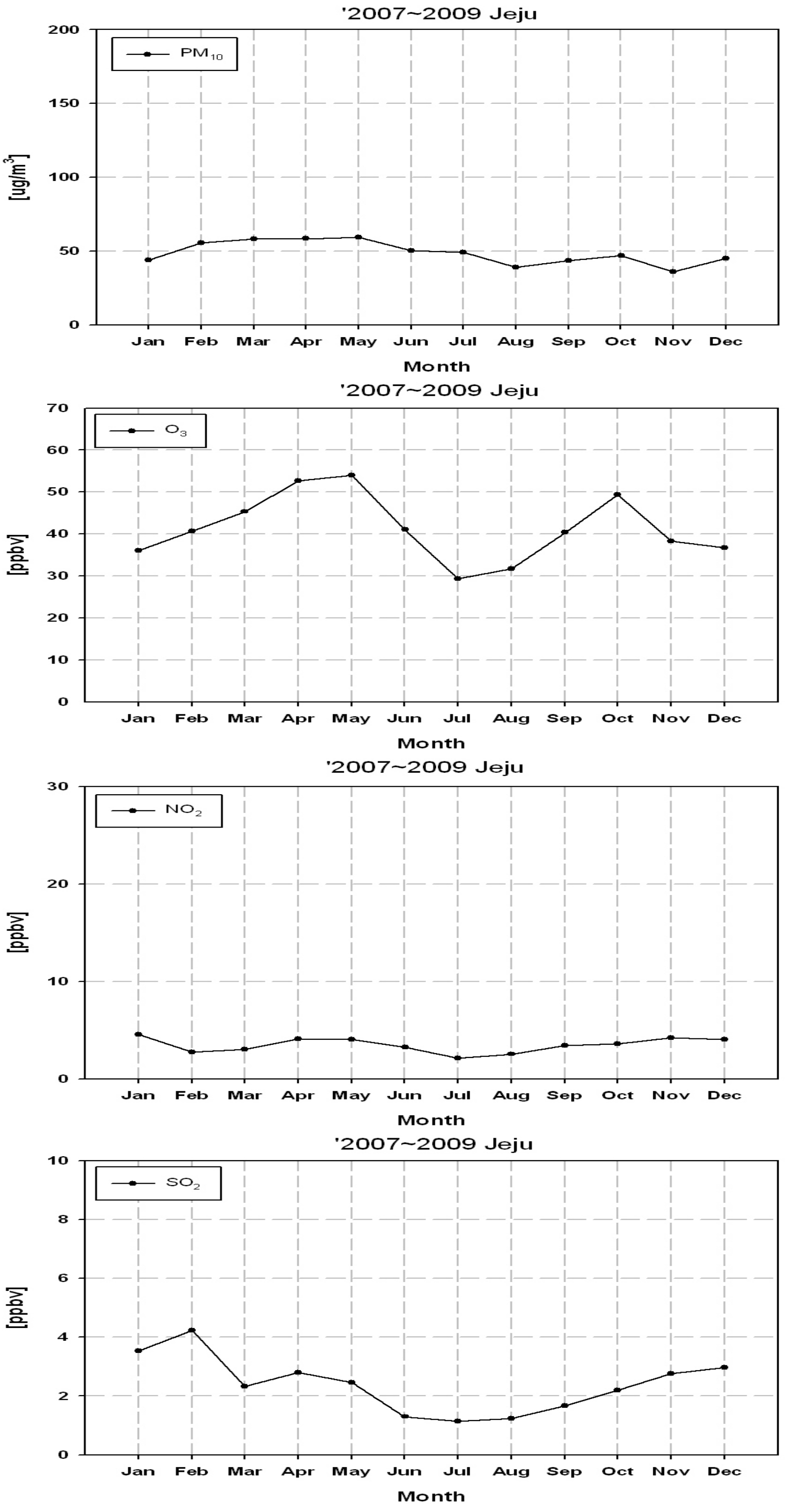


Figure 10.4.5. Average monthly concentrations of SO_2, NO_2, O_3 and PM_{10} at Jeju.

Chemical composition analysis of $PM_{2.5}$ found that SO_4^{2-} and NH_4^+ were major chemical constituents for Imsil and Jeju sites. The concentration level of NO_3^- was comparable to that of SO_4^{2-} and NH_3^+ in Ganghwa site. As shown in Figure 10.4.6, the seasonal average concentrations of SO_4^{2-}, NH_3^+ and NO_3^- varied among the three sites and therefore this suggests there is a need for further studies to on their causes.

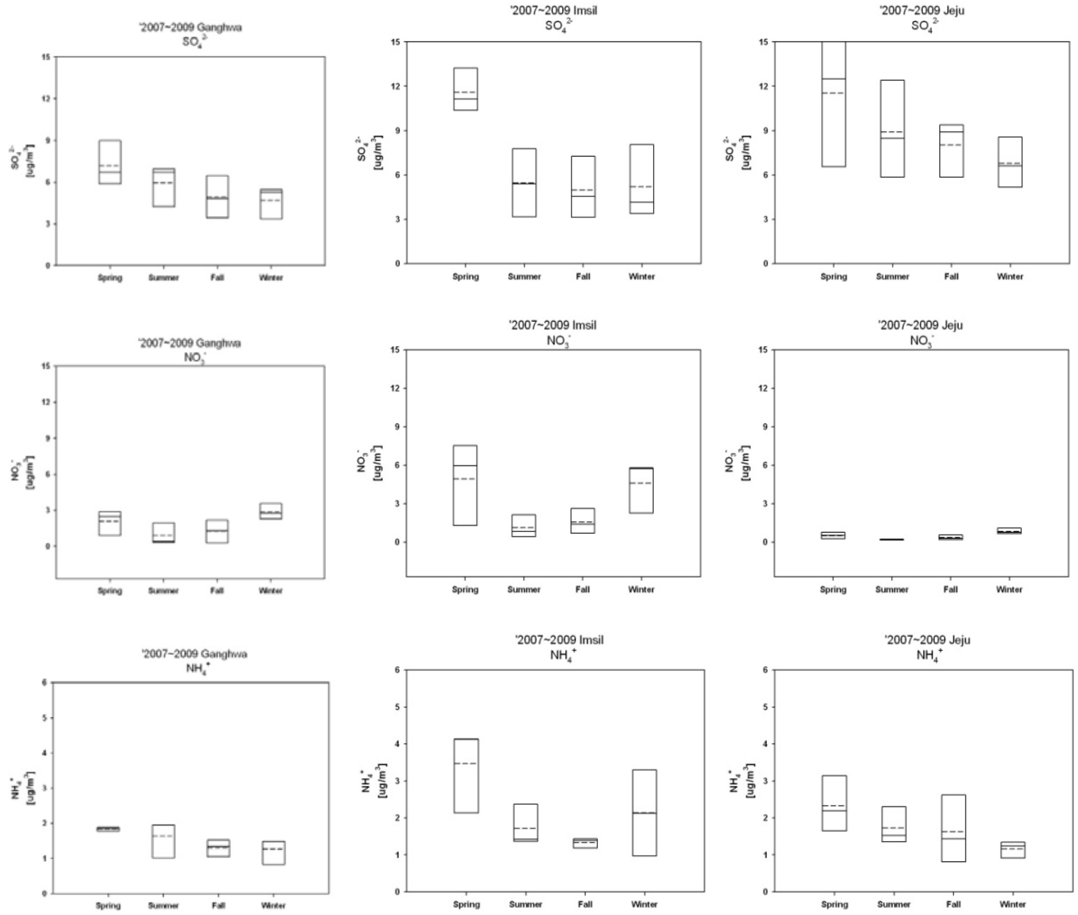


Figure 10.4.6. Seasonal variations of major chemical species concentrations in $PM_{2.5}$ at sites.

National Assessment of the State of Acid Deposition monitoring of Russia

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11. 1 Basic information on National Monitoring Activities.

Since the 1998 Russian Federation has been participating in EANET activities, first in preparatory phase and then, since 2001 in regular phase. Institute of Global Climate and Ecology of Russian Hydrometeorological Service (Moscow) was designated as Russian National EANET Center and Limnological Institute of RAS (Irkutsk) was designated as National EANET Data Center.

Russian EANET monitoring stations were established in the South-East of Asian part of Russia, besides of them there are tens of meteorological stations belonging to Russian Hydrometeorological Service (Roshydromet) which work also includes the atmospheric deposition sampling and measurement. The brief review of the State monitoring activities over the whole Asian part of Russia is presented in Annex 11.1.

11.1.1 Monitoring stations.

At the preparatory phase of national EANET activities two regions of Asian part of Russia suitable for monitoring needs were chosen: South-East Siberia and Far East. Three sites in East Siberia (Irkutsk region) were established during this phase and one site in Far East (Primorsky region, near Vladivostok) was established during the regular phase (Figure 11.1.1).

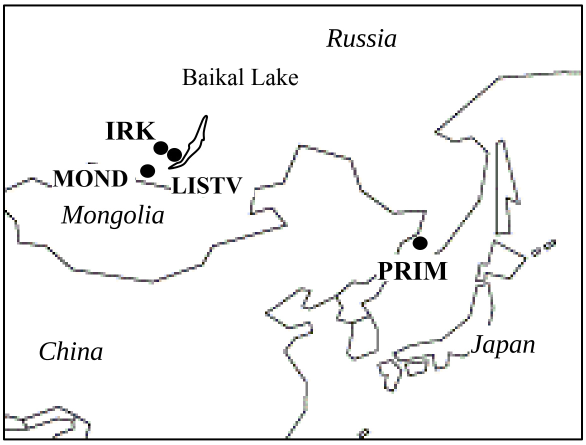


Figure 11.1.1. The location of Russian EANET monitoring sites.

According to the EANET methodology two soil and vegetation monitoring sites (the sensitive and the control) were established around (within the radius of 50 km) each deposition sampling point. Two objects for inland aquatic environment monitoring (one in East Siberia and one in Far East) were also selected (Table 11.1.1). East Siberia is represented by three sites: Irkutsk, Listvyanka, and Mondy which have been working since the 1998. These sites differ in physical-geographical conditions and in the level of anthropogenic emission to the atmosphere.

Irkutsk, urban site is a large industrial center of Eastern Siberia affected by all types of anthropogenic loading. The city is situated inside the broad valley of Angara river which flow from Lake Baikal.

Listvyanka, rural site is located on the South-West shore of Lake Baikal, 70 km Southeast of Irkutsk, near the source of Angara river. Due to influence of relief the winds of NW and SE directions (along Angara river valley) are prevailed for both Irkutsk and Listvyanka sites.

Mondy, remote site is situated in the background region (mountain area near Russian-Mongolian border), at least 200 km away from any large anthropogenic sources.

The rural monitoring station, "Primorskaya" was established in Far East region in 2002 to monitor a long-range transport of pollutants through Asian part of Russia towards the Pacific. Primorskaya station is situated on branch of the Southern Sekhote-Aline Ridge, 25 km Southeast of Ussuriisk city, nearby the Ussuriisky biosphere reserve.

Table 11.1.1. Some geographical characteristics of Russian EANET monitoring stations.

Region, site name, classification and geographical position.	Topography; landscape	Dry/wet deposition	Soil and vegetation	Inland Aquatic
East Siberia (Irkutsk region):				
1. Mondy (remote) ($51^0$40' N; $101^0$00' E; 2005 m)	Upper slope (N) of mountain; forest	+	+	-
2. Listvyanka (rural) ($51^0$51' N, $104^0$54' E, 700 m)	Hilly terrain, peak of the hill; forest.	+	+	+
3. Irkutsk (urban) ($52^0$14' N; $104^0$15' E; 400 m)	Slope (NE) of broad valley, city.	+	+	-
Far East (Primosky region)				
4. Primorskaya (rural) (43 ^{0}42' N; 132 ^{0}07' E; 84 m)	Plane, forest	+	+	+

11.1.2. Sampling and measurement

11.1.2.1 Sampling

Wet deposition. Automatic wet-only samplers are used to collect precipitation during the period of rainfall. However during winter season an automatic wet-only sampler has low sampling efficiency (for solid snow precipitation) and therefore manual sampling is the only way to collect precipitation. Snow is sampled every precipitation event as well as rain. Measurement parameters for rain and snow water are the same: pH, EC, NH_4, Na^+, K^+, Ca^{2+}, Mg^{2+}, $S0_4^{2-}$, $N0_3^-$, HCO_3^- and Cl^-.

Dry deposition. Four stage filter pack method is used for sampling. At urban and rural sites samples are taken weekly, at background site (Mondy)–bi-weekly. Air flow rate is about 1 liter/minute. Measured substances are gases (SO_2, HC1, HNO_3 and NH_3) and water-soluble fraction of particulate matter (NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, HCO_3^- and Cl^-). Besides the above-mentioned parameters ozone is also measured at Mondy station using 1006-AHJ in the frame of cooperative research with JAMSTEC, Japan. Sampling interval for ozone is 10 minutes. Meteorological parameters such as air temperature and humidity, wind direction and velocity are observed directly at sampling sites or obtained from nearest meteorological station.

Soil and vegetation. Soil and vegetation are sampled once every 3-5 years. Measured parameters are:

- for soil: pH (H_2O), pH (KC1), exchangeable Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, H^+, exchangeable acidity, ECEC , carbonate, T-C, T-N . Sampling interval: Every 3-5 years;
- for vegetation: Observation of tree decline, description of trees, under-story vegetation survey and photographic record. Interval: every 3-5 years.

Inland aquatic environment. Monitoring objects are represented by two rivers: Pereemnaya river (East Siberia) and Komarovka river (Far East). Measurement parameters are water temperature, pH, EC, alkalinity, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, transparency, water color, DOC, NO_3^-, PO_4^{3-}. Sampling interval: four times per year.

11.1.2.2. Measurement

Two chemical laboratories analyze and collected samples: 1.) Laboratory of Hydrochemistry and Atmospheric Chemistry of Limnological Institute of SB/RAS, Irkutsk (all mandatory items) and 2.) Primorsky Monitoring Center of Russian Hydrometeorological Service, Vladivostok (wet deposition and surface water samples).

In Limnological Institute the following analytical methods are used to measure ion/element concentrations in atmospheric precipitation, inland water, extracts from aerosols and soils: HC and atomic absorption and flame spectrophotometry for Ca^{2+}, Mg^{2+}, Na^+, K^+; spectrophotometry for NH_4^+, and high-performance liquid chromatography (HPLC) and HC- for anions HCO_3^-, SO_4^{2-}, Cl^-, and NO_3

Primorsky Monitoring Center uses methods of spectra-photometry, titration and atomic absorption.

11.1.3 QA/QC activities

QA/QC programs are carried out at all stages of the monitoring activities. A quality of the analytical data was regularly controlled by means of ion balance calculations and by means of comparing the measured and the calculated electrical conductivities.

The laboratories are involved in the Network Center's inter-laboratory comparison projects (on wet deposition, soil and inland aquatic environment monitoring; Report,1999; 2000; 2001; 2002; 2003; 2004, 2005, 2006, 2007, 2008, 2009). Another inter-laboratory comparison project (on wet deposition) was realized in the frame of Global Atmospheric Watch (GAW) under the aegis of World-wide Meteorological Organization (WMO).

11.2. State of acid deposition in Asian part in Russia

11.2.1. Dry deposition

Gaseous admixtures

At all the monitoring sites SO_2 predominates among the other small gaseous admixtures in the atmosphere. Its highest content observed in Irkutsk (9.4 $mg.m^{-3}$), during cold season when the amount of burning fuel (mostly coal) increases and the atmosphere mixing is low due to anticyclone (Figure 11.2.1). In the region of Eastern Siberia inter-annual variations in the concentration of sulfur dioxide strongly depend on the air temperature in winter months: the colder winter, the higher average concentration. Thus, cold 2005 and 2006 winters resulted in the increased content of sulfur dioxide in the atmosphere. In subsequent years, its concentration has substantially decreased. In 2009-2010, there was again cold winter in the Eastern Siberia, and the concentration of sulfur dioxide has increased (Figure 11.2.2.). At Primorskaya site, in 2005-2009 annual average concentration of sulfur dioxide (2.8 $mg.m^{-3}$) was lower compared to that in Eastern Siberia.

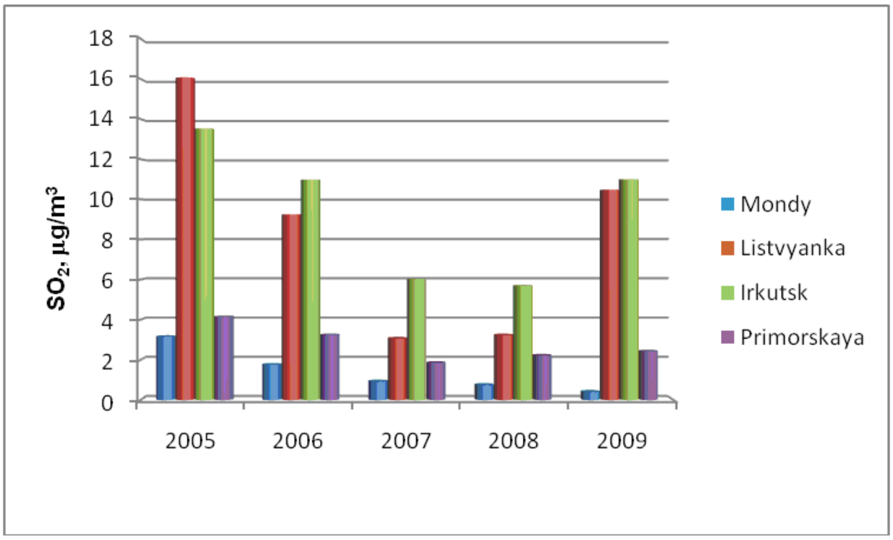


Figure 11.2.1. Annual variations (2005-2009 average) concentration of sulfur dioxide in the atmosphere at the EANET monitoring sites located in the Asian territory of Russia for the period, µg.m^{-3}.

At the remote site Mondy, pronounced seasonal variations of sulfur dioxide concentrations were not observed. At Primorskaya site, seasonal variations were less pronounced compared to those in Eastern Siberia (Figure 11.2.2.).

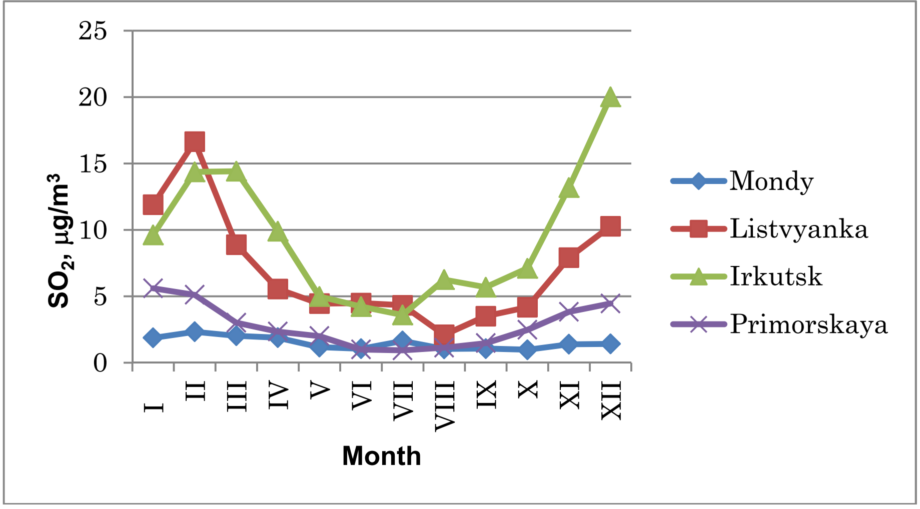


Figure 11.2.2. Seasonal variations (2005-2009 average) concentrations of sulfur dioxide in the atmosphere at the EANET sites located in the Asian territory of Russia, µg·m^{-3}.

The content of ammonia in the atmosphere varies seasonally with the maximum in warm season, when ammonia is forming as a result of biodegradation of vegetation at high humidity; its content decreases in cold season (Figure 11.2.3).

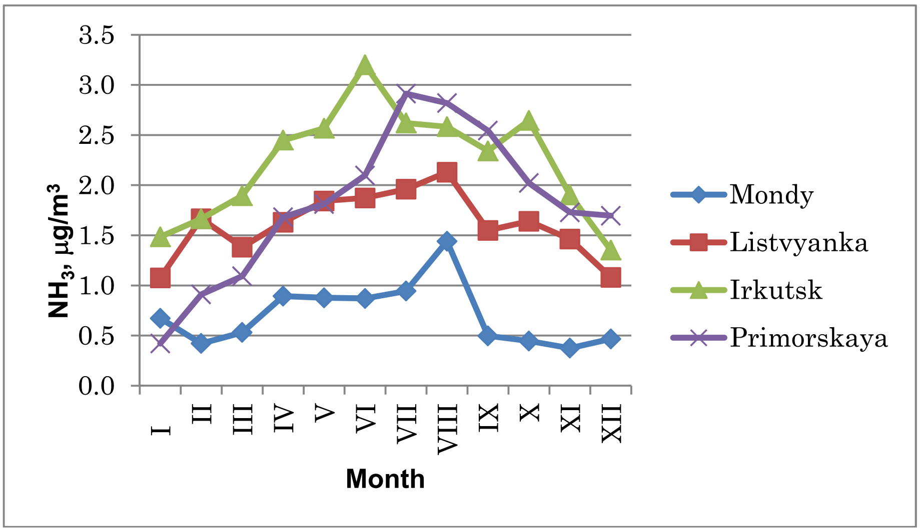


Figure 11.2.3. Seasonal variations (2005-2009 average) concentrations of ammonia in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

In 2006-2009, the concentrations of ammonia were increasing, which may be due to regular fires during dry season. The maximum concentration of ammonia in the Eastern Siberia. was recorded in 2006 (Figure 11.2.4). In summer 2006, there was alternation of hot dry weather with periods of sharp decrease of air temperatures and prolonged rains in the region.

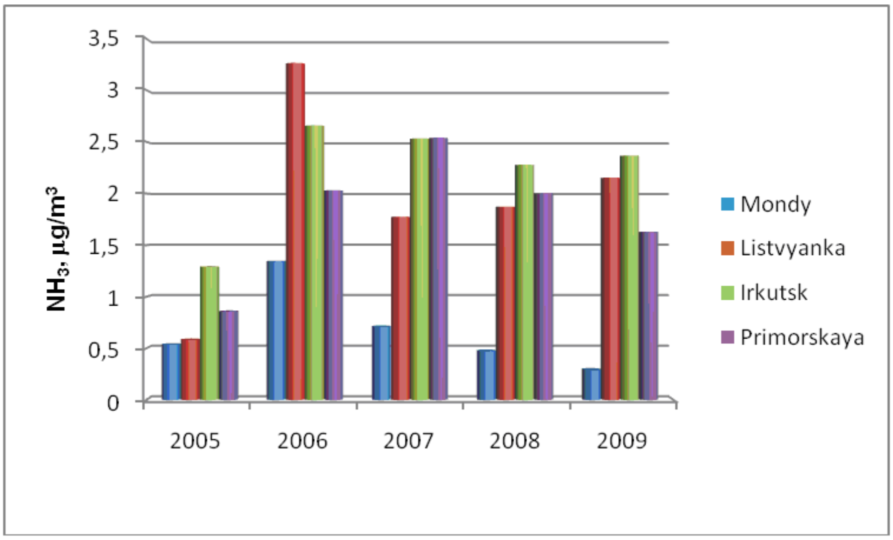


Figure 11.2.4. Annual variations (2005-2009 average) concentrations of ammonia in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

In 2000-2003, the highest concentration of gaseous nitric acid (2.1-2.4 mkg.m^{-3}) was found at Listvyanka site, which 2-3 times exceeded those recorded in the atmosphere of Irkutsk. This may be partly due to development of mass unorganized tourism on the West coast of Southern Lake Baikal. Smoke formed in the atmosphere by point sources and a large concentration of vehicles on limited isolated area contributed to HNO_3 accumulation in the atmosphere. In 2004-2005, the infrastructure was improved and centralized rest places were organized on the territory. As a result, in Listvyanka, the HNO_3 concentration in the atmosphere has decreased one order of magnitude (up to 0.10-0.17 mkg.m^{-3}, Figure 11.2.5).

At Primorskaya site, the concentrations of gaseous nitric acid in 2002-2009 ranged 0.09 to 0.46 mkg.m^{-3}.

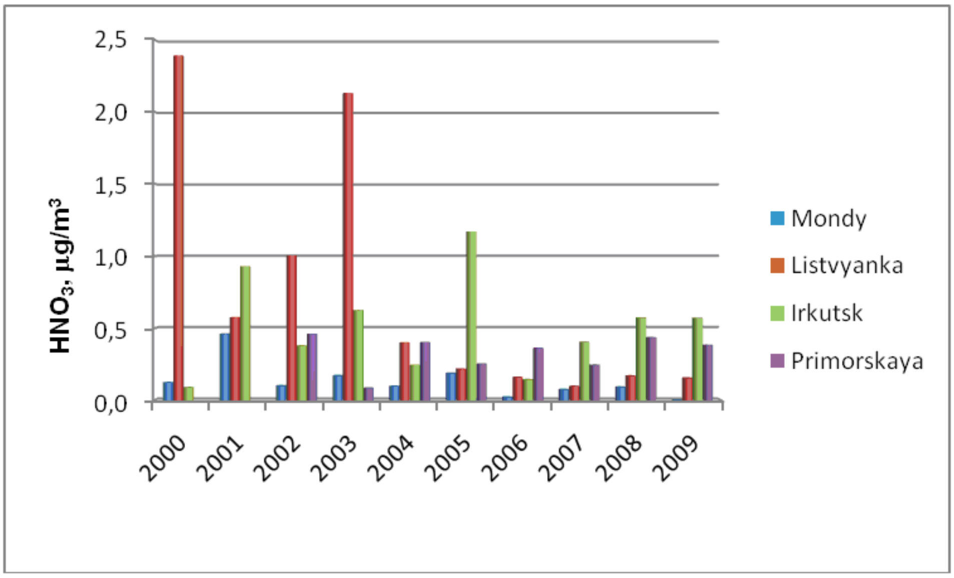


Figure 11.2.5. Annual variations (2005-2009 average) concentrations of nitric acid in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

Gaseous chlorine compounds, particularly HCl, affect significantly the atmospheric chemistry. Gaseous hydrochloric acid is easily dissolved in the drops of water vapor. Dissolved HCl is the most reactive and therefore one of the most dangerous air pollutants. The most pronounced seasonal variations in the HCl concentrations were recorded in the atmosphere of Eastern Siberia. In the atmosphere of the city of Irkutsk, most pronounced peaks in the HCl concentrations (0.4-0.6 mkg.m^{-3}) were recorded in spring (April - May) and autumn (October - November). The highest gas content was observed when there were the winds of South-eastern and North-western quarters. At such transfers of air masses, industrial emissions of the enterprises located in the Baikal region (the cities of Baikalsk, Usol'e, and Sayansk) may serve as the sources of gaseous chlorine compounds. In Listvyanka, the increased monthly average HCl concentrations in the atmosphere (0.2 mkg.m^{-3}) were observed in autumn and winter. Relatively frequent at this seasons South-easterly and southerly winds may facilitate the transport of air masses from the southern coast of Lake Baikal, where the Baikalsk Pulp and Paper Mill is located. At Mondy site, the maximum monthly average concentrations of gaseous chlorine compounds (0.15 mg.m^{-3}) are well pronounced in June and July, when the easterly winds are frequent. The same as in Irkutsk, at Primorskaya site, the maximum annual average HCl concentrations in the atmosphere (0.5 mg.m^{-3}) were observed in spring (Figure 11.2.6). In November, when the winds of East and North-eastern directions prevail, there was the second peak of HCl concentrations (0.7 mkg.m^{-3}) at Primorskaya site.

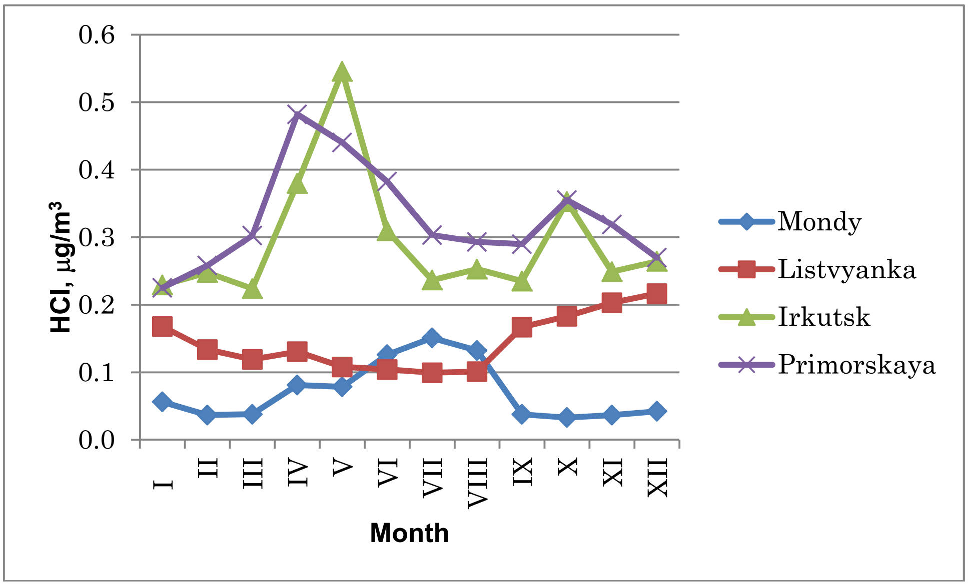


Figure 11.2.6. Seasonal variations (2005-2009 average) concentrations HCl in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

In 2005-2009, a decrease in annual average HCl concentrations in the surface layer of the atmosphere was observed at all sites as compared to 2000-2004 (Figure 11.2.7).

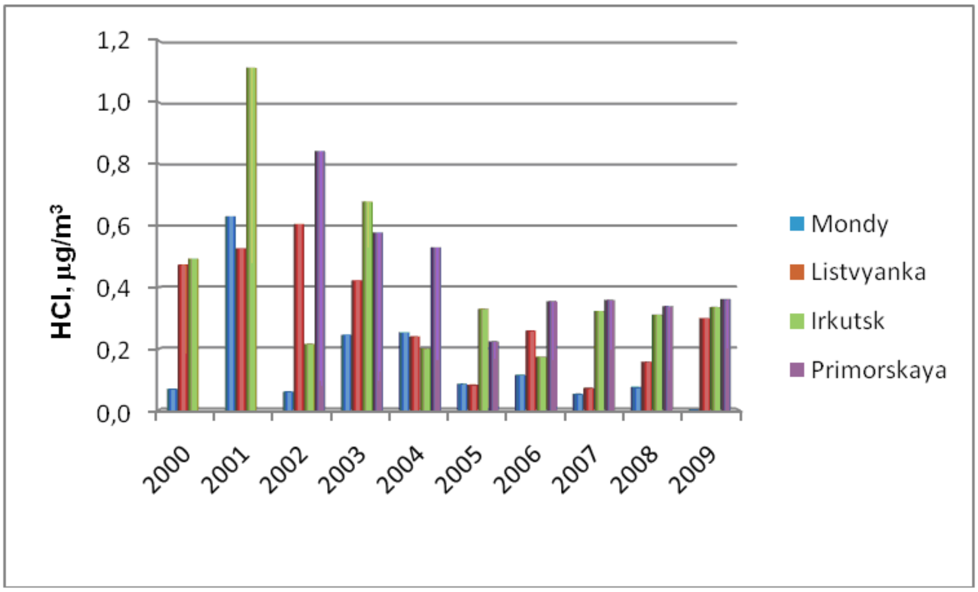


Figure 11.2.7. Annual variations (2000-2009 average) concentrations of HCl in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

Until 2005, in the atmosphere of Eastern Siberia, there was a tendency of the total content of trace gases to decrease. In 2006-2009, their content slightly increased. In the Primorsky region, the total content of trace gases in the atmosphere was unchanged during 2005-2009 period (Figure 11.2.8.).

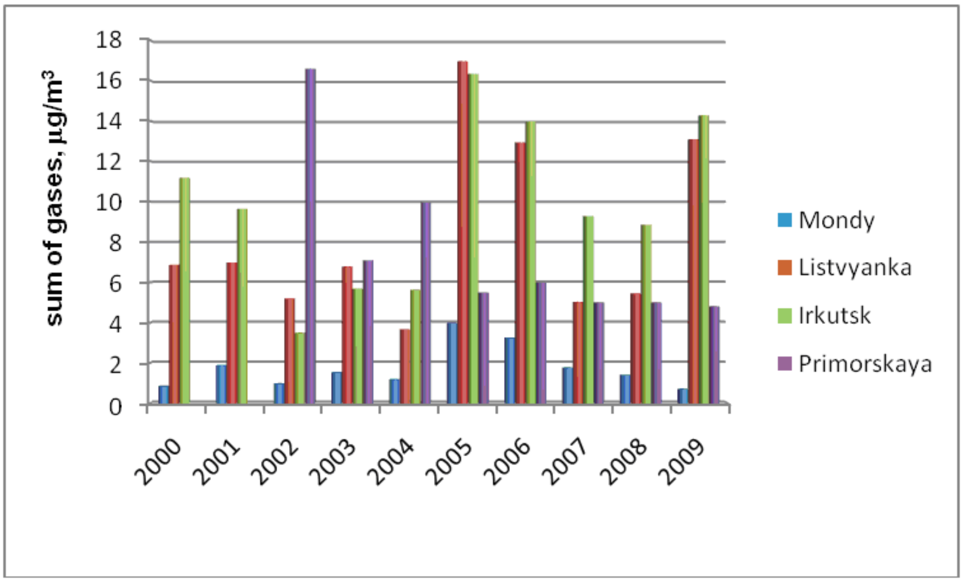


Figure 11.2.8. Annual variations (2000-2009 average) total content of trace gases (NH_3, SO_2, $HCl_{gas.}$, and $HNO_{3\ gas.}$) at the EANET sites located in the Asian territory of Russia, μg.m^{-3}.

Ozone

In the during 14 years at the remote site Mondy was investigation ozone. Unlike stratospheric ozone, the ozone concentration near the earth's surface (SOC) is increasing at a rate of 1-2% per year. It is characterized by large spatial and temporal variability. Under urban conditions, a growth of both ozone concentrations and its fluxes is associated with local pollutants, whereas in the background areas natural factors are of major importance. Despite the large number of data available, the reasons for SOC variability are still unclear. Until recently, there were no permanent long-term observations on SOC in Eastern Siberia. Therefore, in autumn 1996 the background ozone monitoring site was organized by the Limnological Institute in cooperation with The Frontier Observational Research System for Global Change (FORSGC) the Japan Marine Science and Technology Center (JAMSTEC). It aims to find out the seasonal and daily SOC dynamics under background conditions of continental climate

Measurements of the concentrations of ozone and carbon monoxide in the atmospheric surface layer were performed using the ozonometer 1006-AHJ (made in Japan) with a one-minute averaging. Instrumental error does not exceed 10%. At the same time, the atmospheric pressure and air temperature in the room of the ozonometer location are measured.

Daily SOC dynamics was examined using the averaged daily data according to the season of a year. In all cases, the minimum concentration was observed in the night and morning, maximum - in the afternoon and evening. Daily SOC variability is caused by both dynamics of the mixed layer and formation of temperature inversions at night. During a day, SOC variability is higher compared to that in the evening and night.

In winter, the presence of snow cover leads to a smoothing of the diurnal SOC variations, because ozone destruction is less intense on the snow surface compared to that on the surface of open ground. Minimum concentration of ozone was recorded at 9-11 a.m., maximum – at 7 p.m. The daily SOC variability was minimum, the daily amplitude was only 1 ppb. Photochemical generation of ozone was absent (Figure 11.2.9.).

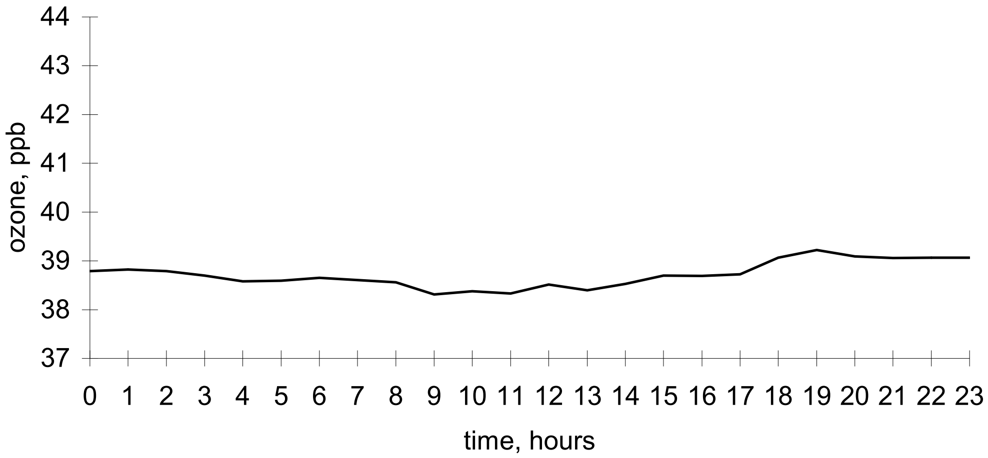


Figure 11.2.9. Annual variations (2000-2009 average) diurnal SOC in winter (January), ppb.

In spring, the situation changes: the minimum SOC was recorded at 10 a.m., the maximum – at 5 p.m. The daily amplitude was 2 ppb. The diurnal ozone concentrations are increased (Figure 11.2.10.) because of general spring SOC maximum recorded in April - May.

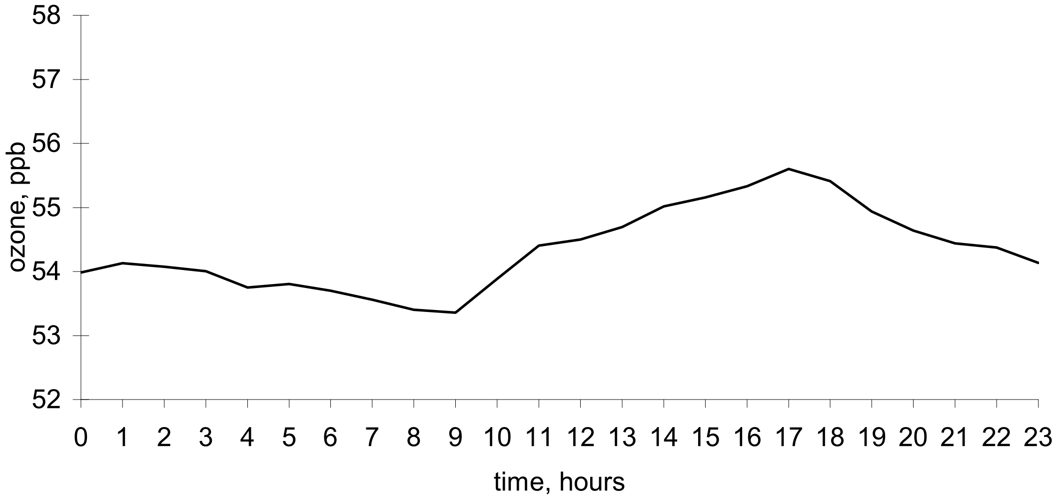


Figure 11.2.10. Annual variations (2000-2009 average) diurnal SOC in spring (April), ppb.

In summer, there are the most pronounced by amplitude the diurnal SOC variations. The minimum was recorded at 8 a.m., the maximum was observed for 3 hours, since 1 p.m. till 4 p.m. The daily amplitude was 5 ppb. The SOC maximum was shifted with respect to noonday solar maximum radiation because of convective exchange of air masses in the afternoon. As a result, there was additional income of ozone-enriched air from the upper layers of the atmosphere to the earth's surface (Figure 11.2.11.).

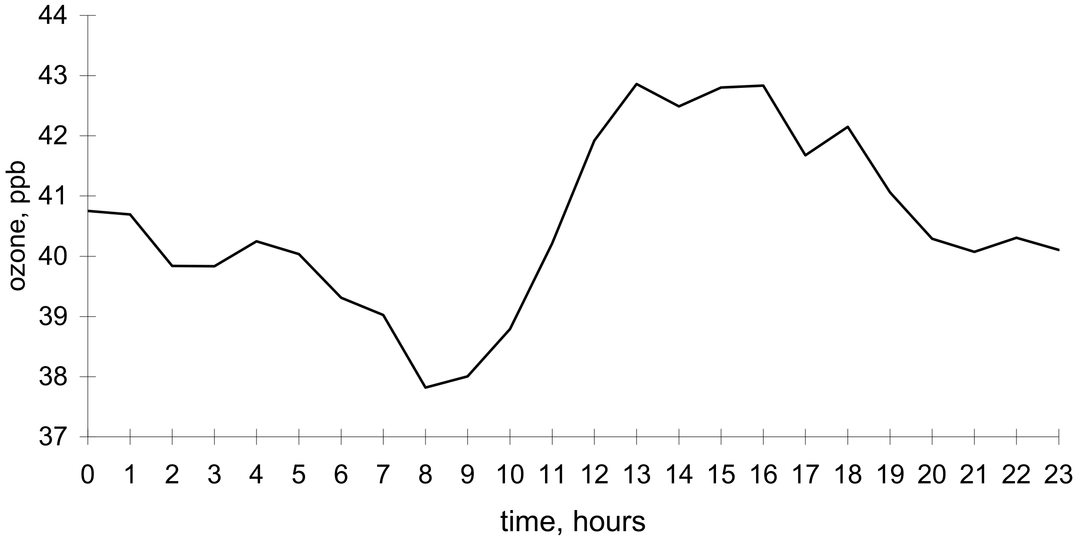


Figure 11.2.11. Annual variations (2000-2009 average) diurnal SOC in summer (July), ppb.

In autumn, the minimum SOC was registered at 9 a.m., the maximum at 4 p.m. The daily amplitude was 2 ppb. This is the lowest annual amplitude, which is due to the minimum in seasonal dynamics SOC values (Figure 11.2.12).

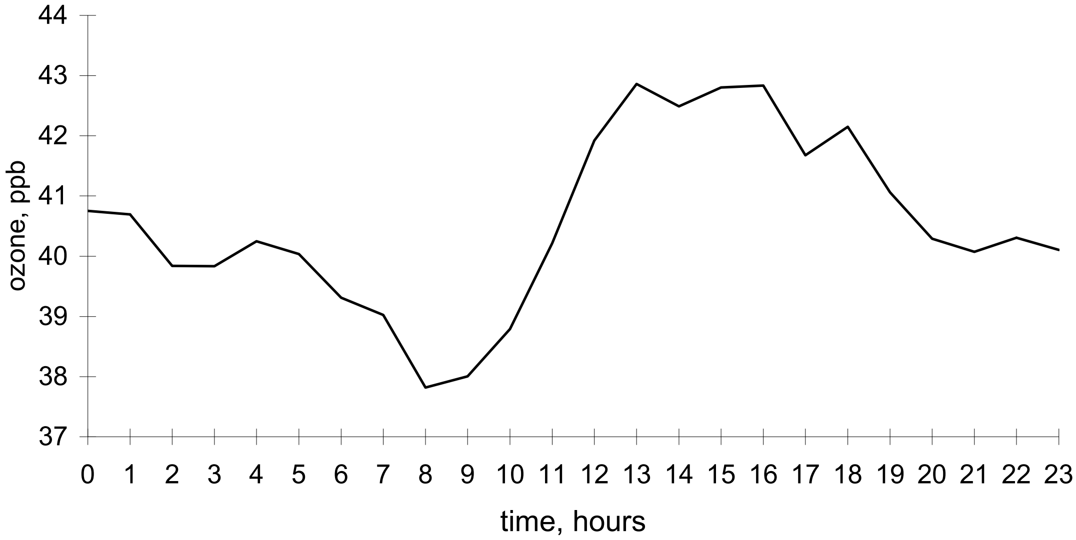


Figure 11.2.12. Annual variations (2000-2009 average) diurnal SOC in autumn (October), ppb.

As stated above, annual SOC variations have a pronounced maximum since late April till early May. During study period, the date of SOC maximum ranged from April 20 to May 19. Over the entire period, the maximum SOC (82 ppb) was recorded on May 5, 2004; annual average maximum was 58 ppb (Figure 11.2.13).

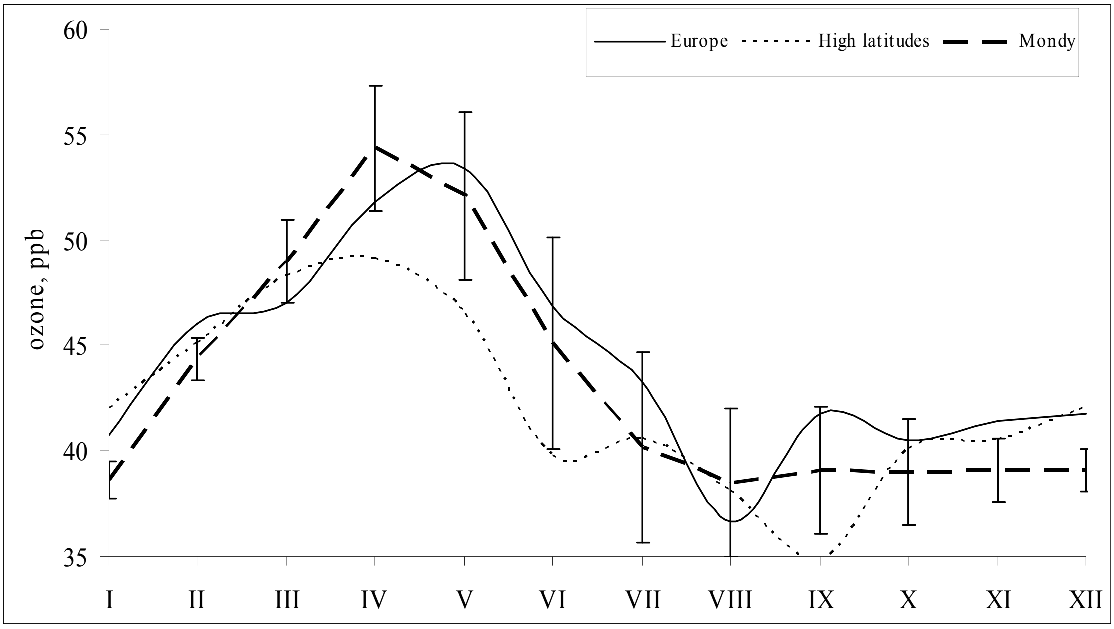


Figure 11.2.13. Annual variations (2000-2009 average) SOC cycle at Mondy site, ppb.

Thus, 14 years of observations on SOC dynamics allowed obtaining the following main results:

Analysis of the annual SOC variations showed the maximum concentration of ozone in April-early May, the minimum in July - August. Variability of surface ozone concentrations, in contrast to the total ozone concentrations, was minimum in cold season and increased in warmer months.

Averaging of SOC and analysis of their daily dynamics in different seasons has revealed the following specific features:

minimum daily SOC variability with an amplitude of 1 ppb is typical of winter
(January); maximum daily SOC variability with an amplitude of 5 ppb is observed in July
diurnal SOC variations in spring and autumn (April and October) are close to each
other and are about 2 ppb.

Atmospheric aerosols

The highest accumulation of impurities in the atmosphere was registered in the area of industrial center (Irkutsk) and at Primorskaya site, the smallest in the remote site Mondy. In the second half of decade, a decrease in the mass concentrations of ions in aerosols was recorded in the atmosphere of the monitoring sites located in Eastern Siberia (Figure 11.2.14.). Thus, at Listvyanka and Mondy sites in 2005-2009, their average concentrations were twice lower as compared with those registered in 2000-2004, in Irkutsk they were 1.3 times lower. Reducing of the ions concentration in the atmospheric aerosols of Eastern Siberia could be related to the climate change occurring in the region, which leads to increase of both annual average air temperatures and the amount of precipitations. In the Primorsky region, the concentration of ions in aerosols, in contrast, has increased by 1.3 times (Figure 11.2.14.).

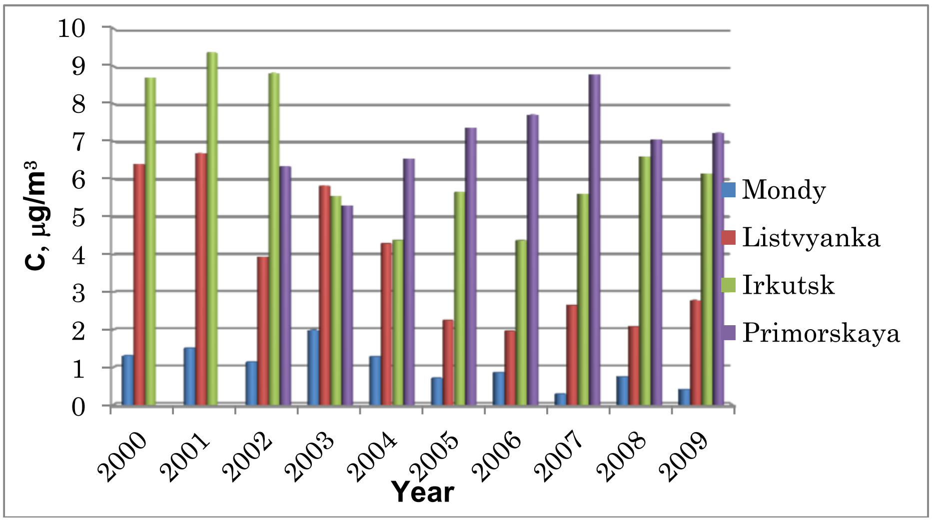


Figure 11.2.14. Annual variations (2000-2009 average) total content of ions in the soluble fraction of aerosols in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

Comparison of the composition of soluble fraction of aerosols over the period 2005-2009 shows no principal differences in the qualitative composition of aerosols. At the sites Listvyanka and Mondy, the annual average concentrations of cations in aerosols are basically sorted as follows: $NH_4^+ > Ca^{2+} > Na^+, K^+ > Mg^{2+}$; at Primorskaya site: $NH_4^+ > Ca^{2+}, Na^+, K^+ > Mg^{2+}$. The quantitative ratio of annual average concentrations of other anions depends on the season. At all sites, the SO_4^{2-} ion dominated among the anions.

Analysis of the seasonal variability of the amount and composition of aerosols, has revealed a relationship between the meteorological parameters and accumulation and dispersion of inpurities in the air of the monitoring sites. Increased mass of ions in cold season is due to the increase of surface high-pressure field, characterized by descending air fluxes leading to erosion of cloudiness and precipitations.

Growing temperature inversions, in turn, lead to the accumulation of pollutants in the atmosphere of Eastern Siberia. This is especially true for aerosols in Irkutsk (Figure 11.2.1.15). In this period, the chemistry of aerosols is formed under the influence of sources common for all modern urbanized areas: power engineering, transport, and industrial enterprises.

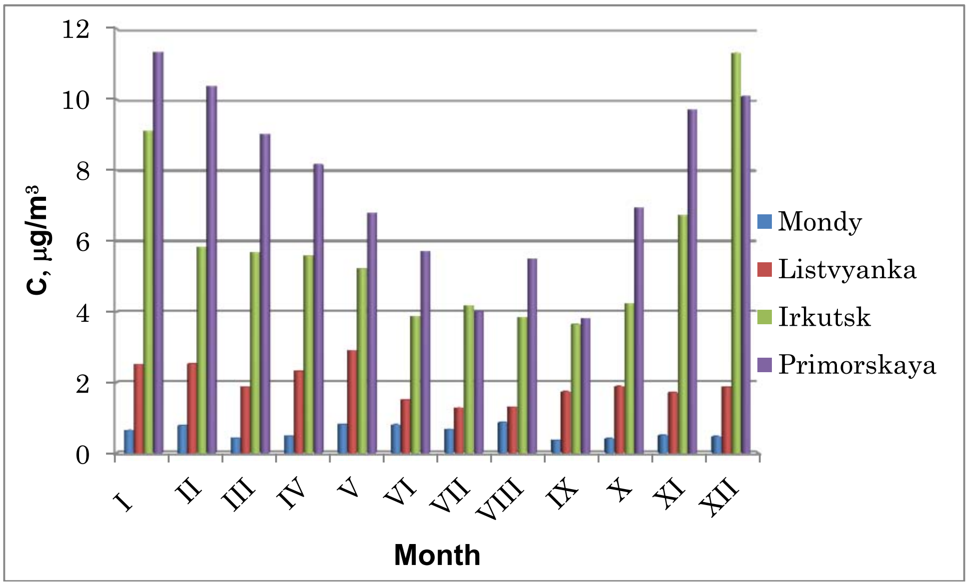


Figure 11.2.15. Seasonal variations (2005-2009 average) total concentrations of ions in the soluble fraction of aerosols in the atmosphere at the EANET sites located in the Asian territory of Russia, µg.m^{-3}.

At the monitoring sites Irkutsk and Listvyanka, the increased concentrations of ions in aerosols recorded in spring are associated with the emission of substances that have accumulated in the snow cover. During this period, the turbulent heat excange increases, the process of convection in the atmosphere over the bare soils intensifies. The minimum amount of ions in the aerosols is in summer, when deep cyclones often come out from the regions of Mongolia and stay for a long time in the South part of Eastern Siberia. Prolonged rains associated with these cyclones purify the air from impurities, and the concentration of ions in aerosols decreases. At Mondy site, the increased mass concentration of ions is observed in summer; it is associated with an increased input of soil aerosol. At Primorskaya site, the maximum total content of ions occurred in winter. In warm season, when there is an increase in rainfall, the concentrations are minimal.

The same trends are typical of dry deposition of substances from the atmosphere (Figure 11.2.16.). On the example of monitoring sites located in Eastern Siberia, one can see the differences in dry deposition of substances on the underlying surface even within the same region. The input of substances from the atmosphere was calculated by the formula:

$D = CV\Delta t$,

where D – the input of substances, C- average concentration for the period Δt, V – the rate of dry deposition taking into account the type of surface and climatic conditions. The quality and quantity of deposited substances are strongly affected by the level of anthropogenic load experienced by the study area. During 2005-2009, on average 3.3 kg.ha^{-1} of ions per year were deposited with the soluble fraction of atmospheric aerosols in the region of Irkutsk. The deposition ranged 2.4 kg.ha^{-1} in 2006 to 3.9 kg.ha^{-1} in 2008. In Listvyanka, during 2005-2009, the deposition varied 1.2 kg.ha^{-1} to 1.8 kg.ha^{-1} and was within 1.5 kg.ha^{-1} per year on average. The lowest fluxes of soluble substances, on average, 0.4 kg.ha^{-1} per year, were registered in the remote site Mondy.

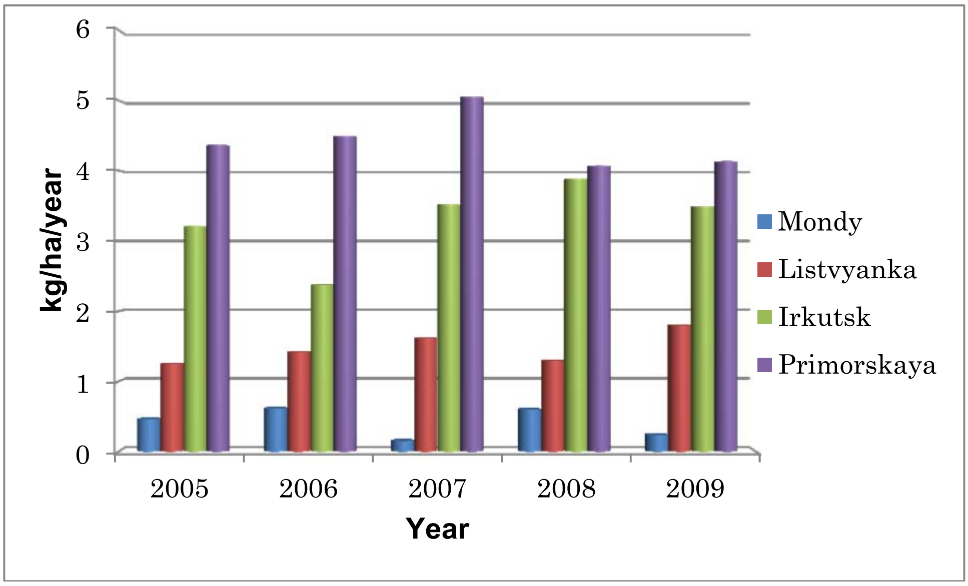


Figure 11.2.16. Annual average amount of ions coming with the soluble substances during dry deposition at the EANET monitoring sites located in the Asian territory of Russia for the period 2005-2009, kg.ha^{-1}.yr^{-1}.

Deposition of the atmospheric sulfur and nitrogen compounds is of special importance when assessing the acidification of natural environments. Minimum annual fluxes of sulfur as SO_4^{2-} were recorded at Mondy site. They ranged 0.03 to 0.11 kg.ha^{-1}.yr^{-1}. Maximum sulfur flux with aerosol material on the ground surface (0.72 to 0.98 kg.ha^{-1}.yr^{-1}) was registered at Primorskaya site. A significantly greater amount of sulfur is deposited in the form of gas component (SO_2). Maximum sulfur fluxes from the atmosphere with gas impurities were recorded, in contrast to those with aerosols, at the sites Listvyanka and Irkutsk located in Eastern Siberia: 2.0 to 9.1 and 4.7 to 9.6 kg.ha^{-1}.yr^{-1}, respectively (Table 11.2.1.). In 2005-2009, the excess of total sulfur fluxe with trace gases over those with aerosols was at Mondy station more than 14 times, in Listvyanka more than 20 times, in Irkutsk almost 13 times, while for Primorskaya station the excess was only 2 times.

Table 11.2.1. Sulfur fluxes with aerosols and trace gases on the ground surface at the EANET monitoring sites located in the Asian territory of Russia for the period 2005-2009, kg.ha^{-1}.yr^{-1}.

Year	Mondy	Listvyanka	Irkutsk	Primorskaya	Mondy	Listvyanka	Irkutsk	Primorskaya
	S_{aer} (SO_4^{2-})				S_{gas} (SO_2)			
2005	0.08	0.12	0.48	0.79	3.11	9.06	9.56	2.86
2006	0.11	0.28	0.39	0.85	0.75	7.08	4.68	1.88
2007	0.03	0.32	0.63	0.98	0.52	2.02	5.80	0.99
2008	0.10	0.20	0.48	0.72	0.70	2.44	4.78	1.51
2009	0.05	0.33	0.39	0.75	0.14	4.95	5.24	1.09

The nitrogen flux with dry deposition on the ground surface is lower compared to that of sulfur. The maximum fluxes were found in the industrial and rural areas (Table 11.2.2.). It is characteristically, that at Primorskaya site in 2005-2009, the total annual atmospheric flux of nitrogen with aerosols was about the same as that with trace gases: 3.2 and 3.7 kg.ha^{-1}, respectively. In Eastern Siberia, the differences between such fluxes are significant. Thus, at Mondy site, the nitrogen flux with trace gases NH_3 and HNO_3 was up to 6 times higher compared to that with the NO_3^- and NH_4^+ ions, in Listvyanka – 4.3 times higher, in Irkutsk – 2.7 times higher.

Table 11.2.2. Fluxes of nitrogen with atmospheric aerosols and trace gases on the ground surface at the EANET monitoring sites located in the Asian territory of Russia for the period 2005-2009, kg.ha^{-1}.yr^{-1}.

Year	Mondy	Listvyanka	Irkutsk	Primorskaya	Mondy	Listvyanka	Irkutsk	Primorskaya
	N_{aer} (NO_3^- + NH_4^+)				**N_{gas} (NH_3 + HNO_3)**			
2005	0.06	0.19	0.37	0.67	0.26	0.18	0.54	0.40
2006	0.06	0.19	0.27	0.72	0.59	1.45	1.02	0.88
2007	0.01	0.19	0.40	0.72	0.35	0.77	1.43	1.03
2008	0.09	0.13	0.42	0.54	0.20	0.56	0.98	0.89
2009	0.02	0.16	0.34	0.56	0.04	0.71	0.87	0.51

Thus, despite the different location of the monitoring sites, their different geographical characteristics as well as different level of anthropogenic load, all of them have generally the same sources of gaseous impurities in the air. The major suppliers of NH_3 and $HNO_{3\ gas.}$ compounds are road transport, heat-and-power engineering, and summer forest fires. The calculations indicate that in 2005-2009, the total atmospheric input of sulfur and nitrogen with gas impurities has increased at the sites located in Eastern Siberia compared to those in 2000-2004. At the same time, the total input with aerosol material has decreased. At Primorskaya site, there was the opposite effect. The flux of constituents deposited with aerosol material has increased, whereas that with trace gases has decreased (Figures 11.2.17., 11.2.18.).

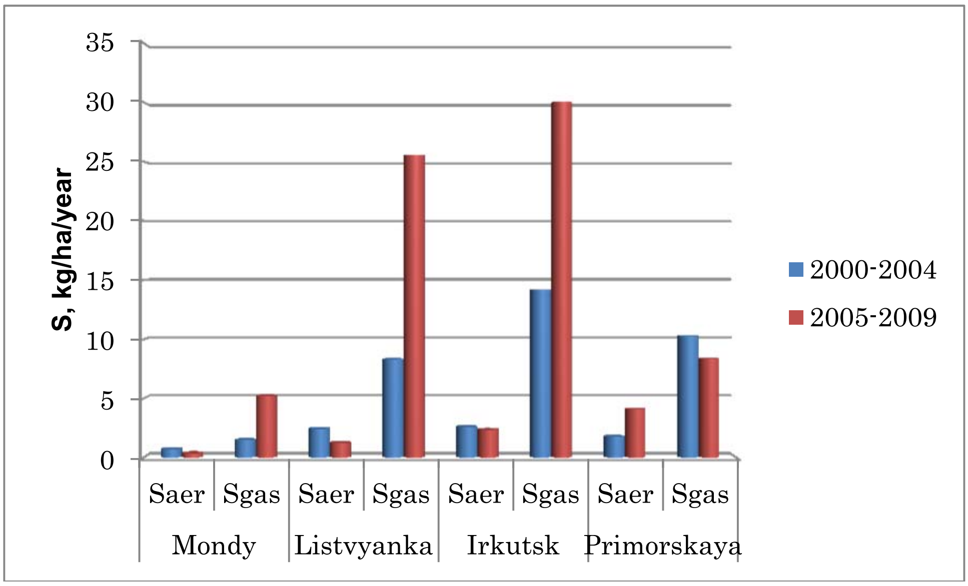


Figure 11.2.17. The total input of sulfur with dry deposition at the EANET monitoring sites located in the Asian territory of Russia for the period 2005-2009.

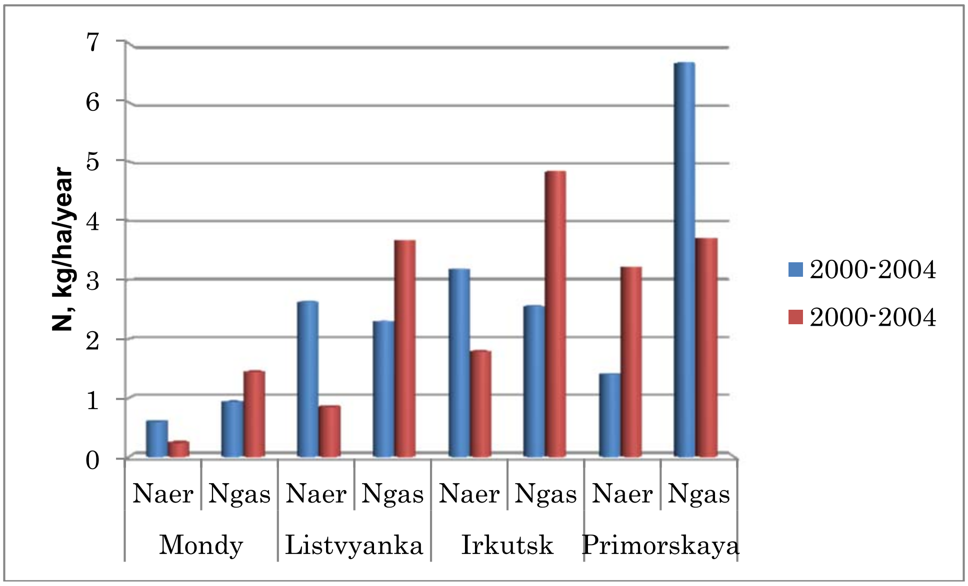


Figure 11.2.18. The total input of nitrogen with dry deposition at the at the EANET monitoring sites located in the Asian territory of Russia for the period 2005-2009.

11.2.2. Wet deposition

The monitoring 2005-2009 studies of the chemistry of the atmospheric precipitations (AP) in the Eastern Siberia and Primorsky region in Russia show that except for 2005 the most mineralized rainfall are typical of the urban Irkutsk site (Figure 11.2.19.). At this site, the average TDS in AP was 19 mg.l^{-1}. In 2005, the highest TDS in AP was registered at Primorskaya station, the lowest TDS – at the background station Mondy. At the stations of the monitoring of the atmosphere in Eastern Siberia, there is a trend of TDS in AP to increase gradually since 2005 till 2008. At the Primorskaya station, on the contrary, TDS in the precipitations have decreased since 2006 till 2009.

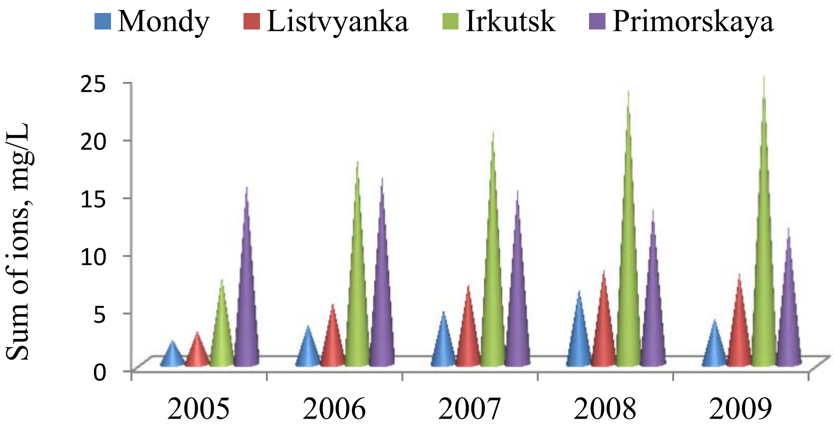


Figure 11.2.19. Annual variations (2005-2009 average) of TDS in the atmospheric precipitations at the EANET monitoring sites.

At all sites, TDS in AP of warm season was usually much lower compared to that in cold season (Figure 11.2.20). This is most clearly manifested at Mondy station, characterized by TDS in the snow on average 2.6 times higher than in the rains. The only exceptions were more mineralized rains compared to snow registered at Primorskaya station in 2005. In Irkutsk, TDS in snow was on average 3.5 times higher compared to that at the background station Mondy. Snow precipitations falling at the stations Listvyanka and Mondy have approximately the same TDS (Figure 11.2.20a). However, in

Listvyanka inter-annual TDS variations were less pronounced. In Irkutsk, TDS in snow was on average 3.2 mg.l^{-1} higher compared to that at Primorskaya station. In Irkutsk, TDS in snow gradually increases during the observation period. At this site, in 2008 TDS in the rains was 2.8 times higher than in 2005. At Primorskaya station, inter-annual TDS variations in the rains were less pronounced.

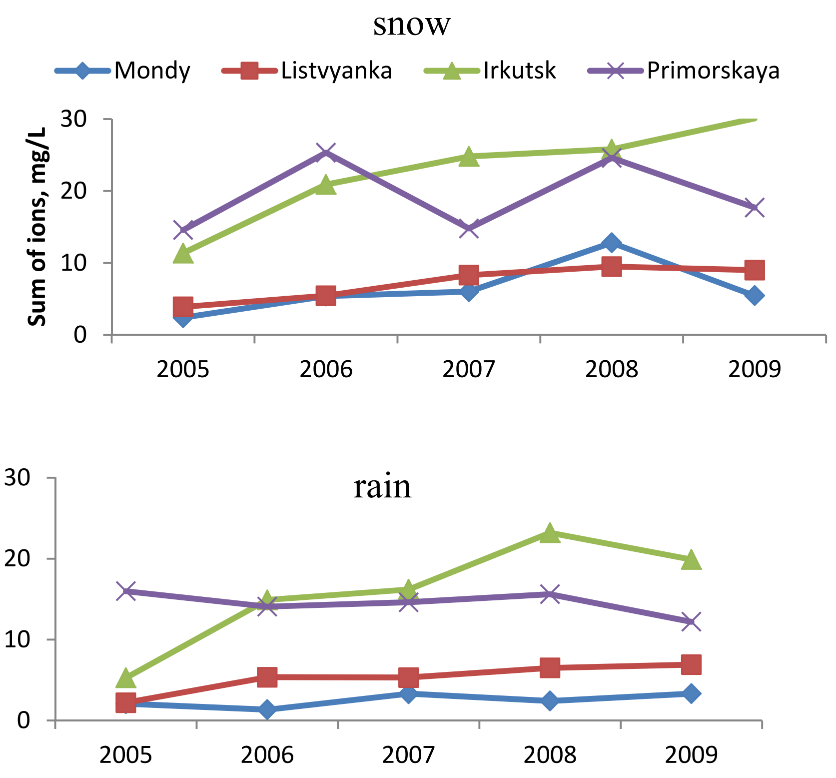


Figure 11.2.20. Annual variations (2005-2009 average) TDS in the atmospheric precipitations of warm and cold seasons at the EANET monitoring sites.

Sulfate and calcium are major ions in the atmospheric precipitations. Among the anions, they are followed by bicarbonates at the stations Irkutsk and Mondy and by nitrates at Listvyanka and Primorskaya stations. Among the cations, they are followed by the hydrogen ion in Listvyanka, by the ammonium ion – at the other stations. At all stations, a share of bicarbonates and nitrates in snow exceeds that in rains. The exception is Mondy station, where the contribution of nitrates is higher in rains (Figure 11.2.21). In Mondy, the bicarbonate ion dominates among anions in cold season. At all stations, a contribution of ammonium and hydrogen ions was higher in AP of warm season. The ammonium ion dominates in the rains at the stations Mondy and Primorskaya, hydrogen ion – at Listvyanka station.

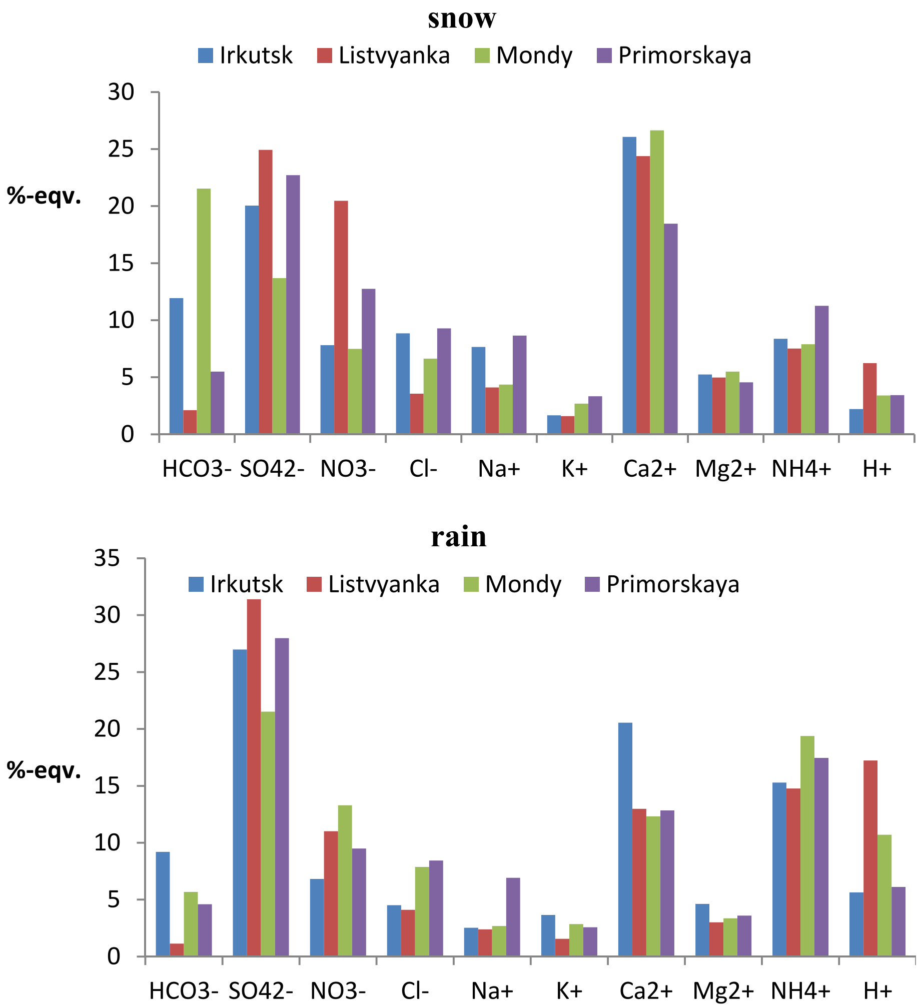


Figure 11.2.21. Annual variations (2005-2009 average) relative ion composition of the precipitations of warm and cold seasons at the EANET monitoring sites (2005-2009).

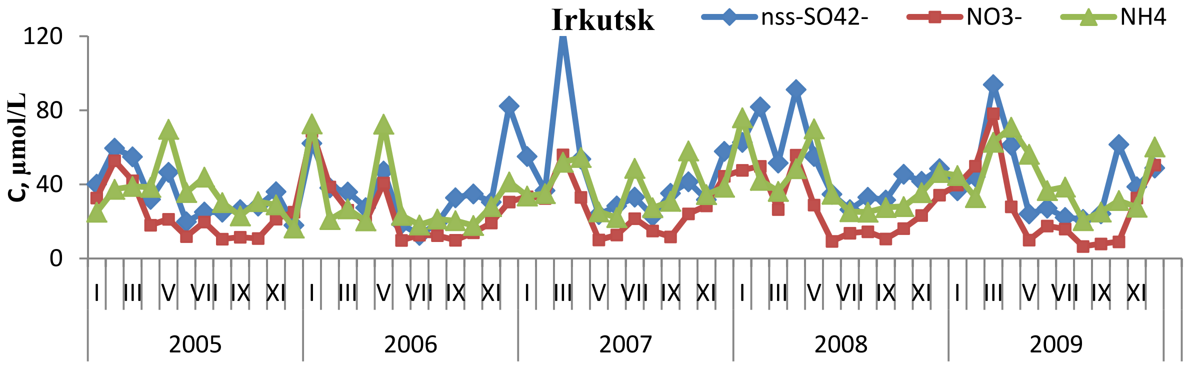
Inter-annual dynamics of the ion composition of AP is shown in Table 11.2.3. At the stations located in eastern Siberia, the average annual concentrations of most ions have increased since 2005 till 2008. At Primorskaya station, only concentrations of nitrates and bicarbonates have significantly increased during this period.

Figure 11.2.22 shows the inter-annual dynamics of the average weighted monthly concentrations of individual ions. In Irkutsk, the content of sulfates, nitrates, and ammonium was the highest in cold season: in March 2007 and 2009, and in January 2008. In Listvyanka, the concentrations of these ions increased sharply during the forest fire in May 2006, at Mondy station in July 2007. At Primorskaya station, the concentrations of sulfates and nitrates increased in January 2008, of the ammonium ion in May 2009.

Table 11.2.3. The chemical composition of precipitations at the EANET monitoring sites, µmol.l^{-1}

Year	HCO_3^-	SO_4^{2-}	NO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+
Irkutsk									
2005	34.4	41.8	25.8	24.0	17.5	7.8	42.2	9.7	46.1
2006	83.7	50.6	32.7	33.4	28.8	19.7	68.8	13.8	46.2
2007	82.1	63.4	33.6	39.1	33.5	22.3	70.7	14.9	52.9
2008	110.8	75.0	35.2	40.4	32.8	35.2	86.7	17.7	58.1
2009	83.6	64.9	32.6	109.4	98.9	30.8	73.1	14.8	52.2
average	**78.9**	**59.1**	**32.0**	**49.3**	**42.3**	**23.2**	**68.3**	**14.2**	**51.1**
Listvyanka									
2005	0.8	23.9	21.4	8.4	5.5	2.3	15.0	3.1	21.1
2006	1.8	26.2	22.9	6.0	5.5	2.6	14.5	2.9	17.1
2007	4.9	25.8	36.5	8.0	7.1	3.1	21.4	4.2	26.0
2008	4.4	33.4	37.7	10.2	7.7	6.3	25.4	5.1	30.0
2009	15.7	28.9	33.2	5.7	8.2	3.9	26.5	5.7	20.8
average	**5.5**	**27.6**	**30.4**	**7.6**	**6.8**	**3.7**	**20.6**	**4.2**	**23.0**
Mondy									
2005	7.7	5.0	5.8	7.5	2.5	1.8	5.4	1.3	10.9
2006	20.2	7.1	7.9	4.6	3.1	2.7	13.7	2.3	6.4
2007	26.1	9.5	9.7	8.2	9.2	2.9	13.4	2.7	21.2
2008	47.5	11.3	10.1	6.3	5.2	4.3	24.6	5.6	15.1
2009	24.9	9.1	10.8	3.3	3.2	3.6	11.7	2.4	19.3
average	**25.3**	**8.4**	**8.8**	**6.0**	**4.6**	**3.0**	**13.7**	**2.9**	**14.6**
Primorskaya									
2005	24.9	63.2	34.2	39.2	45.7	14.3	37.2	11.1	67.7
2006	26.7	67.9	43.2	34.4	31.3	11.8	41.7	9.4	78.8
2007	23.6	57.5	44.5	37.5	40.9	12.8	36.7	9.4	55.0
2008	35.1	64.8	49.0	43.7	40.9	17.9	42.2	12.3	66.6
2009	22.0	49.4	46.4	33.0	33.5	12.0	31.9	7.8	66.1
average	**26.5**	**60.5**	**43.5**	**37.6**	**38.4**	**13.8**	**37.9**	**10.0**	**66.9**

Over five years of observations, the highest average weighted concentrations of sulfates were recorded in Irkutsk and at the Primorskaya station in March, at Listvyanka station in May, at Mondy station in February (Figure 11.2.23). The highest concentrations of nitrates in Irkutsk also occurred in March, in Listvyanka in February, at Mondy in July, at Primorskaya in January. The highest content of ammonium was recorded mainly in May.



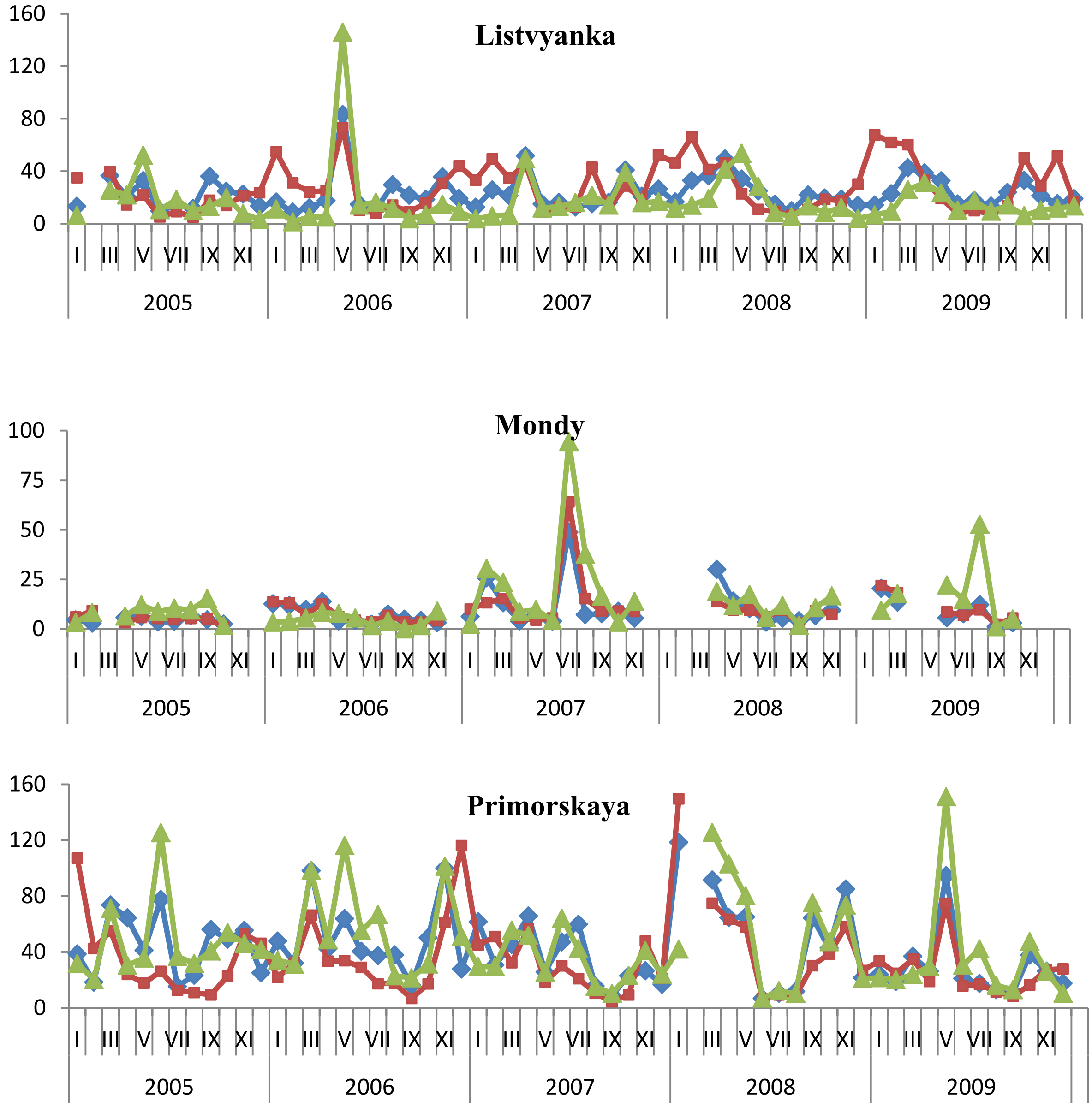
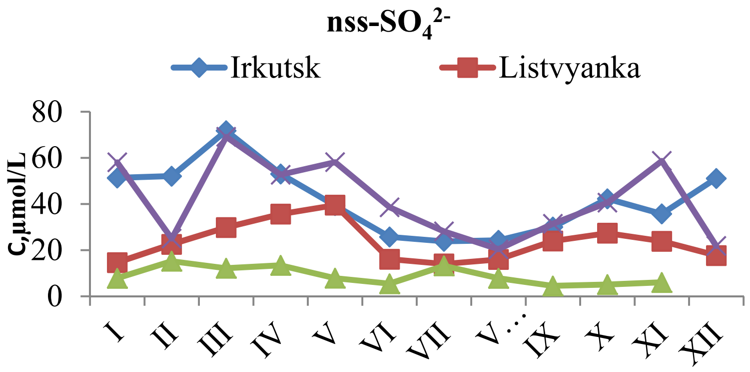
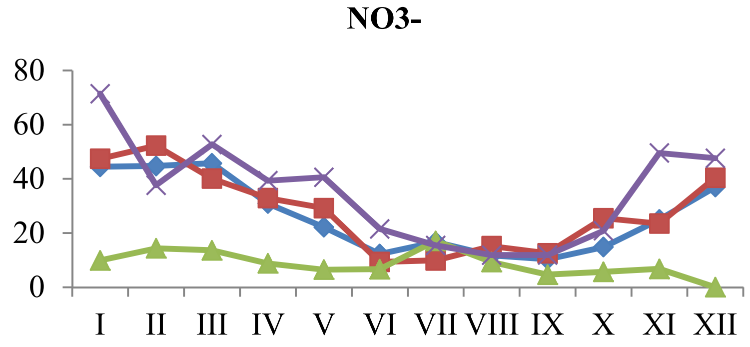


Figure 11.2.22. Annual variations (2005-2009) of the average weighted concentrations of ions in the atmospheric precipitations at the EANET monitoring sites.





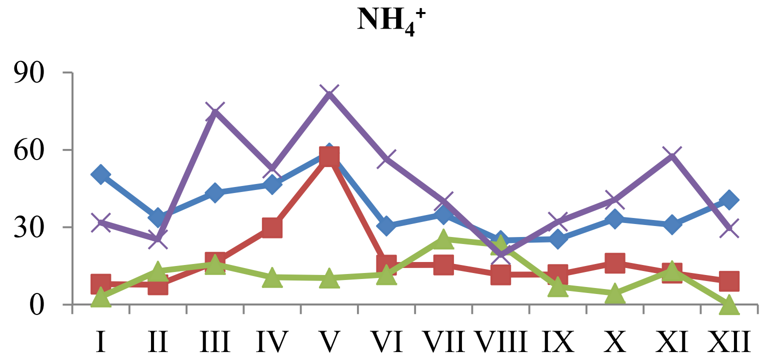


Figure 11.2.23. Seasonal dynamics (2005-2009) of the average weighted concentrations of ions in the atmospheric precipitations at the EANET monitoring sites.

In Irkutsk, maximum concentrations of sulfates and nitrates in the atmospheric precipitations in cold season are due to high air pollution by gas emissions of thermal power plants and vehicle exhausts. At this time, the rainfall is low and meteorological conditions while the Siberian anticyclone dominate in the region, do not contribute to the dispersion of air pollution. At the rural station Listvyanka, besides road transport, boilers, and house stoves, there is an additional source of pollution: transportation of the air contaminants from Irkutsk and other industrial centers of the Baikal region along the Angara River valley. In Listvyanka, the same as in Irkutsk, specific features of the winter meteorological conditions (high frequency of calms and low wind speeds) contribute to the accumulation of pollutants in the atmosphere. At the background Mondy station, the increased concentrations of ions in cold season are due to the natural factors: small amount of snow and resulted high contribution of soil erosion into formation of the snow chemistry. At Primorsky station, which reflect the regional background of the southern Far East, the high concentration of ions in the snow, most likely is related to the transfer of acidifying pollutants from neighboring regions, since there are not own significant sources of emissions of acid gases. Increased concentrations of ammonium and sulfates in May are usually caused by forest fires and garbage burning.

In 2005-2009, the lowest pH values in AP were observed at the Listvyanka station (Figure 11.2.24). At this rural station, inter-annual pH variations are slightly expressed, the average of five years pH is 5.01. The highest pH value (average of five years 5.92) was recorded in Irkutsk. At the background station Mondy, average pH 5.73 is lower compared to that in Irkutsk, inter-annual pH variations are small. In eastern Siberia, the lowest pH in AP was recorded in 2005, at Primorskaya station in 2007.

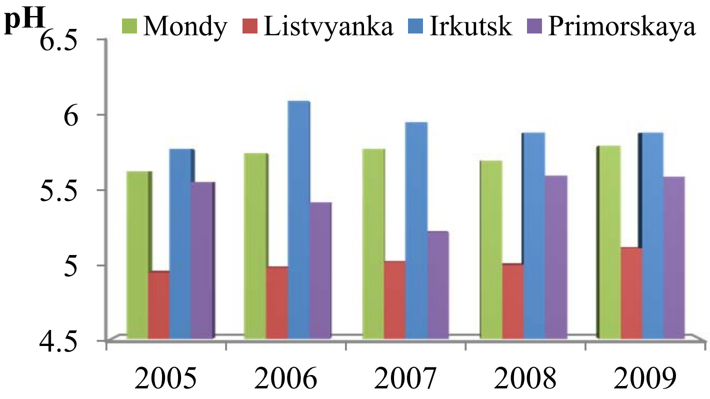


Figure 11.2.24. Annual variations (2005-2009)of pH in the atmospheric precipitations.

At all stations, except for Primorskaya, pH is higher in AP of cold season (Figure 11.2.25). The average for 2005-2009 pH in cold and warm seasons were as follows: in Irkutsk 6.38 and 5.58, in Listvyanka 5.21 and 4.85, at Mondy 6.05 and 5.48, at Primorskaya 5.57 and 5.44 respectively. There are not any specific patterns in pH dynamics, although in 2009 at all stations except for Irkutsk pH slightly increased compared with 2005.

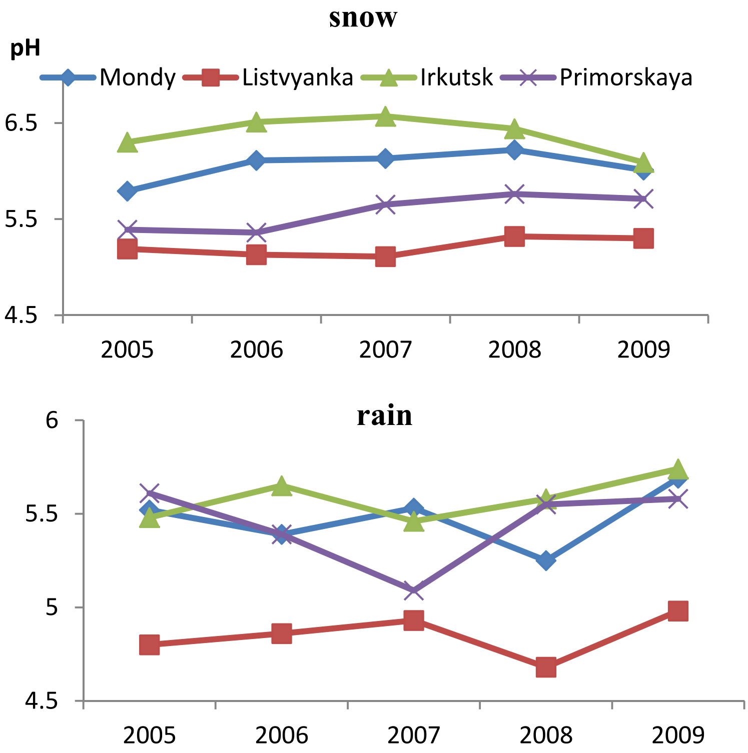


Figure 11.2.25. Annual variations (2005-2009 average) of pH in the atmospheric precipitations of warm and cold seasons.

In seasonal pH dynamics, there was the minimum in February-April. The maximum was recorded in Listvyanka and Primorskaya in October, in Irkutsk and Mondy maximum was registered in June and July (Figure 11.2.26). Inter-annual pH dynamics is shown on Figure 11.2.27. The lowest pH in AP were measured at the Listvyanka and Primorskaya sites in 2006 (May and November), at Irkutsk station in 2008 (June), at Mondy station in 2007 (July).

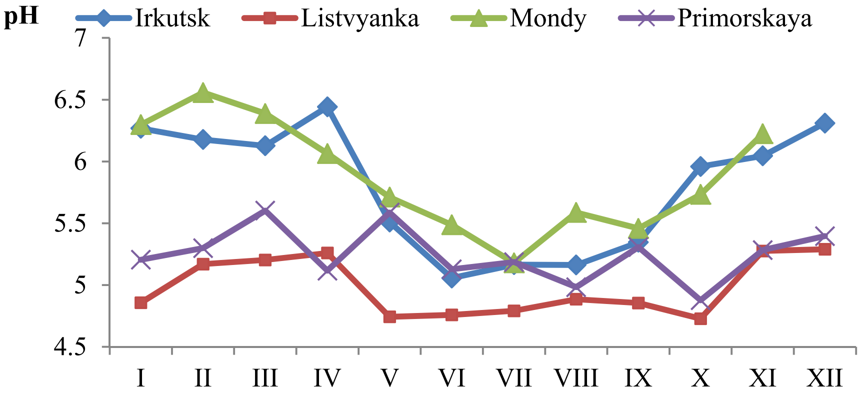


Figure 11.2.26. Seasonal dynamics (2005-2009) of the average weighted pH values in the atmospheric precipitations.

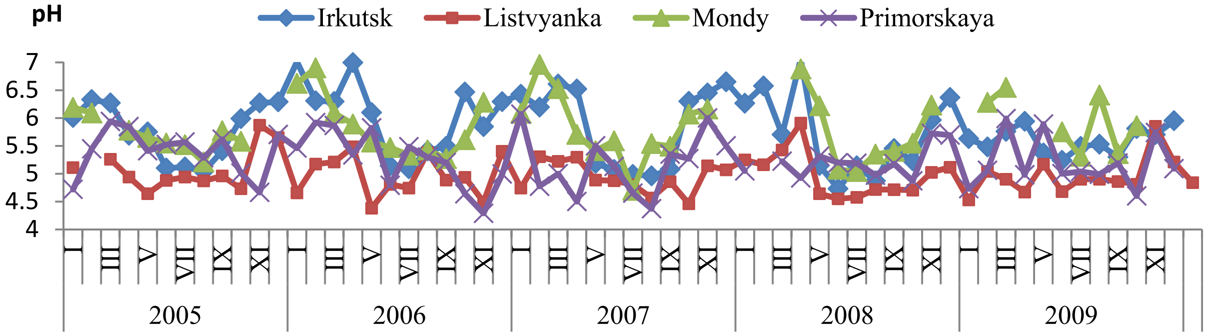


Figure 11.2.27. Annual variations (2005-2009) of the average weighted pH values in the atmospheric precipitations.

During the five-year observation period, on average 57% of precipitations at Listvyanka station had pH below 5.0. Most often there were acid precipitations in 2005, most rare – in 2009 (Figure 11.2.28). At the stations Primorskaya and Irkutsk, there was much less acid precipitations: on average 29 and 16% respectively.

Repeatability of pH in precipitations at the monitoring stations of the atmosphere is shown on Figure 11.2.29.

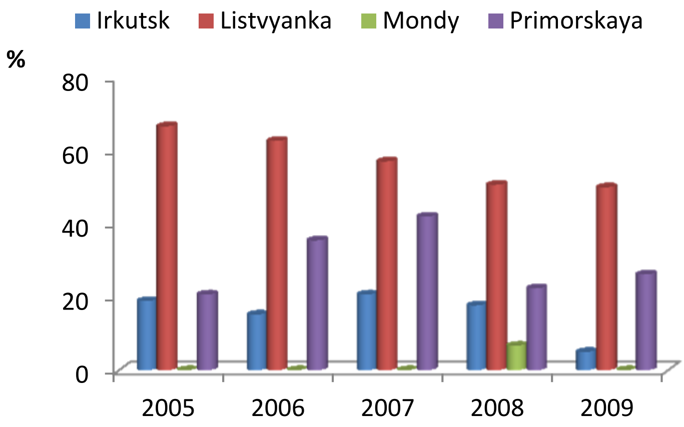
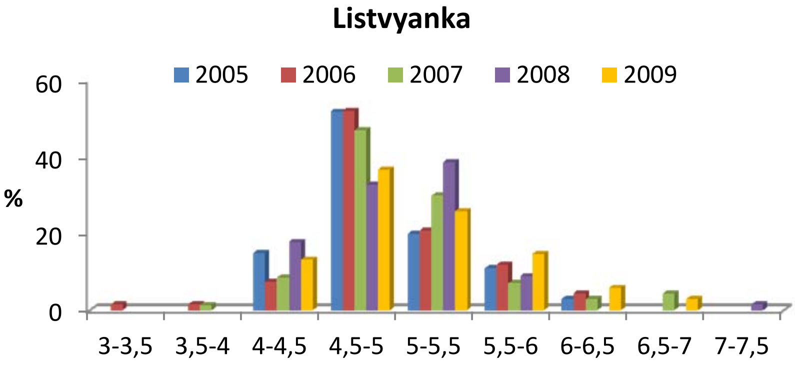


Figure 11.2.28. Annual variations (2005-2009) of the percentage of precipitations with pH<5.0.



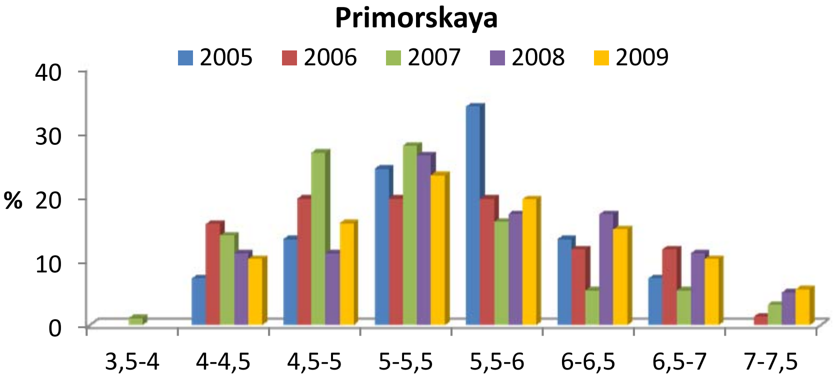


Figure 11.2.29. Repeatability of different pH values in the precipitations at Listvyanka and Primorskaya sites.

Wet deposition of ions at the monitoring stations in eastern Siberia and Primorsky Territory for 2005-2009 is shown in Table 11.2.4. The highest amount of ions was deposited at Primorskaya station because of the highest amount of precipitations at this site (Figure 11.2.30). The ion fluxes with precipitations in the city of Irkutsk 2.5 times exceeded those in Listvyanka due to higher concentrations of ions in AP. The least flux of ions was deposited at the background station Mondy (Table 11.2.3, Figure 11.2.30). It is 9.5 times less compared to that at Primorskaya station.

Fluxes of sulfates and nitrates at Primorskaya station 2.5-4.1 times exceeded those in Listvyanka (Figure 11.2.31). At Primorskaya station, the highest deposition of total amount of ions, nitrates, sulphates, and hydrogen ions was recorded in 2007, when rainfall was the highest for the entire period of observations (Figure 11.2.30).

Table 11.2.3. Wet deposition of ions at the EANET monitoring sites, kg.ha^{-1}.yr^{-1}

Year	HCO$_3^-$	SO$_4^{2-}$nss	NO$_3^-$	Cl$^-$	Na$^+$	K$^+$	Ca^{2+} nss	Mg^{2+}	NH$_4^+$	H$^+$	Sum
Irkutsk											
2005	6.3	15.3	6.2	2.8	1.2	0.8	5.5	0.8	3.4	0.04	42.5
2006	6.9	8.9	3.7	1.6	0.8	1.1	4.3	0.5	1.6	0.03	29.4
2007	7.1	15.6	5.4	2.2	1.1	1.7	5.0	0.7	2.9	0.06	41.9
2008	8.4	19.5	5.6	3.0	1.2	1.8	6.2	0.8	3.3	0.09	50.1
2009	*13.2*	12.8	4.5	*3.8*	*1.9*	*4.5*	5.0	0.8	2.8	0.02	*49.5*
Ave.	**7.2**	**14.8**	**5.2**	**2.4**	**1.1**	**1.3**	**5.2**	**0.7**	**2.8**	**0.05**	**41.0**
Listvyanka											
2005	0.2	9.5	4.7	1.1	0.5	0.3	2.2	0.2	1.6	0.07	20.4
2006	0.6	7.7	3.7	0.7	0.3	0.4	1.7	0.2	1.0	0.09	16.4
2007	0.5	6.9	5.3	0.6	0.3	0.2	1.5	0.2	1.2	0.09	16.7
2008	0.3	8.1	3.7	0.7	0.2	0.5	1.3	0.2	1.3	0.09	16.5
2009	*1.3*	5.6	3.1	0.3	0.3	0.3	1.6	0.2	0.8	0.04	13.4
Ave.	**0.4**	**8.0**	**4.4**	**0.8**	**0.3**	**0.4**	**1.7**	**0.2**	**1.3**	**0.09**	**17.5**
Mondy											
2005	1.0	1.7	1.0	0.8	0.13	0.14	0.7	0.08	0.5	0.01	6.1
2006	0.9	2.2	1.2	0.6	0.13	0.15	0.8	0.12	0.2	0.02	6.4
2007	4.1	3.0	1.8	0.5	0.25	0.33	0.9	0.15	1.9	0.01	12.9
2008	1.5	1.4	1.0	0.3	0.09	0.16	0.7	0.10	0.4	0.01	5.5
2009	1.0	0.9	0.6	0.1	0.06	*0.15*	0.3	0.03	0.4	0.00	3.6
Ave.	**1.8**	**2.1**	**1.2**	**0.6**	**0.15**	**0.20**	**0.8**	**0.11**	**0.7**	**0.01**	**7.7**
Primorskaya											
2005	4.9	25.7	9.6	5.5	3.6	2.0	5.9	1.0	5.3	0.06	63.9
2006	5.4	27.3	10.7	4.0	2.4	1.3	6.2	0.8	5.8	0.09	64.0
2007	5.5	28.9	11.7	6.5	4.5	2.4	5.4	1.0	5.3	0.14	71.6
2008	3.5	21.2	11.4	5.0	2.9	1.9	4.2	0.8	5.0	0.07	56.1
2009	4.2	18.4	*9.8*	4.5	2.9	1.5	3.9	0.6	4.6	0.09	50.0
Ave.	**4.8**	**25.8**	**10.9**	**5.2**	**3.4**	**1.9**	**5.4**	**0.9**	**5.3**	**0.09**	**63.9**

During 2005-2009, the atmospheric fluxes of nitrates and hydrogen ions have increased at Primorskaya site, of potassium ions at Mondy site, of bicarbonates in Listvyanka. As to the other ions, their atmospheric fluxes have decreased since 2005 till 2009, while the total amount of precipitations has decreased compared to 2005 only in Eastern Siberia (Figure 11.2.30, Table 11.2.3).

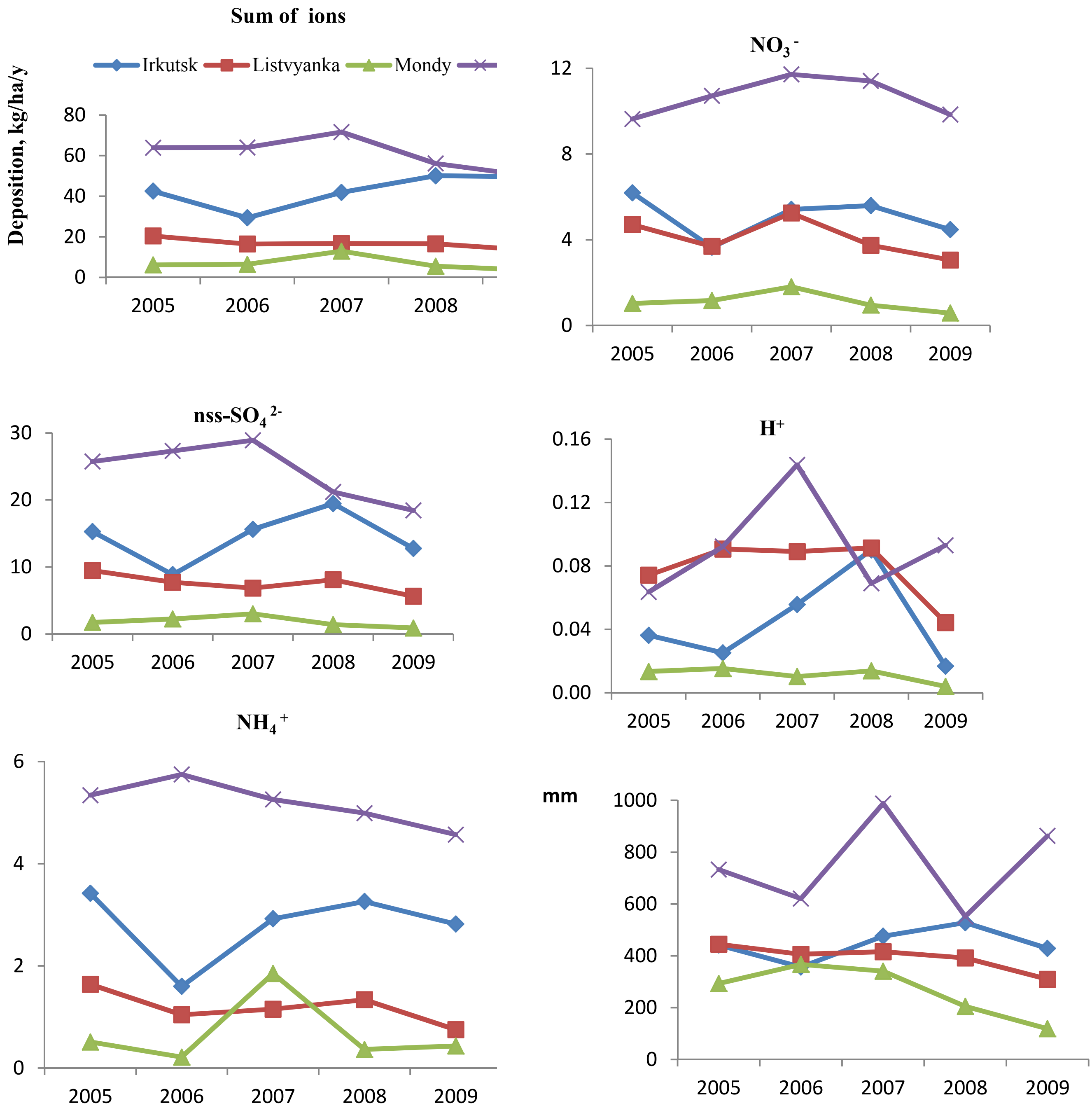


Figure 11.2.30. Annual variations (2005-2009) of wet deposition of ions and the amount of precipitations at the monitoring sites.

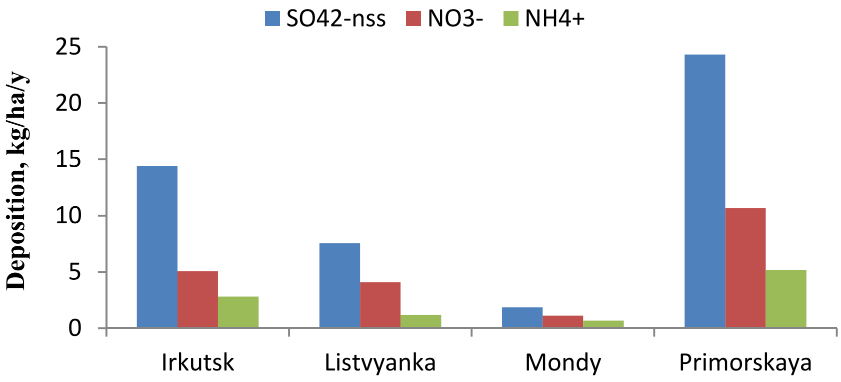


Figure 11.2.31. Average annual fluxes of ions at the monitoring stations (2005-2009).

11.2.3. Inland aquatic environment

11.2.3.1. The Pereemnaya River

The Pereemnaya River, the tributary of Southern Lake Baikal, was taken as a model object to study the influence of acidified atmospheric precipitations on the chemistry of surface waters. The river originates near the Sochor mountain (the northern slope of Khamar-Daban Ridge) at an altitude of 2,316 m. Its length is 42 km, catchment area is about 360 km^2. The average height of the basin is 1,260 m, slope of the river is 34.9. The Archean rocks represented mainly by gneisses, schists, and pegmatites are developed in the basin. Most of the basin is part of the taiga soil zone, with the soils characterized by mainly acidic pH. The river is feeded by the atmospheric precipitations. In the area of the Khamar-Daban Ridge and the Pereemnaya River basin, annual amount of precipitations is the highest for the Baikal region; it is up to 1,060-1,720 mm. The thickness of snow cover may reach 2 m.

During the study period (2005-2009), pH in the Pereemnaya River waters ranged 6.46 to 7.12. Higher pH values were recorded in summer (Figure 11.2.3.1). The increased pH values were registered in 2007 summer; during 2006 and 2009 pH was constantly below 7.

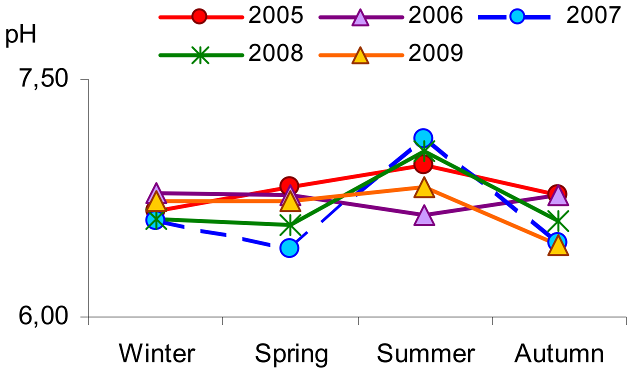


Figure 11.2.32. Fluctuations of pH values in the water of the Pereemnaya River in 2005-2009.

Waters of the Pereemnaya River are well-aerated, during a year, the concentration of dissolved oxygen ranged 10.7 to 11.9 mg.l^{-1}. Lowered oxygen concentrations are typical of the summer since the higher temperature, the less oxygen solubility in the water. In winter, oxygen concentrations are higher because there are scours formed on the ice surface.

The content of total dissolved solids (TDS) in the waters of the Pereemnaya River ranged 18.6 to 34.2 mg.l^{-1} (Figure 11.2.33.). Low TDS in these waters is a result of highly washed soils and weak chemical weathering of constituent rocks (gneisses, schists, and pegmatites) in the catchment basin of the Pereemnaya River. During a year, the maximum concentrations of major ions are typical of the winter when the river is feeding by the ground waters. The minimum concentrations are recorded in April, when there is the input of snow waters. In May, TDS in the water slightly increases (to 19-20 mg.l^{-1}) due to the input of constituents from the plant litter and the upper top soils. During the summer-autumn low water (July - September), the concentrations of major ions gradually increase (Figure 11.2.33.). As to the inter-annual variability, both TDS and the concentrations of Ca^{2+}, Mg^{2+}, HCO_3^-, and SO_4^{2-} have increased in the waters of the Pereemnaya River during recent two years. This is probably related to the low water content in the river in this period.

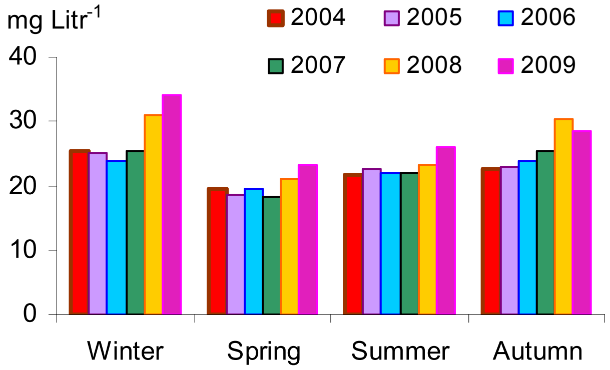


Figure 11.2.33. Seasonal TDS fluctuations in the water of the Pereemnaya River in 2004-2009.

In the 1950-60s, HCO_3^- and Ca^{2+} ions were the major components in the water of the Pereemnaya River. However, the water chemistry has gradually changed. The concentration of sulfates in the fluvial waters increases (Figure 11.2.34.), which is related to the input of acid atmospheric precipitations into the river. In snow waters in the river basin, pH does not exceed 4.6. The ratio between the equivalent concentrations of base cations C = ($Ca^{2+} + Mg^{2+} + NH_4^+ + Na^+$) and anions A = ($SO_4^{2-} + NO_3$) in snow waters has decreased 0.9 to 0.7 during the study period (Netsvetaeva, 2010). Long input of the acidified precipitations changes the relative composition of major ions in the waters of the Pereemnaya River. During recent years, the sulfate and calcium ions mainly dominate among ions in these waters. Earlier, such changes from the bicarbonate fluvial waters to the sulfate ones were registered just sporadically.

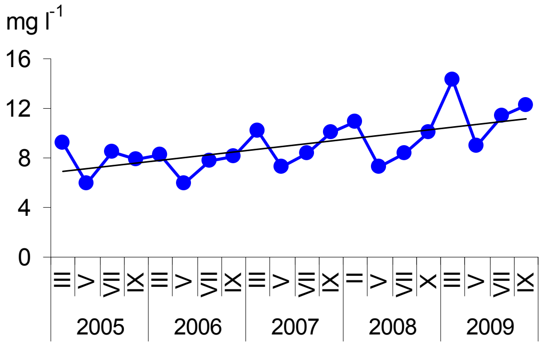


Figure 11.2.34. Variations in the concentration of sulfates in the water of the Pereemnaya River.

Seasonal dynamics of the concentration of nitrate nitrogen is constant during all years of observations. The maximum concentrations are recorded when snow is melting, because there is high content of nitrates in snow waters. The minimum concentrations were found in summer (Figure 11.2.35), which may be associated with the plankton development in the river water. Since 2005 till 2009, the content of nitrate nitrogen in fluvial water gradually increased (Figure 11.2.35); the highest concentrations were recorded in 2008 and 2009 springs.

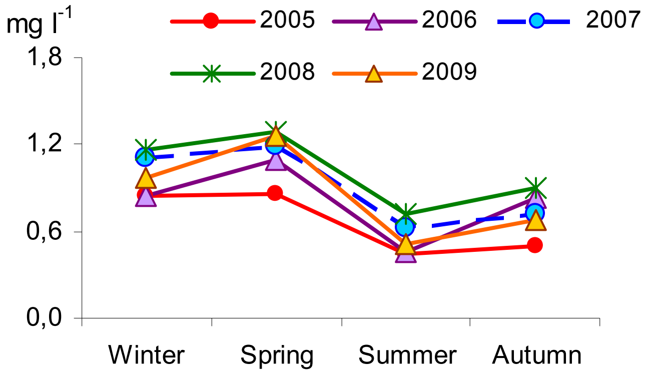
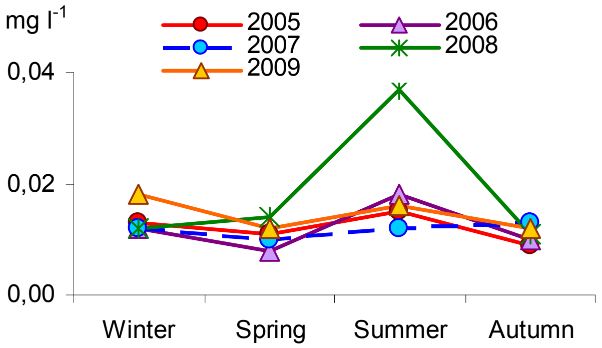


Figure 11.2.35. Seasonal fluctuations of the concentrations of nitrate nitrogen in the water of the Pereemnaya River in 2005-2009.

The concentrations of ammonium and nitrite nitrogen are low. Their seasonal and inter-annual variations are mainly related to the input from the catchment area as well as to the dynamics of the water discharge. Increased concentrations of ammonia are registered during spring tide and summer floods. The concentrations of total and mineral phosphorus in the water ranged 0.011 to 0.038 and 0.004 to 0.011 mg $PO_4^{3-}l^{-1}$, respectively. The lowest concentrations of total phosphorus were observed during the spring snowmelt, the highest concentrations – in summer (Figure 11.2.36a). Seasonal dynamics of the concentrations of mineral phosphorus is mainly opposite to that of total phosphorus (Figure 11.2.36b). As to the inter-annual dynamics of the concentrations of both total and mineral phosphorus, it is rather similar for both constituents; however their absolute concentrations vary in wide range.

a)



b)

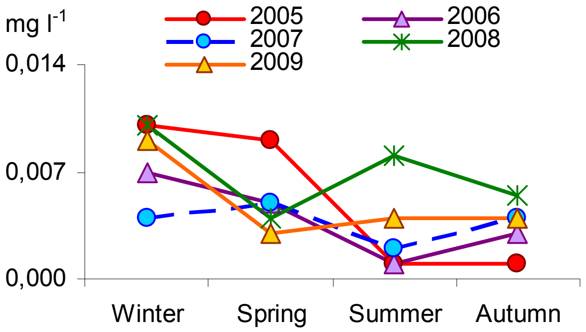


Figure 11.2.36. Seasonal variations in the concentrations of total (a) and mineral (b) phosphorus in the water of the Pereemnaya River.

To characterize the organic matter in the water, the content of dissolved organic carbon (DOC) as well as the chemical oxygen demand by permanganate oxidation (COD_{perm}) was determined. The DOC concentration in the water of the Pereemnaya River varied widely, both within a year, and from year to year (Figure 11.2.37). The lowest DOC was observed in winter, when the river is feeding by the ground waters. In spring and summer, DOC in the water increased due to its input from the watershed. The only exception was 2007, when extremely low DOC concentrations were registered in summer, which is not typical of this season. On the contrary, in 2007 autumn, DOC concentrations were the highest for the entire study period. The lowest DOC was recorded in 2009.

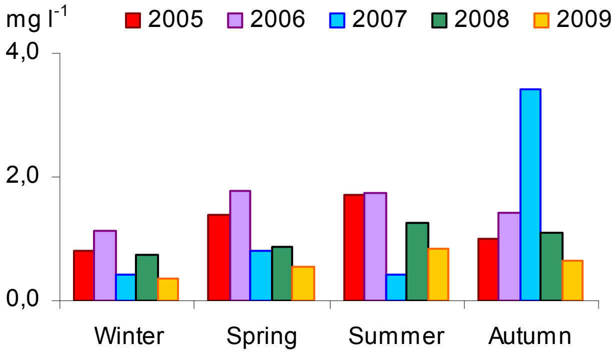


Figure 11.2.37. Dynamics of the concentrations of dissolved organic carbon in the water of the Pereemnaya River.

Thus, 2005-2009 results show that the water of the Pereemnaya River is characterized by low content of major ions and increased concentrations of sulfates and nitrate nitrogen. A gradual increase in the concentration of sulfates in the fluvial waters is established, which resulted in the fact that according to the composition of major ions, they belonged to the class of sulfate, group of calcium throughout entire 2009.

11.2.3.2. The Komarovka River

The mountain Komarovka River was taken as a model object to study the influence of the atmospheric precipitations on the chemistry of surface waters in the Primorsky territory. The river originates in spurs of the Sikhote-Alin Ridge at an altitude of 380 m above sea level. The river, which is a left tributary of the Razdolnaya River, belongs to the basin of Japanese Sea. Its length is about 66 km. Mean annual water discharge varies 0.66 $m^3.s^{-1}$ to 3.79 $m^3.s^{-1}$, averaging 1.55 $m^3.s^{-1}$. The observation site is located at the hydrological post “Tsentral’nyi” located in the area of Primorskaya station, 34 km above the city of Ussuriysk and 44 km from the river mouth.

In 2005-2009, hydrochemical observations were carried out during major seasons: in February, April, June, September, and November. The temperature of fluvial waters ranged 0.1° to 12.5°C with the minimum recorded in November and February and maximum in June. The water pH varied 7.1 to 7.45 and only in June 2009 it amounted to 6.8. The riverine water is rich in dissolved oxygen, the lowest concentration (10.7 $mg.l^{-1}$) was recorded in June, the highest concentrations (up to 13.4 $mg.l^{-1}$) are typical of the period of ice cover (November). In this season, the water temperature is declining and solubility of oxygen increases; the oxygen consumption for destruction processes also reduces.

The content of TDS is low, depending on the season it ranges 50 to 61 $mg.l^{-1}$ (Figure 11.2.38). Seasonal fluctuations of TDS are small.

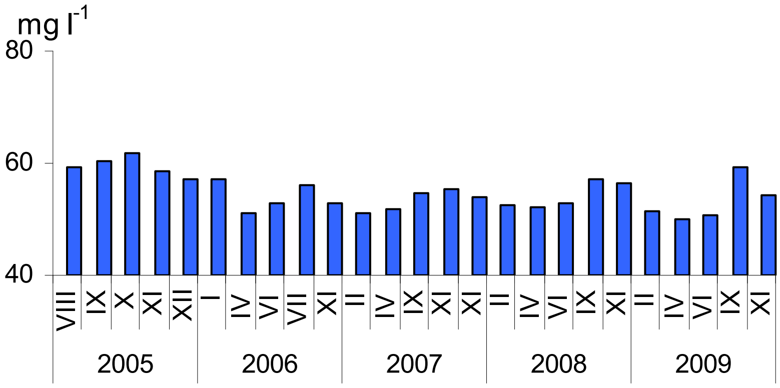


Figure 11.2.38. Fluctuations of TDS in the water of the Komarovka River, 2005-2009.

Examination of the data obtained during five years of observations (Table 11.2.4) does not give a definite picture of the distribution of ions both seasonally and from year to year. So, in 2007, the increased concentrations of calcium ions and sulfates were recorded in February, while the concentrations of bicarbonates, sodium, and potassium ions were the lowest ones. In April (during spring tide), the concentrations of calcium ions and sulfates have decreased, while those of bicarbonates and sodium ions have increased. In 2008 and 2009, the highest concentrations of sulfates were observed in April, of bicarbonates in September and November. Despite of these seasonal differences in the concentrations of major ions in different years, the water of the Komarovka River is of bicarbonate class, group of calcium during the entire period of observations.

Table 11.2.4. The concentrations of major ions in the water of the Komarovka River in 2005-2009.

Sampling time	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-
2005							
August	3.4	0.6	8.6	2.2	2.7	12.3	28.7
September	2.7	0.4	9.1	2.6	2.9	8.3	34.3
October	3.8	0.8	9.6	2.4	3.5	9.9	34.5
November	3.8	0.6	9	1.8	3.1	12.5	27.6
December	3.0	0.5	8.9	2.3	3.2	12.8	26.1
2006							
January	3.1	0.5	8.5	2.3	3.5	9.3	25
April	3.0	0.6	8.4	2.3	3.3	9.5	23.6
June	3.2	0.6	8.4	2.1	2.8	8.4	25.2
July	3.4	0.6	8.4	2.3	2.8	7.1	31.2
November	2.9	0.6	8.7	2.4	3.2	9.1	25.6

2007							
February	2.6	0.4	8.4	2.4	3.4	12.4	21.0
April	3.2	0.8	7.4	2.3	4.5	9.7	23.6
June	4.2	0.7	7.5	2.5	3.8	10.4	25.3
September	3.2	0.6	8.4	2.3	4.4	8.4	27.6
November	3.7	0.8	8.4	2.2	3.8	11.7	23.1
2008							
February	3.4	0.6	8.0	1.9	3.2	12.5	21.5
April	3.7	0.7	8.6	1.5	3.2	13.4	20.1
June	3.7	0.5	7.5	2.4	2.5	13.1	23.0
September	4.6	0.7	8.3	2.1	3.2	12.3	25.8
November	3.5	0.5	8.2	2.6	3.2	9.1	29.0
2009							
February	3.4	0.4	8.2	2.2	4.6	12.8	18.9
April	3.3	0.8	7.6	2.1	3.5	13.8	17.7
June	3.7	0.7	7.8	1.7	3.2	13.2	19.1
September	4.1	0.7	9.0	2.1	3.2	12.9	26.0
November	3.3	0.4	8.4	2.2	3.8	10.3	25.2

In the water of the Komarovka River, nitrate nitrogen dominated among nutrients throughout a year (Figure 11.2.39). In 2005-2007, the NO_3^- concentrations were more than 3 times lower compared to those registered during next two years. In 2005-2007, slight seasonal variations in the concentrations were observed, which resulted from the variations in the water content and summer consumption of nitrates by the phytoplankton. A sharp increase in the NO_3^- concentrations was observed in winter and spring 2008. In summer and autumn, the concentrations were lower for one order of magnitude. In 2009, high NO_3^- concentrations were registered during a year. We believe that this increase may be due to the input of domestic wastewaters to the river.

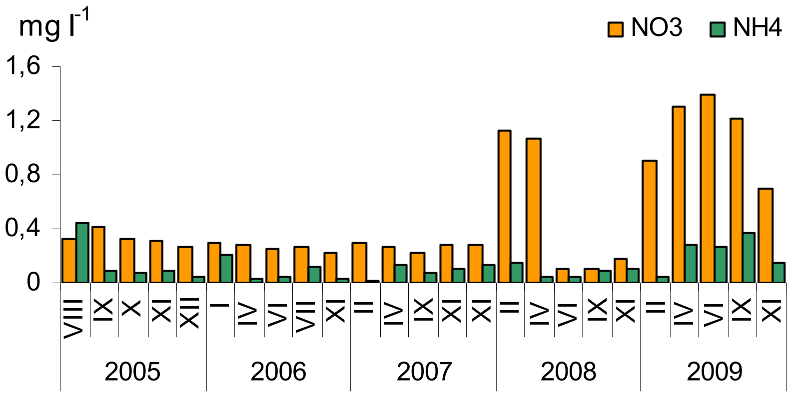


Figure 11.2.39. The concentrations of nitrate and ammonium nitrogen in the water of the Komarovka River, 2005-2009.

Regular changes in seasonal dynamics of the ammonia nitrogen concentrations are not established. In 2006 and 2008, higher concentrations were observed in winter, whereas in 2007 and 2009 during the spring tide. During the study period 2005-2009, the highest NH_4^+ concentrations were observed in 2009. The silicon concentration varied 2.9 to 3.9 mg.l^{-1}, they show no seasonal and inter-annual changes.

The concentration of mineral phosphorus in riverine waters varied over a wide range from zero to 0.072 mg.l^{-1}. In 2006, 2007, and 2009, the increased concentrations were observed during the spring tide. They decreased in the summer-autumn season. In 2008, on the contrary, the increased concentrations were observed in summer and autumn. In general, the concentrations of phosphorus and mineral nitrogen in the water of the Komarovka River have gradually increased during five years of observations.

In winter, the chemical oxygen demand for permanganate oxidation (COD_{perm}) was 0.8 to 2.4 mg.l^{-1}, being the lowest for a year (Figure 11.2.40). The increased COD_{perm} values 3.7 to 6.4 mg O.l^{-1} were recorded during the spring tide, which is associated with the input of organic matter from the watershed. It should be noted that since 2007, the content of organic substances in the water of the Komarovka River has increased in all seasons, which is probably due to the input of domestic wastewaters.

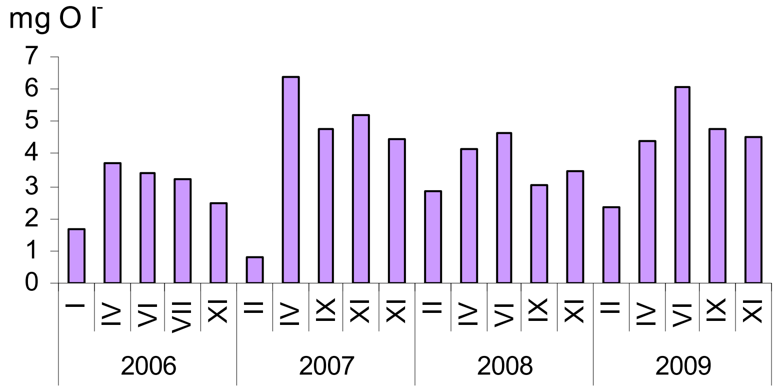


Figure 11.2.40. The chemical oxygen demand for permanganate oxidation in the water of the Komarovka River.

11.3. Conclusions

Until 2005, in the atmosphere of Eastern Siberia, there was a tendency of the total content of trace gases to decrease. In 2006-2009, their content slightly increased. In the Primorsky region, the total content of trace gases in the atmosphere was unchanged during 2005-2009 period.

In 2005-2009, the total atmospheric input of sulfur and nitrogen with gas impurities has increased at the sites located in Eastern Siberia compared to those in 2000-2004. The total input with aerosol material has decreased. At Primorskaya site, there was the opposite effect. The flux of constituents deposited with aerosol material has increased, whereas that with trace gases has decreased

The most mineralized precipitations with the average TDS 19 mg.l^{-1} fall on in Irkutsk (the urban site), the least mineralized precipitations with the average TDS 4.2 mg.l^{-1} at the background site Mondy. In Eastern Siberia, TDS in AP have increased since 2005 till 2008. In Primorsky Territory, on the contrary, TDS have reduced since 2006 till 2009. TDS in the precipitations of cold season is, as a rule, higher compared to that in rains. This is especially pronounced at the background station Mondy.

Sulfates and calcium were the major ions in precipitations at the monitoring stations, although at Mondy site the contribution of bicarbonate ions exceeded that of sulfates in cold season. In warm season at the sites Primorskaya and Mondy, a share of ammonium ion exceeded that of calcium ion; in Listvyanka a share of hydrogen ion exceeded that of calcium ion.

During 2005-2009, the most acidic precipitations were recorded in Listvyanka (pH = 5.01), the most alkaline ones in Irkutsk (pH = 5.92). In the snow pH is generally higher than in the rain. In Eastern Siberia, the lowest pHs in precipitations were observed at all sites in 2005, in the Primorsky region in 2007. At the sites Listvyanka and Primorskaya, the most acid rains fall in October, at the sites Irkutsk and Mondy in June-July. In Listvyanka, 57% of all examined precipitations had pH below 5.0, at the Primorskaya and Irkutsk sites a share of such precipitations was 29% and 16% respectively.

The highest input of ions on the underlying surface was revealed at the Primorskaya site characterized by the maximum rainfall. The least amount of ions (9.5 times less than that at Primorskaya site) was deposited at the background site Mondy, characterized by the lowest ion concentrations in the precipitations as well as by the lowest rainfall.

Mondy refers to the continental background site during ten years of observations no significant trends both in total rainfall and in the content of acid components or other ions in precipitations were recorded at this site.

The water of the Pereemnaya River is characterized by low content of major ions and increased concentrations of sulfates and nitrate nitrogen. A gradual increase in the concentration of sulfates in the fluvial waters is established, which resulted in the fact that according to the composition of major ions, they belonged to the class of sulfate, group of calcium throughout entire 2009.

The content and relative composition of major ions in the water of the Komarovka River was rather stable during five years of observations. According to the ion composition, the water belongs to bicarbonate class, group of calcium. During recent two years, the concentrations of mineral nitrogen, phosphorus, and organic matter in the water have increased, which is possible due to the increased input of domestic wastewaters into the river.

11.4. References

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Annex 11.1

National State Monitoring Activities in Asian Russia on Precipitation Chemistry and Atmospheric Deposition

A.11.1 Introduction

Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) took functions of the National Focal Point at the regular phase of EANET and has conducting all relevant monitoring and coordination activities with support of national contributors. Federal Public Institute of Global Climate and Ecology (IGCE) of Roshydromet and Russian Academy of Sciences (RAS), Moscow was designated to be the Russian National EANET Center on network development with support to NFP at national and international levels. Along with the Limnological Institute of Siberian Branch RAS (LIN), Irkutsk has acting as National EANET Data Center to organize and conduct monitoring activities and data acquiring in Asian part of Russia.

There are a large number of monitoring stations of several national networks established and operated under the umbrella of Roshydromet, and IGCE provides them various scientific and methodological supports as well as some other research institutes. The programs of some networks include the measurements of atmospheric concentrations and wet deposition of airborne pollutants. The review of national monitoring activities related to precipitation chemistry and acid deposition over the whole Asian part of Russia is presented below.

A.11.2 Baseline Information on the National Atmospheric Monitoring Activities Related to Acid Deposition

A.11.2.1 Outline of the national monitoring systems and activities on acid deposition

The Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) is a governmental authority (under the Ministry of Natural Resources and Ecology) responsible for monitoring of environmental pollution in Russia including measuring precipitation chemistry and evaluating acid depositions and their effects, pollutant contamination of the atmosphere and other related environmental media as well as climate changes.

There are several governmental monitoring networks operated in Asian Russia be related to acid deposition problems that were developed by Roshydromet as relatively independent systems of environmental quality control:

- Urban air quality control;
- National precipitation chemistry and acidity monitoring network including regional WMO-GAW stations;
- Russian EANET monitoring sites,
- Monitoring of chemical pollution of snow cover;
- Integrated background monitoring network.

Most of these networks cover the whole territory of Russia, except EANET which sites are located only in eastern Siberia and Primorsky Kray. All of the mentioned networks conduct monitoring programs which are related or immediately concerned to acid deposition problems. The review of their approaches and applied methodologies demonstrated that their performing activities are of the most correspondence to experience and capacities of EANET:

Urban air quality monitoring network was established at the beginning of 1960s for measuring air pollutants' concentrations in urban territories. After 2005, more 660 sites in 250 towns in Russia were operating where the short-time (of 20 minutes) concentrations of SO_2, NO_x, CO, SPM and other specific pollutants (defined in governmental list of hazardous contaminants) are measured three or two times per day.

Precipitation chemistry and acidity monitoring network was established at the end of 1960s. Nowadays, the Russian national monitoring system of chemical composition and acidity of atmospheric precipitations consists of about 130 sites in urban, rural and remote areas. All major ions, conductivity and pH are determined in fall-out atmospheric water after the collecting in bulk samplers during a week or month. Part of this network sites were selected as WMO-GAW regional stations to provide data for global and regional assessments under the GAW umbrella as well as to trace background level of precipitation chemistry composition.

Network of snow cover chemical composition was organized over the whole northern Russian territory to evaluate deposition of major ions and specific pollutants by the analysis of snow samples gathering through whole layer of snow accumulation every year before melting. Up to 1000 sampling sites provide spatial information on integrated dry and wet deposition fluxes during snow season. Main ions and pH are determined by wet chemistry analytical methods in regional laboratories.

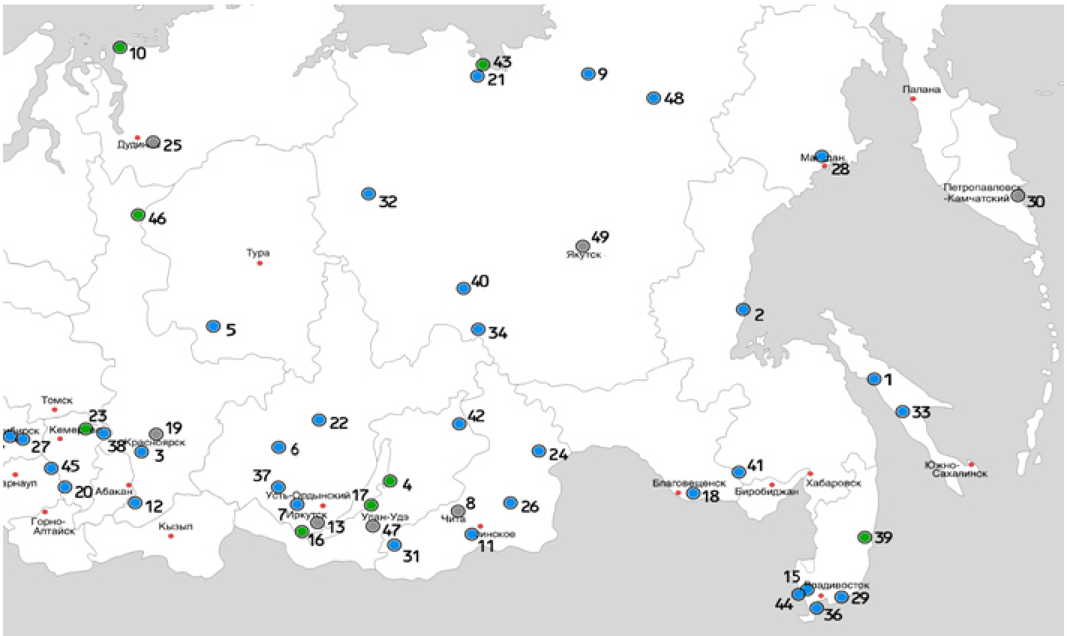
Integrated Background Monitoring Network (*IBMoN*) was established in the former Soviet Union as a specific observation system realizing an integrated approach to the assessment of a re-distribution and cycling of environmental pollutants. In accordance with principles of its design *IBMoN* was considered as a part of UNEP Global Environmental Monitoring System (UNEP/GEMS). Their monitoring programs include measurements of pollutant concentrations in different environmental media such as air, precipitation, surface water, bottom sediments, soil, snow cover, and biota in the areas out of direct anthropogenic influence (far from main urban, industrial centers or highways). The initial design project suggested opening at least 16 stations over the territory of Russia to provide comprehensive information on the state of each type of large-scale bio-geographical ecosystems over Russia under the closer cooperation with a number of biosphere reserves (BR). However, there were 9 stations as a maximum really operated in Russia during the whole period of the network activity and now only there are 5 sites conducting measurements and sampling.

A.11.2.2 National environmental monitoring program on precipitation chemistry over the Asian territory of Russia for 2001-2009

There are about 70 precipitation chemistry monitoring sites been established over the Asian territory of Russia (ATR) by the year of 2000. The location of sites situated eastwards from 80 E is presented in Annex Figure 11.1.1. The sites of background areas are highlighted by green, some of them are the part of WMO-GAW regional network (Muller *et al.*, 2007).

Manual wet-only samplers and bulk samplers are used to collect precipitation during the period of rainfall. However during winter season a wet-only sampler has low sampling efficiency (for solid snow precipitation) and therefore manual sampling is the only way to collect precipitation. Snow is sampled every precipitation event as well as rain to be merged into weekly or monthly sampling volume. Measurement parameters for rain and snow water are the same: pH, EC, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^- , HCO_3^- and Cl^- .

Analysis of samples are performed in regional laboratories. Unfortunately, there are no regular intercomparison activity been organized at the national level among the laboratories, however, for the last years most of them were involved into international inter-laboratory comparison projects within EMEP, WMO and EANET to trace their performance.



Annex Figure 11.1.1. Russian national precipitation chemistry composition and acidity network over Siberia and Far East (as for 2005): grey points is city sites; blue – urban and sub-urban (semi-rural) sites; green is remote and regional GAW sites.

A.11.2.3 Principles of data interpretation and publications

Analysis and generalization of data, their interpretation, local forecasts and evaluation of the state of the environment based on these data are annually published in a number of issues, such as annual "Review of the state and pollution of the environment in Russian Federation" and "Reviews of the state of background environmental over the territory of CIS". Reviews of the state of the environment are also annually prepared and published separately for each region of Russia. Most of them are in Russian but some of them have summary and parts translated into English.

The system of the data availability and their usage by different environment stakeholders is not developed very well. Currently, copies of each annual review are sending to a list of libraries and to all regional centers of the Federal Service on Hydrometeorology and Environmental Monitoring. Free copies of the Review could also be available upon the request. The interest to such publication is quite high and obviously much higher than very limited number of copies which are usually published. Reviews for several last years are also available in the Internet.

A.11.3 Results on Precipitation Chemistry and Acid Deposition in Asian Russia

This review was prepared based on published reports on the environmental pollution in Russian federation prepared by Roshydromet and IGCE annually from 1990s (Roshydromet, 2010, 2009; IGCE, 2009).

A.11.3.1. Precipitation chemistry at regional GAW stations.

The WMO-Global Atmosphere Watch (GAW) regional network includes three Russian stations over Asian territory of Russia (ATR): Turukhansk (No 46 at Annex Figure 11.1.1), Khuzhir (Baikal lake, No.17) and Ternej (Sikhote-Alin' BR IBMoN station, Far East, No.39). At the national level a criterion for the data condition was defined to select stations as relevant to background level: average values of mineralization (the sum of all ions) in precipitation must not exceed 15.0 $mg.l^{-1}$ for long-term observations. At the station Khamar-Daban, the mineralization exceeded mentioned value three consecutive years, and amounts of ion sums there in 2009 were 1.5-3 times higher than ones at other background stations.

Compared with previous years the data from Khamar-Daban station were excluded from the analysis, and this site is also not recommended to be as regional GAW-PC station.

Annual average values of total mineralization in precipitation had variations from 4.5 to 12 mg.l^{-1} at Asian remote territories been relatively low in 2008 (comparing with 2005-2006) and slightly higher in 2009 (Annex Table 11.3.1). Maximum monthly values were much higher raised up to 36 and 78 at Khuzhir and Ternej, correspondently.

Annex Table 11.3.1. Weight-averaged annual concentrations (mg.l^{-1}) of major ions in precipitation at the GAW regional monitoring sites in Asian Russia, 2008-2009.

GAW-PC station	Year	Precipitation, mm	SO_4	Cl	NO_3	HCO_3	NH_4	Na	K	Ca	Mg	∑ions	pH	*EC*, µSm.cm^{-1}
			mg.l^{-1}											
Turukhansk (46*)	2008	593.40	1.76	1.04	0.69	3.48	0.47	0.95	0.30	0.50	0.32	9.51	6.20	19.70
Turukhansk (46)	2009	427.80	3.40	1.00	0.60	2.90	0.70	0.70	0.30	0.40	0.80	10.80	6.30	23.30
Khuzhir (17)	2008	222.50	1.56	0.52	0.45	1.82	0.30	0.16	0.15	0.31	0.27	5.55	6.40	28.20
Khuzhir (17)	2009	239.40	1.90	1.10	0.60	3.70	0.40	0.90	0.40	0.20	0.50	9.80	6.30	28.80
Ternej (39)	2008	1,376.40	1.80	0.78	0.69	0.12	0.25	0.42	0.12	0.28	0.06	4.56	5.20	22.20
Ternej (39)	2009	1,175.30	2.20	1.00	1.00	0.60	0.40	0.60	0.20	0.50	0.10	6.80	5.20	33.80

See No and location of sites at Annex Figure 11.1.1.

The total mineralization at Russian GAW-PC sites was mostly determined by three compounds: sulfate, hydrocarbonate, and nitrate. They provided more 56 to 69% of total sum (by weight, in average) in rain water. The chlorine content was detected in the limits of 0.4-1.3 mg.l^{-1}.

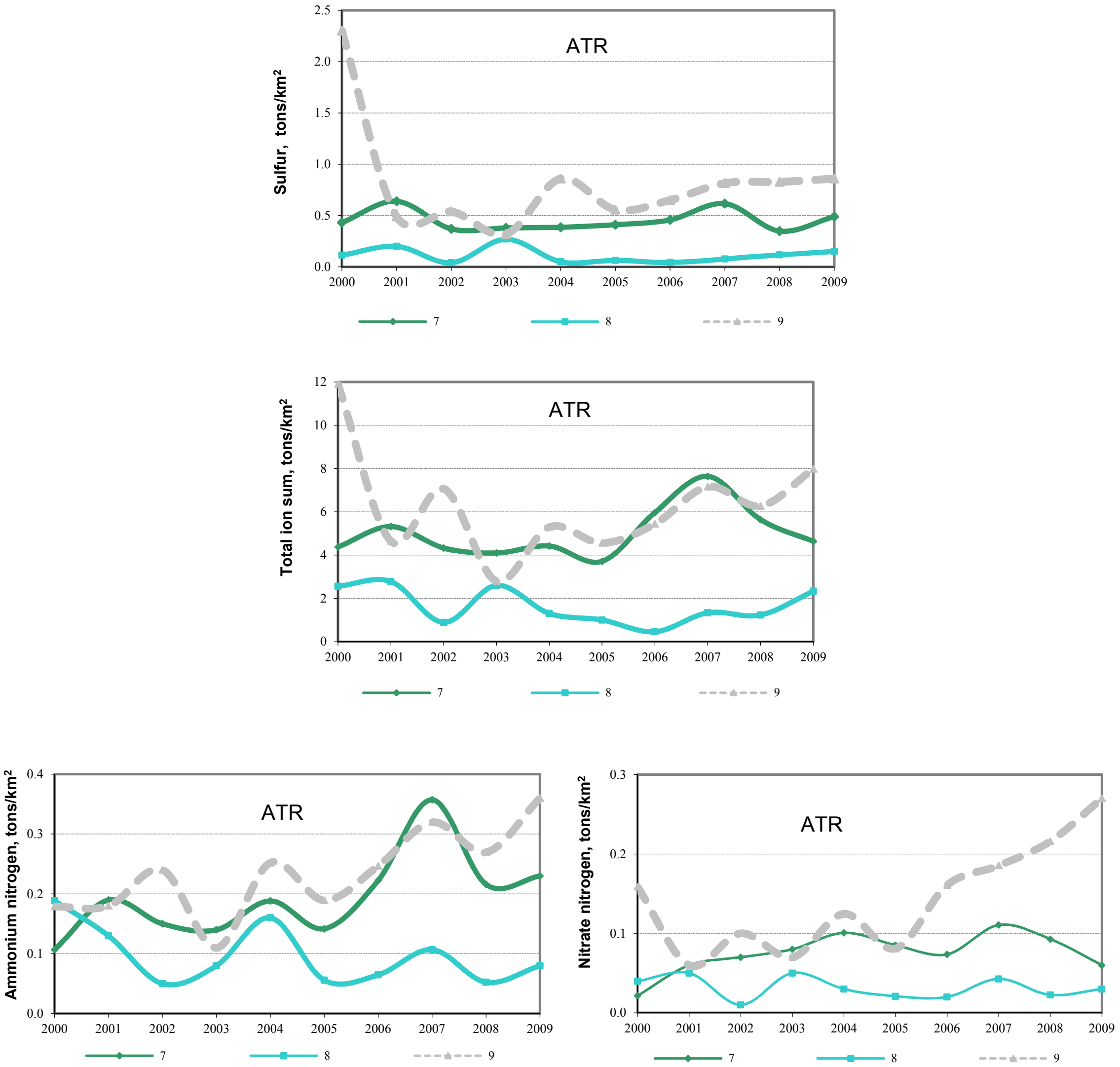
Sulfates dominate in the rain water at Turukhansk and Ternej (at Pacific coast) while there is a precipitation of bicarbonate type at other ATR stations. The nitrate content in rain water at the stations of Russian Asia-Pacific region is less than in European Russia. It may reflect higher continental dust particles and sulfate in the air of the eastern regions of Russia.

Generally, the total wet deposition of sulfur in Russia are more than of nitrogen (Roshydromet, 2010) and it's more evident at the Asian GAW-PC sites where total nitrogen fall-out is much less than sulfur one (Annex Table 11.3.2). The deposition of ammonium nitrogen in ATR is about 2.5-4.0 times greater than of nitrate nitrogen.

Annex Table 11.3.2. Wet deposition of sulfur, nitrogen and all ions (*M*) at the GAW regional sites in Asian Russia, 2009.

Станция	S (SO_4)	N (NO_3)	N (NH_4)	∑N	M	S/∑N	N(H)/ N(O)
	Tons.km^{-2}						
Turukhansk (49)	0.49	0.06	0.23	0.29	4.6	1.70	3.92
Khuzhir (17)	0.15	0.03	0.08	0.11	2.3	1.39	2.34
Ternej (39)	0.86	0.27	0.36	0.64	8.0	1.36	1.33

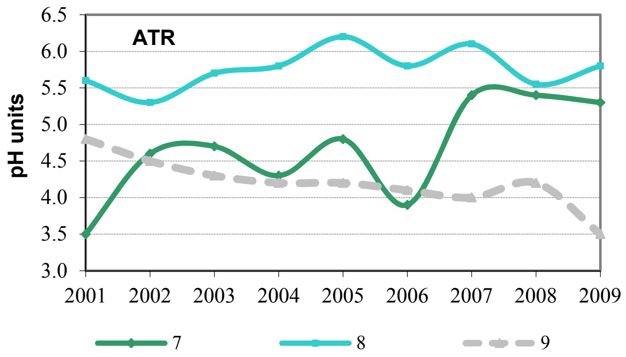
Quantitative changes in precipitation chemical composition and deposition fluxes over the past 10 years can be traced by inter-annual variations of average wet deposition of sulfur and nitrogen, as well as of the amount of ions (Annex Figure 11.3.1).



Annex Figure 11.3.1 Multi-year variations of annual wet deposition at GAW-PC regional monitoring sites for 2000-2009 (tons.km^{-2}): Turukhansk (7), Khuzhir (8) and Ternej (9).

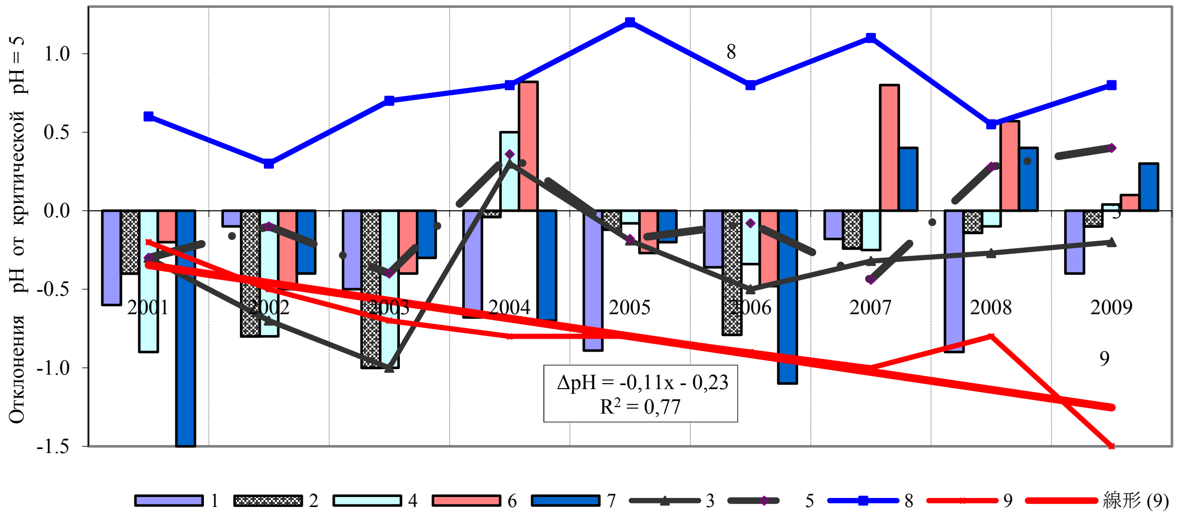
For the remote areas the total wet deposition depends on the amount of annual precipitations which are changed year to year being highest at Ternej (more than 1100 mm.yr^{-1}). However, the deposition amounts of total ion sum and ammonium nitrogen were the similar with Turukhansk with less precipitation amounts.

Annual sulfur depositions in Russian GAW-PC stations were 0.1 to 0.9 tons.km^{-2} being higher in mountain areas. At Pacific coast (Ternej) the nitrate nitrogen deposition increases gradually from 2005 with average rate about 0.05 tons.km^{-2}.yr^{-1}, and it is well correspondent to changes of pH at this GAW-PC station (Annex Figure 11.3.3). Ammonium nitrogen fall-out is mostly increasing at the most of Asian Russian sites for the last 8 years. It might be marked the range of Cl wet deposition became evidently narrowed to be about 0.2-1.2 tons.km^{-2} in 2009.



Annex Figure 11.3.2. Minimum values of pH at the remote GAW-PC sites for 2001-2009: Turukhansk (7), Khuzhir (8) and Ternej (9).

The pH=5.0 was proposed as the critical value for natural water acidity because lower this level there is a change of some precipitation properties as well as appearing toxicity of natural waters. The absorption of carbon dioxide decreases in rain waters with pH < 5.0 while the solubility of calcium carbonate is increased, so the concentration of hydrocarbons is reduced to detection limit of analysis. The three typical marches are presented in Annex Figure 11.3.3. The pH in precipitation has never been above the critical value for the whole period at the Khuzhir station (*line 8*). As the contrast there was a steady increase of precipitation acidity in Ternej (*line 9*) for 2001-2009 which can be characterized by linear expression ($\Delta pH = -0.11x - 0.23$). An initial pH of precipitation in Ternej (located in the Sikhote-Alin' BR) was approximately 4.75, and it had reached pH=3.5 in 2009 by decreasing on about 0.11 pH units annually.



Annex Figure 11.3.3. A deviation of pH minimum from critical value (pH=5.0) for 2001-2009 at the Russian GAW-PC sites: European – Ust-Vym (1), Voeikovo (2), Oka-Terrase BR (3), Voronezh BR (4); European mountains – Caucasus BR (5) and Shadzhatmaz (6); Asian – Turukhansk (7), Khuzhir (8) and Ternej (9).

A.11.3.2. Precipitation chemistry at rural and urban territories

The data of 142 stations for the state 2009 review of the Federal network for chemical composition of atmospheric precipitation in the Russian Federation (PCC-network) with 6 new stations comparing with 2008. It's evident the stations are distributed among seven state federal districts (FD) very unevenly, therefore there are 21 sites in Far Eastern Federal District (covering Yakutiya, Chukotka, Kamchatka, Magadan oblast, Primorsky Kray and other four administrative regions along Amur river) and 36 stations in vast Siberian FD (regions eastern from 70 E to Far Eastern FD).

Weight-averaged annual mineralization (sum of ions) had varied for Asian Russia from 19 to 27 mg.l^{-1} in 2009 (Annex Table 11.3.3) been narrowed than earlier (17.4 to 39.4). When the data from northern Siberia (Dikson and Norilsk-city) are excluded the mean total sum of ions and sulfate were decreased by factors of 1.2-1.5. The samples with mineralization less than 3 mg.l^{-1} are corresponding to 10% of precipitation amounts.

Annex Table 11.3.3 Average weighted ions concentrations in the precipitations of Asian Federal Districts, 2009.

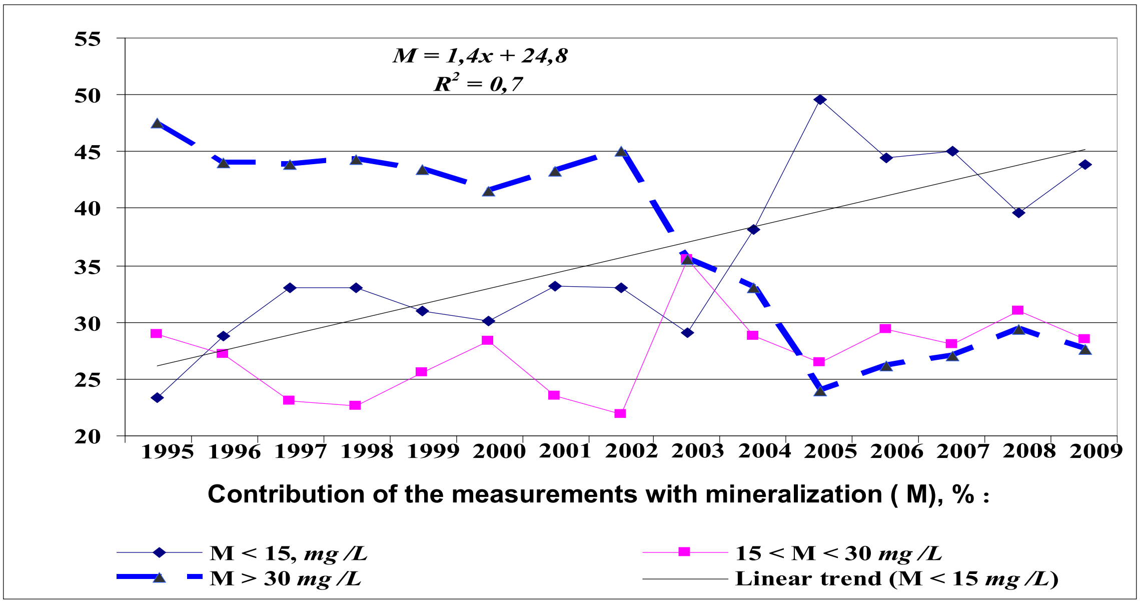
Federal District	**Precipitation,** mm	**SO_4**	**Cl**	**NO_3**	**HCO_3**	**NH_4**	**Na**	**K**	**Ca**	**Mg**	**Zn**	**$\sum_{ions}$**	**pH**	**EC** µSm.cm^{-1}
		mg.l^{-1}												
Far Eastern	641,9	4,0	3,2	1,0	5,8	0,5	1,6	0,4	1,1	1,0	0,1	18,8	6,0	36,9
Siberian	515,6	4,7	2,0	1,4	9,1	0,6	1,2	0,7	1,4	1,9		23,0	6,6	53,0
Siberian (incl. Norilsk)	515,6	7,2	2,0	1,4	9,5	0,7	1,2	0,7	1,6	2,4		26,8	6,6	60,7

The territories of Siberian FD can be attributed to medium level of overall air pollution while far Eastern FD might be characterized as comparatively lower. Hydrocarbonates are dominated everywhere in rain water ranging from 30% to 41% of total mineralization, then other compounds are ranked from sulfate to chloride and nitrates. The contribution of sulfate is up to 21% over Far Eastern FD and 27-29% in Siberia. The content of nitrate varies slightly and contributes at the level of 5-10% in all districts.

Observing the changes of ion input to acidity (in *eq* units) the dominated influence of sulfate has left in the past decreased from 35-40% (in *eq* units) to 25% in Siberia. The concentrations of nitrogen compounds are stable for the last five years at the level of 20-25% in total ion sum.

Cations consist about 30% of the ions in precipitation with dominating in most cases by calcium which measured up 9-15%. In the Far East DF rain water contains more sodium, or about the same amount as calcium to contribute about 10% of total mineralization.

The character of changes in share of the ion sum measurements on Annex Figure 11.3.4 for three intervals of values: not more than 15 mg.l^{-1}, 15 <M ≤ 30 and more than 30 mg.l^{-1} for the period 1995-2009. It is obviously that the proportion of precipitation with a mineralization less than 15 mg.l^{-1} (defined as regional background levels) has increased gradually especially after 2003. Its part was evaluated as 25% in 1995 with averaged grow about 1.4% per year. The low-mineralized ("cleaner") precipitation consisted up to 50% of all measured ones in 2009 with correspondent decreasing of probability of high-mineralized atmospheric waters (M > 30 mg.l^{-1}).



Annex Figure 11.3.4. A tendencies of changes for 1995-2009 in ion sum measurements for the intervals of values: not more than 15 mg.l^{-1}, 15 <M ≤ 30 mg.l^{-1}, and more than 30 mg.l^{-1} The linear trend was provided for the measurements with M> 15 mg.l^{-1}.

Ranges of annual wet deposition for ion sums were evaluated as 10.3-19.7 tons.km^{-2} while of sulfate was less than 2.8-4.6, of nitrogen (both nitrate and ammonium) was less than 0.8 tons.km^{-2} The average values of hydrocarbonate deposition were approximately equal to the sum of sulfate deposition, nitrate, chlorine, and ammonium fluxes.

Annex Table 11.3.4. Wet deposition of sulfur, nitrogen and all ions (*M*) over the Federal district areas in Asian Russia, 2008.

Регион	S (SO_4)	N (NO_3)	N (NH_4)	∑N	M	S/∑N	N (H)/N (O)
	tons.km^{-2}						
Northern and Central Siberia	1,4	0,2	0,3	0,5	17,1	2,7	1,6
Southern Siberia	1,5	0,3	0,4	0,7	15,3	2,3	1,3
Eastern Siberia	1,2	0,2	0,3	0,5	10,3	2,7	1,5
Far East	1,0	0,3	0,4	0,6	12,2	1,6	1,4

A.11.4 Conclusions on the results of national monitoring

Russian national precipitation chemistry monitoring network at the Asian territory of the country consists of different categories of sites: regional GAW-PC and background monitoring; semi- and urban sites, where pollutants concentration in both air and precipitation are measured. Analysis and generalization of monitoring results, their interpretation, and evaluation of the state of the environment are annually published in governmental reports and review issues. The most comprehensive of them is “Review of the state of the environmental pollution in Russian Federation” which is also available in the Internet.

Long term monitoring data obtained from the background monitoring stations over Russia shows that generally for Russia territory there is a tendency for decreasing of sulfur and increasing of nitrogen concentrations. At the same time, sulfur concentration in precipitations of Siberian and Far

East background regions stays practically stable and even a bit increases during more than 30 year's measurement period.

Predominated ions in the precipitation of Russian Asia are sulfate and bicarbonates. Far East region is characterized by the lowest pH value with the tendency to decrease for the last 10 years. Values of pH in precipitation in Ternej (located in the Sikhote-Alin' BR) had reached pH=3.5 in 2009 by decreasing of about 0.11 pH units annually.

Average concentrations of ion sum in urban sites are higher than in rural or remote areas over Asian Russia while nitrogen compounds in urban sites almost the same or slightly higher. The proportion of precipitation with a mineralization less than 15 $mg.l^{-1}$ (defined as regional background levels) has increased gradually with averaged grow about 1.4% per year up to 50% of all measured ones in 2009 with correspondent decreasing of probability of high-mineralized atmospheric waters ($M > 30$ $mg.l^{-1}$).

A 11.5. References

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Muller, G., R. Artz, *et al*. 2007. WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008-2015. WMO-GAW No 172. Geneva, WMO-TD No 1384, 96 p.

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ROSHYDROMET. 2009. Review of the state and pollution of the environment in Russian Federation for 2008. Moscow, 182 p.

Status of Acid Deposition in Thailand

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12.1. Basic Information on National Monitoring Activities

12.1.1. Outline of the activities on acid deposition and national monitoring plan

Since acid deposition monitoring includes a wide range of activities, such as monitoring of both wet and dry depositions and monitoring of ecological impacts on soil, vegetation and inland aquatic environments which involve various agencies in Thailand, a Sub-committee on Acid Deposition Monitoring Network in Thailand was established by the Pollution Control Board to oversee the implementation of acid deposition monitoring activities in Thailand. The committee is composed of representatives from various relevant agencies as shown in Figure 12.1.1. The Air Quality and Noise Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment serves as the secretariat of the committee.

The Air Quality and Noise Management Bureau has been appointed by the Royal Thai Government as the National Focal Point and National Center in Thailand for the Acid Deposition Monitoring Network in East Asia (EANET). Thailand participated in the preparatory phase of (EANET) during 1998-2000 and, then jointly announced to implement EANET activities on a regular basis together with the others nine East Asian countries, namely People's Republic of China, Indonesia, Japan, Republic of Korea, Malaysia, Mongolia, the Philippines, Russian Federation, and Vietnam at the Second Intergovernmental Meeting held in Japan during October 25-26, 2000.

There are 6 EANET monitoring sites: two urban (Bangkok and Samutprakan), three rural (Pathumthani, Chiang Mai and Nakhon Ratchasima) and one remote site (Kanchanaburi). The monitoring activities have started since the year 2000.

In addition to the EANET activities, the Pollution Control Department established 4 other acid deposition monitoring stations cover all regions of Thailand. They include: 1. Nakhon Pathom (West), 2. Chonburi (East), 3. Ayutthaya (Central), and 4. Songkhla (South). The regional stations monitor both wet and dry depositions. The wet deposition daily sampling is collected by the automatic wet sampler, and the dry deposition employs the four-stage filter packs collected every 10 days in monthly basis. The monitoring work has started since the year 2000. The status of acid deposition in Thailand presented in this report is based on the EANET data only.

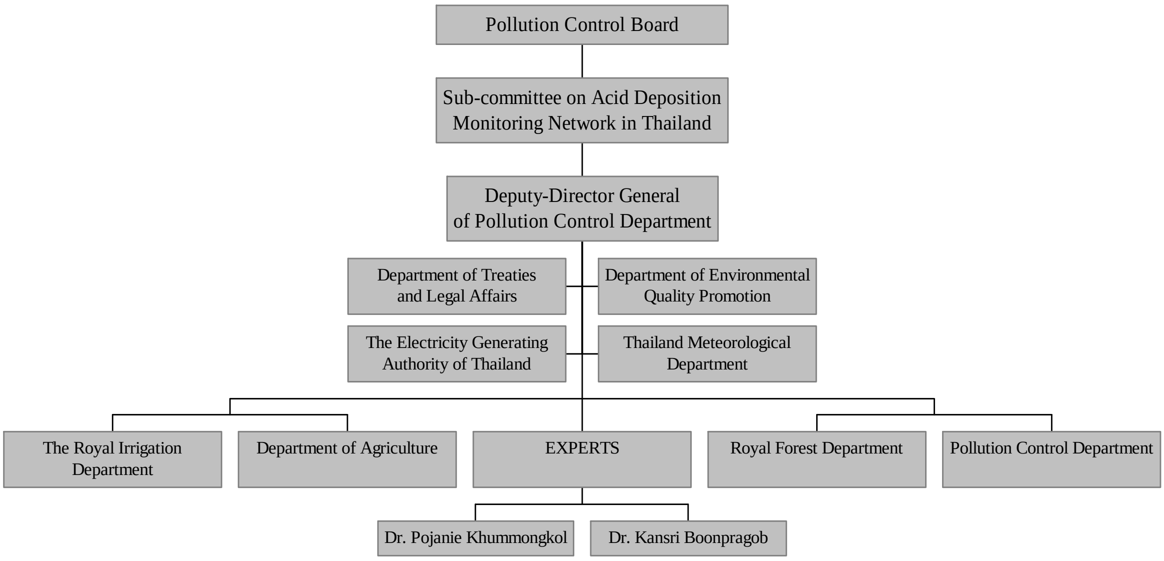


Figure 12.1.1. Organization chart of sub-committee on acid deposition monitoring network in Thailand.

12.1.2 Monitoring program from 2005 to 2009

National Monitoring Plan from 2005 to 2009 in Thailand were developed by the Air Quality and Noise Management Bureau, Pollution Control Department which included the monitoring sites, activities and monitoring parameters, the responsible agencies as well as the monitoring schedule. The monitoring and analysis schemes included four major environmental aspects; Wet and Dry Deposition, Soil and Vegetation and Inland Aquatic Environment, are carried out in line with EANET monitoring guidelines.

12.1.3 Monitoring stations

There are 6 designated EANET monitoring sites as shown in Figure 12.1.2.

(1) Vachiralongkorn Dam (VLK), Kanchanaburi province (Remote Site): monitoring for wet deposition, dry deposition are monitored by automatic analyzer and filter pack, Inland aquatic environment and soil and vegetation are included.

(2) Pollution Control Department/The Public Relation Department (PCD/PRD), Bangkok (Urban Site): PRD site monitoring for dry deposition by automatic analyzer and Filter pack and PCD site is monitoring for wet deposition Both sites located in the same area

(3) Thai Meteorological Department (TMD), Samutprakan Province (Urban Site): monitoring for wet deposition and dry deposition by automatic analyzer.

(4) Environmental Research and Training Center (ERTC), Pathumthani Province (Rural Site): monitoring for wet deposition and dry deposition by filter pack.

(5) Chiang Mai University (CMU)(Mae-Hia Campus), Chiang Mai Province (Rural Site): monitoring for wet deposition and dry deposition by filter pack.

(6) Sakaerat Silvicultural Research Station (SKR), Nakhon Ratchasima Province (Rural Site):
monitoring for wet deposition and dry deposition by filter pack.

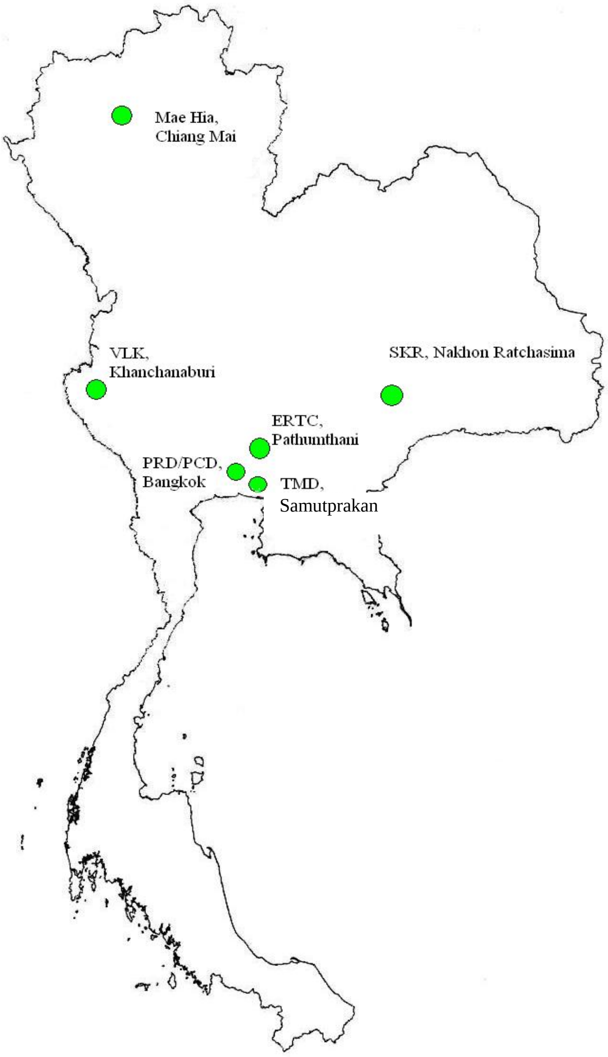


Figure 12.1.2. EANET monitoring sites in Thailand.

12.1.4 Sampling and measurements

The measurement parameters and monitoring interval are summarized as shown in Table 12.1.1.

12.1.4.1. Wet deposition monitoring

Wet deposition is monitored by "wet-only-sampler" resulted in concentration and rain gauge is used for precipitation measurement. Twenty-four hours composite samples are collected in polyethylene collecting bottles. Rain samples are weighted and then analyzed for chemical composition (EC, pH and ionic species). If the samples cannot be analyzed in one day or need to be transferred from the sampling location to the laboratory, the samples are required to refrigerate at 4^{o}c or kept in a box with freezer packs and sent to the laboratory on daily basis.

12.1.4.2. Dry deposition monitoring

Atmospheric gases concentrations, *i.e.* SO_2, NO_x and O_3, are measured by automatic analyzers at the Vachiralongkorn (VLK) Dam, PRD and TMD. At VLK site, SO_2, NO_x and O_3 are monitored for 2 weeks, three times per year in March, July and November. At TMD and PRD site, SO_2, NO_x and O_3 are monitored continuously all year round.

Atmospheric gases and aerosols concentrations are measured by filter pack method at CMU, PCD, SKR and ERTC. Duration of sampling in every site except VLK is 10 days/sample continuously. For VLK the sampling frequency is three times per year (14 days/sample) at the same monitoring period using an automatic analyzer. That samples are analyzed for SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Mg^{2+} and Ca^{2+} in particulate (aerosol) and analyzed for SO_2 , HNO_3 NH_3 and HCl in gas phase.

12.1.4.3 Soil and vegetation monitoring

Soil and vegetation are monitored at Vachiralongkorn dam in every 3 years. Samples are collected from two locations at Vachiralongkorn dam, namely Vachiralongkorn dam location and Vachiralongkorn-Puye location. The locations of both sites are shown in Figure 12.1.3.

12.1.4.4 Inland aquatic environments monitoring

Inland aquatic environments are monitored at Vachiralongkorn dam, Kanchanaburi. samples are collected from two locations in Vachiralongkorn reservoir, namely Ban Pong Chang (BPC) and Ban Pang Pueng (BPP) station. The sampling frequency for Inland Aquatic Environment is every 3 months, 4 times per year in March, June, September and December. The locations of both sites are shown in Figure 12.1.3.

Table 12.1.1. Measurement parameters and monitoring interval.

Items	Measurement parameters	Monitoring interval
Wet deposition	1. pH, 2. EC, 3. NH_4^+, 4. Na^+, 5. K^+, 6. Ca^{2+}, 7. Mg^{2+}, 8. SO_4^{2-}, 9. NO_3^- , 10. Cl^- , 11. Amount of precipitation 12. CH_3COO^-, 13. $HCOO^-$, 14. PO_4^{3-}	- daily
Dry deposition		
- Automatic analyzer	1. SO_2, 2. NO_2, 3. NO, 4. O_3, 5. Particulate Matter (PM_{10})	- hourly
- Filter pack	1. HNO_3 , 2. SO_2, 3. NH_3, 4. HCl, 5. Aerosol	- 10 days
Soil	1. pH (H_2O), 2. pH (KCl), 3. exchangeable (Na^+, K^+, Ca^{2+}, Mg^{2+}), 4. Exchangeable acidity, 5. ECEC, 6. Moisture content	every 3 years
Vegetation	1. Observation of tree decline, 2. description of trees	every 3 years
Inland aquatic	1. Water temperature, 2. pH, 3. EC, 4 alkalinity, 5 NH_4^+,	
environment	6. Na^+, 7. K^+, 8. Ca^{2+}, 9. Mg^{2+}, 10. SO_4^{2-}, 11 NO_3^- , 12. Cl^- ,13. NO_2^- ,PO_4^{3-} , COD, transparency	4 times/year

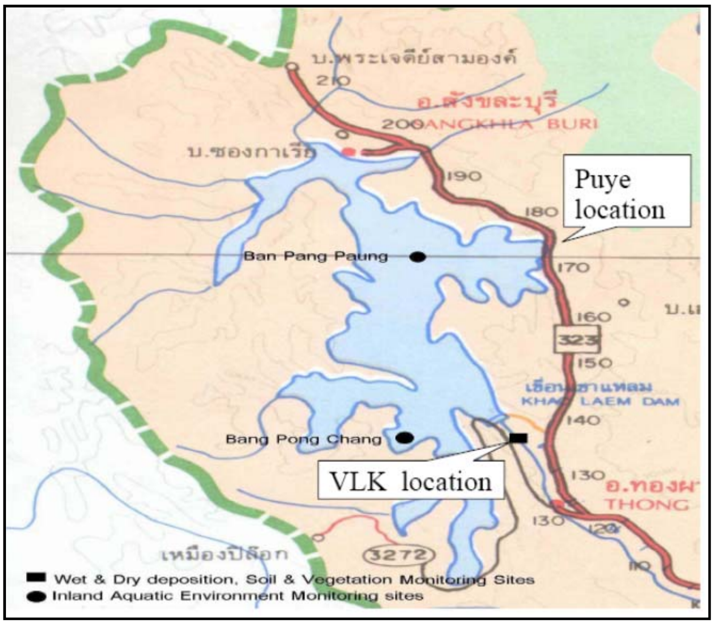


Figure 12.1.3. Inland aquatic environment and soil and vegetation monitoring locations at Vachiralongkorn dam.

12.2. State of Acid Deposition in Thailand

12.2.1 Atmospheric deposition

12.2.1.1 State of wet deposition

The status of wet deposition in Thailand presented in this report was analyzed base on the EANET data of 5-year period from 2005 to 2009. In 2005, there are 5 EANET monitoring sites: two urban sites (Bangkok and Samutprakan), two rural sites (Pathumthani and Chiang Mai), and one remote site (Kanchanaburi). One more remote site which is located at Sakaerat Silvicultural Research Station (SRS) in Nakhon Ratchasima has been added for EANET monitoring sites since 2006.

(1) Precipitation and ionic balance

The monthly average rainfall during the study period (2005-2009) depicted the wet and dry season in Thailand. The distribution of rainfall at all monitoring sites was illustrated in Figure 12.2.1, i.e., April – October (wet season) and November – March (dry season). The highest average rainfall amount per year during the period was found in urban sites, approximately 1700 mm with the peak in September-October. At rural sites, the average rainfall per year over the study period was approximately between 1200 mm-1400 mm with the peak in May and September. While at the remote sites, the average rainfall amount per year was found between 1,400 mm–1,600 mm with wider period of the rain, i.e., March through October. The total amount of precipitation in different monitoring sites during the study period is shown in Table 12.2.1.

The ratio of total cations to that of anions (Σcations/Σanions) is an indicator for the completeness of measured parameters. If all the major anions and cations are included in the measurement, the ratio of Σcations/Σanions was expected to be unity. In this study, the sum of cations was represented by Na^+, NH_4^+, K^+, Mg^{2+}, $Ca^{2+}$and H^+ and the sum of anions were represented by Cl^-, NO_3^-, SO_4^{2-}, $HCOO^-$, CH_3COO^-, PO_4^{3-} and HCO_3^-. It should be noted that the HCO_3^- was determined by calculation and it will be accounted in the total anions only in the case of pH value was greater than 6.0. The ratio of total cations to that of anions (Σcations/Σanions) was ranged between 1.0 and 1.9. The ratio Σcations/Σanions at rural site in Chiang Mai was found close to the unity, contrary to the one of remote site in Kanchanaburi that found 1.9. The balance of cations and anions at different monitoring sites was shown in Figures 12.2.1-12.2.4. The anions deficiency was observed almost at all sites.

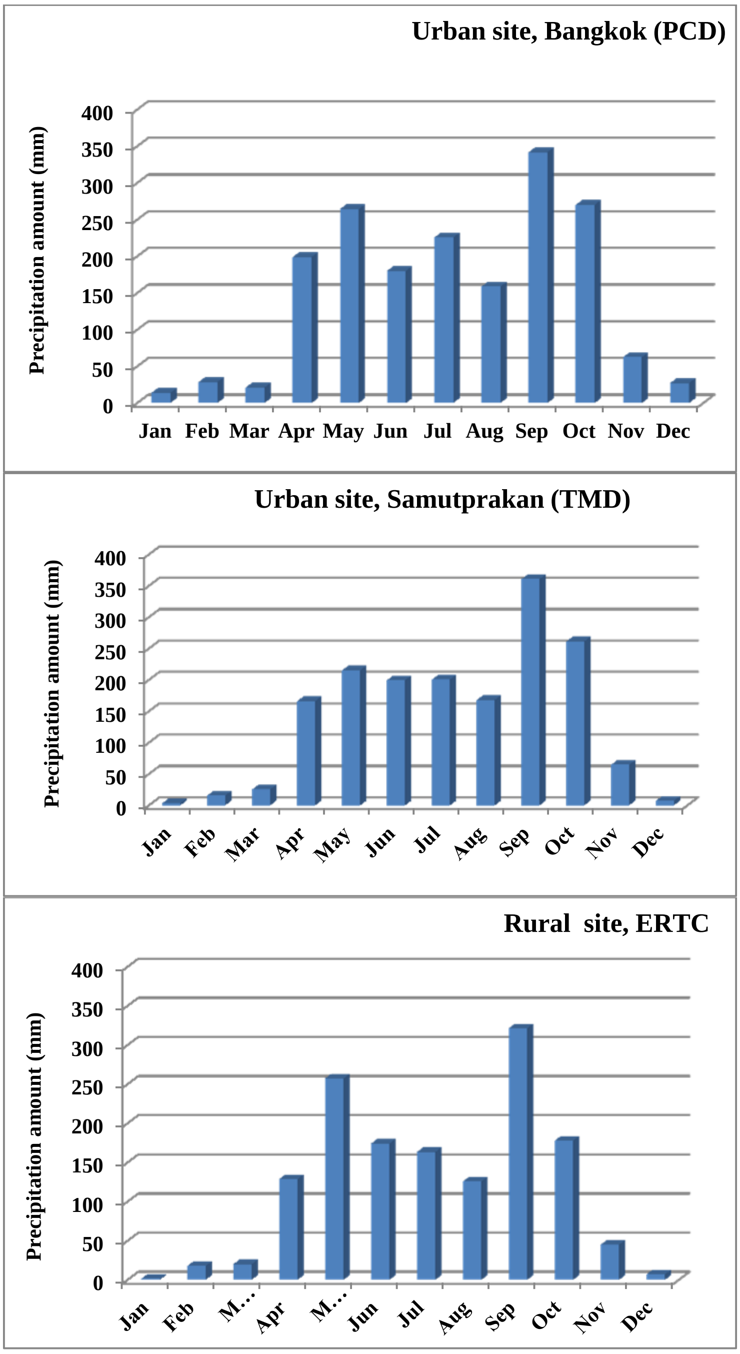


Figure 12.2.1. Monthly average rainfall during the study period 2005-2009.

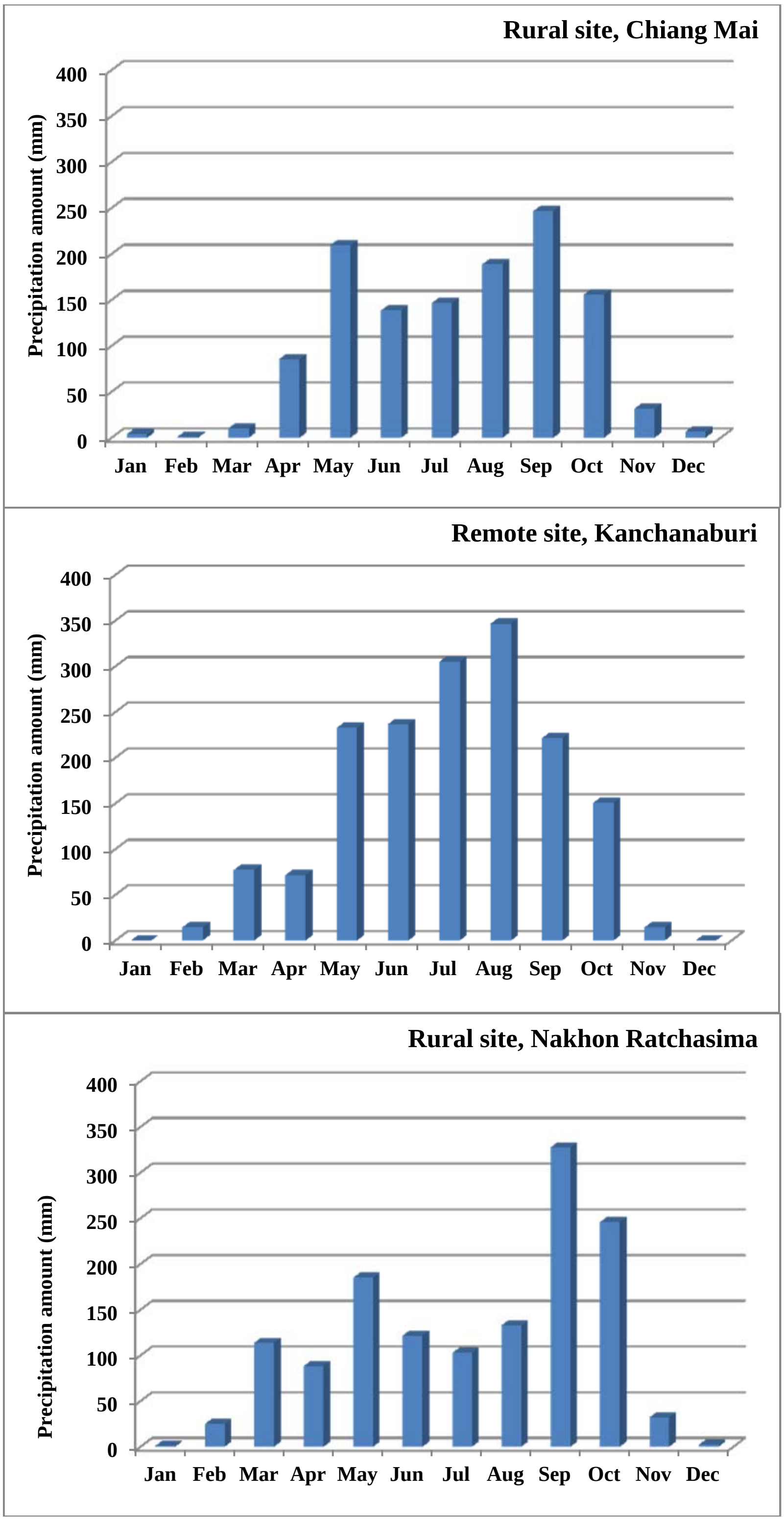


Figure 12.2.1. Monthly average rainfall during the study period 2005-2009 (continued).

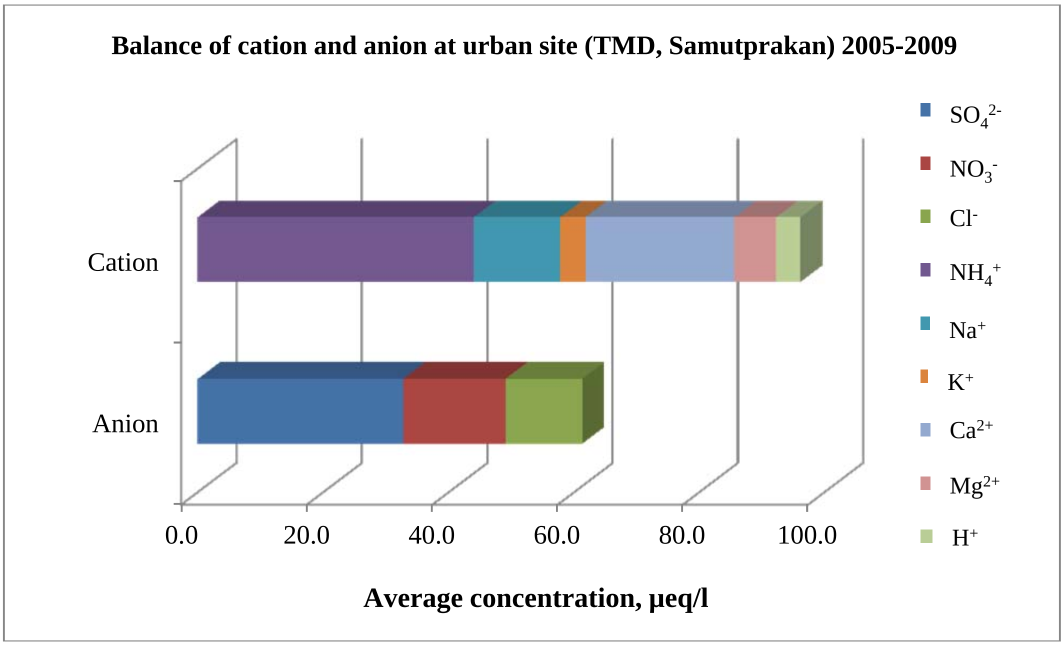
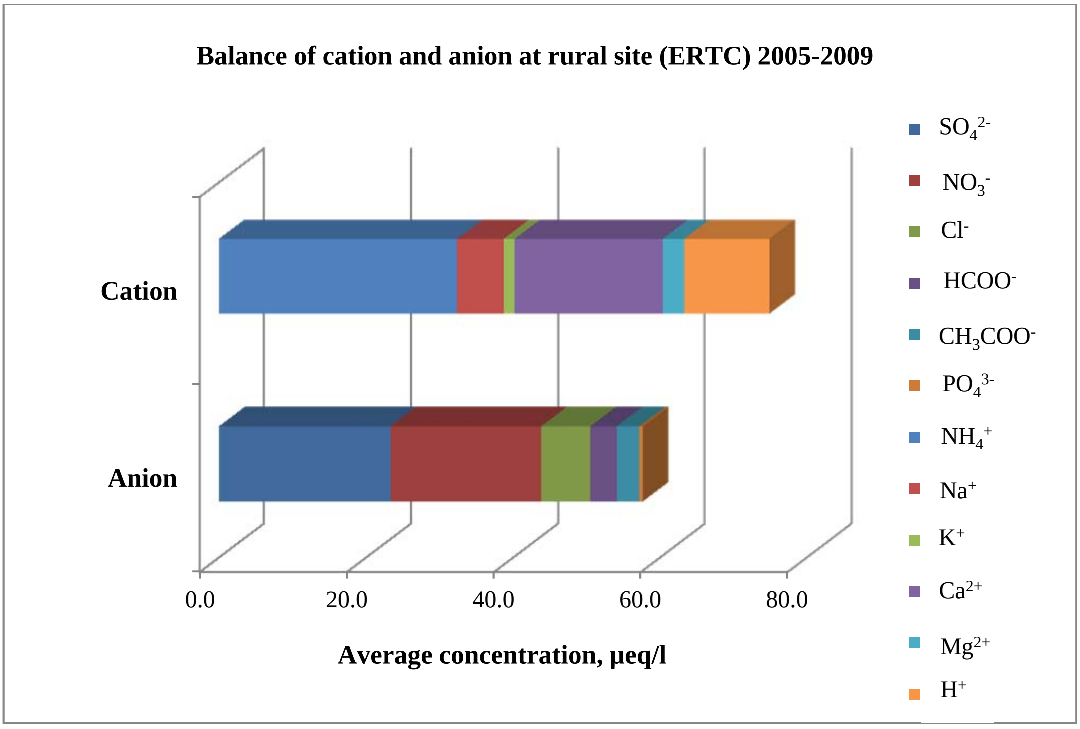


Figure 12.2.2. Balance of cation and anion at urban sites 2005-2009.



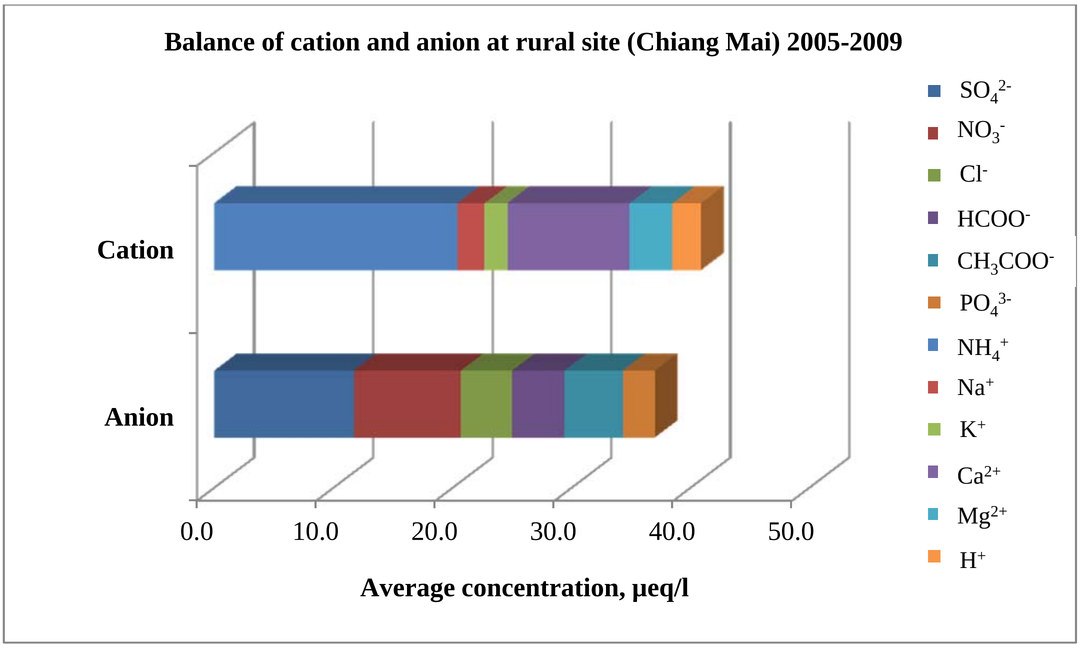
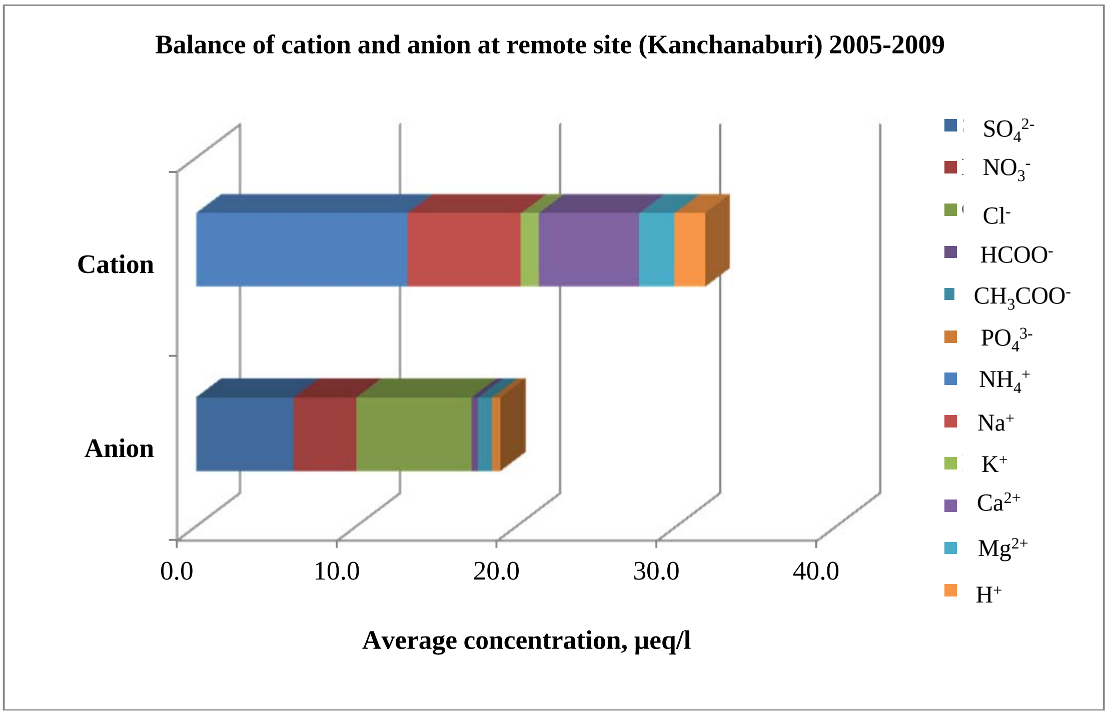


Figure 12.2.3. Balance of cation and anion at rural sites 2005-2009.



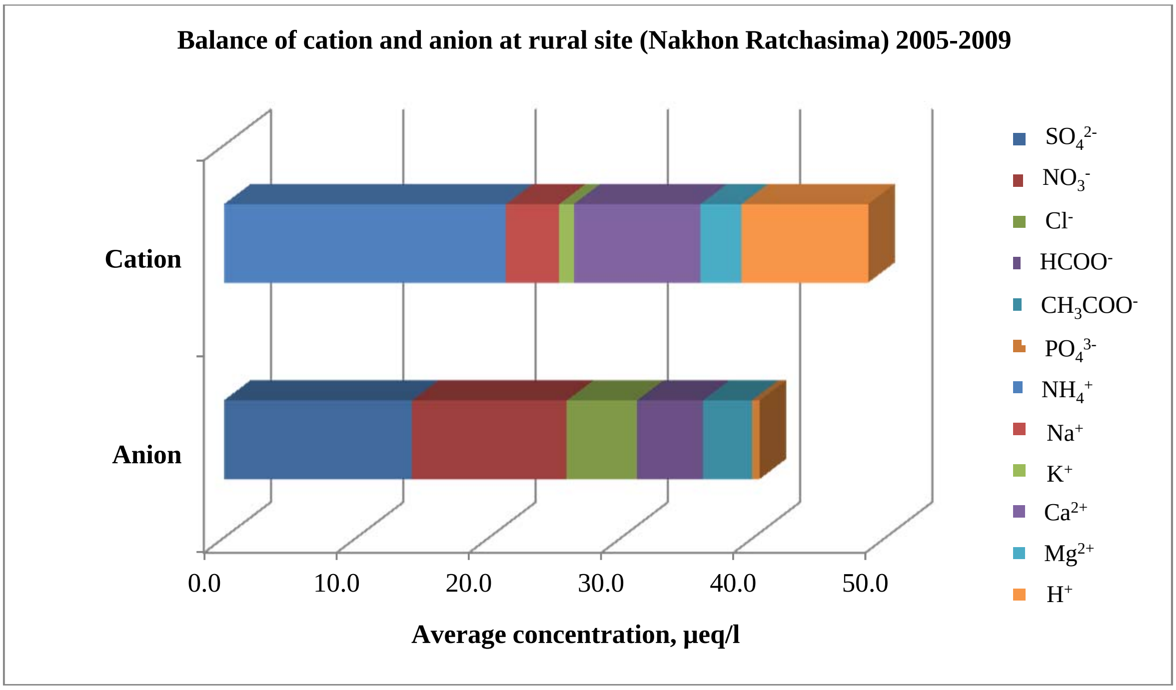


Figure 12.2.4. Balance of cation and anion at remote sites 2005-2009.

Table 12.2.1. Total precipitation amount (mm) at the monitoring stations during 2005-2009.

Year	Urban (Bangkok-PCD)	Urban (Samutprakan -TMD)	Rural (Pathumthani)	Rural (Chiang Mai)	Remote (Kanchanaburi)	Rural (Nakhon Ratchasima)
2005	2006.4	1551.5	1268.2	1427.4	1657.9	
2006	1588.6	1370.3	1576.3	1419.8	1282.4	1144.7
2007	1578.1	1470	1374.6	937.5	1448.7	1382.1
2008	1775.8	1733.7	1670.3	1286.4	1961.9	1734.6
2009	2072.3	1989.2	1313.8	1052.0	1997.6	1258.9

(2) Variation of pH

The acidity of rainwater depends on the concentration of cationic and anionic species. Acidic pH reveals the presence of strong acids, such as SO_4^{2-} and NO_3^-, while neutral or alkaline pH values indicate neutralization of acids by NH_4^+ and soil dust. A frequency distribution of pH during 2005-2009 is shown in Figures 12.2.5-12.2.7. The naturally existing CO_2, NO_x and SO_2 will dissolve into the clouds and rain droplets then result in pH values of the rain in the clean atmosphere to be between 5.0 and 5.6 (Atmospheric acidity 1992). In this study, the frequency distribution showed the overall mean values of pH frequency distribution in urban areas were larger than 5.6, i.e., Bangkok-PCD pH 5.8 with n=342 and Samutprakan-TMD pH 5.9 with n=467. For rural areas the overall mean values of pH frequency distribution were lower than 5.6 at Pathumthani site (pH 5.5, n=467) and higher than 5.6 at Chiang Mai site (pH 6.1, n=485). The frequency distribution of pH at remote sites showed overall mean values of pH 6.0 with n=424 in Kanchanaburi and the overall mean values of pH 5.3 with n=408 in Nakhon Ratchasima. The annual pH volume weighted mean was calculated from the volume weighted concentration of H^+ of the rain collected daily. The volume weighted mean pH of precipitation at different monitoring sites is illustrated in Figure 12.2.8. The variation of volume weighted average of pH at urban through remote sites during 2005-2009 showed decreasing tendency of pH except for Pathumthani. The results showed pH tendency is toward acidity with no significant variation in pH values.

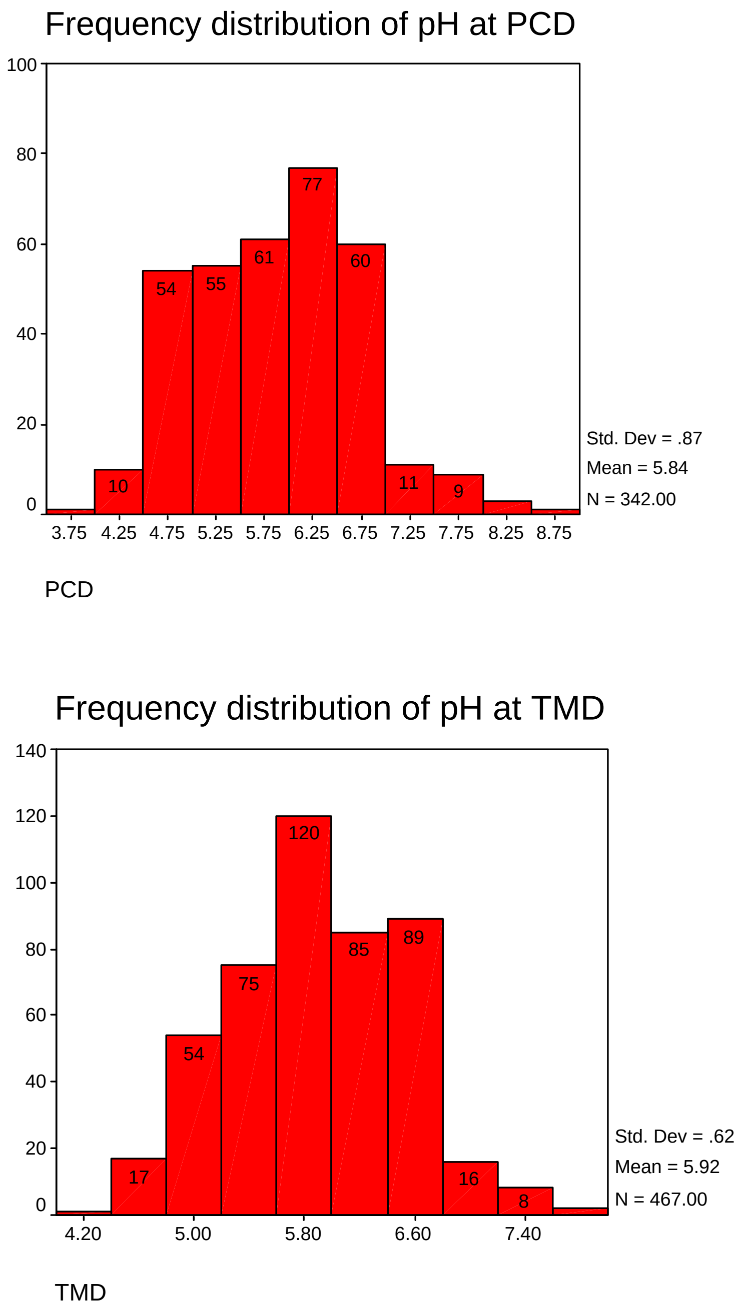
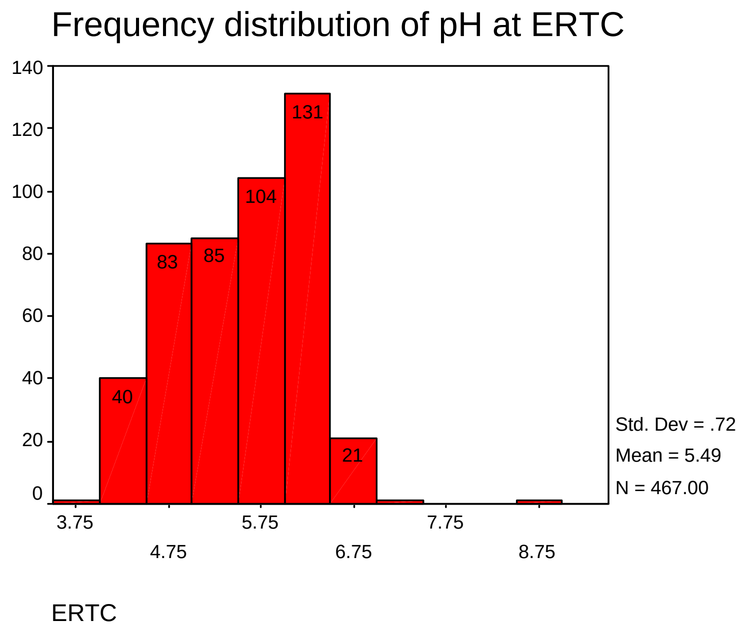


Figure 12.2.5. Frequency distribution of pH during 2005-2009 at urban sites.



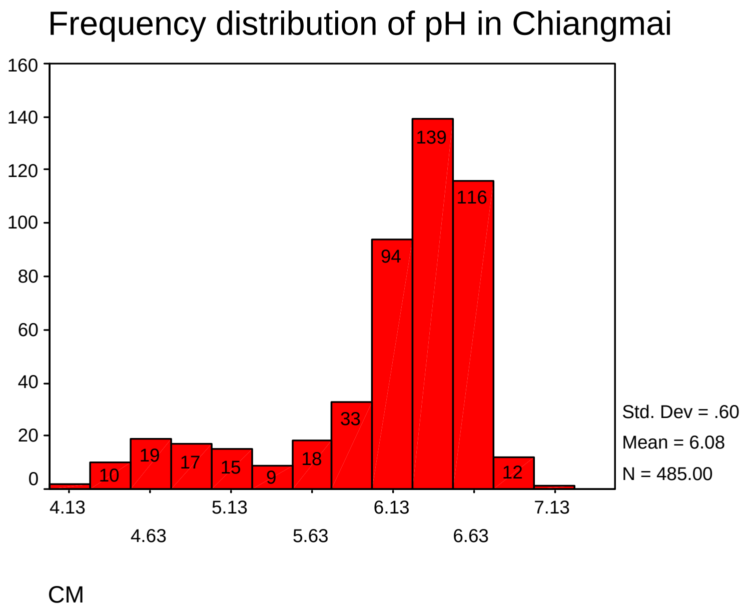
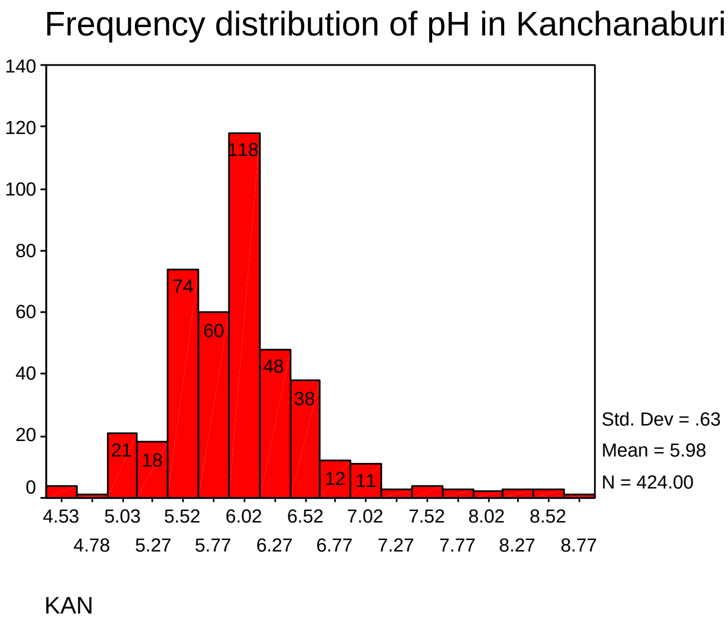


Figure 12.2.6. Frequency distribution of pH during 2005-2009 at rural sites.



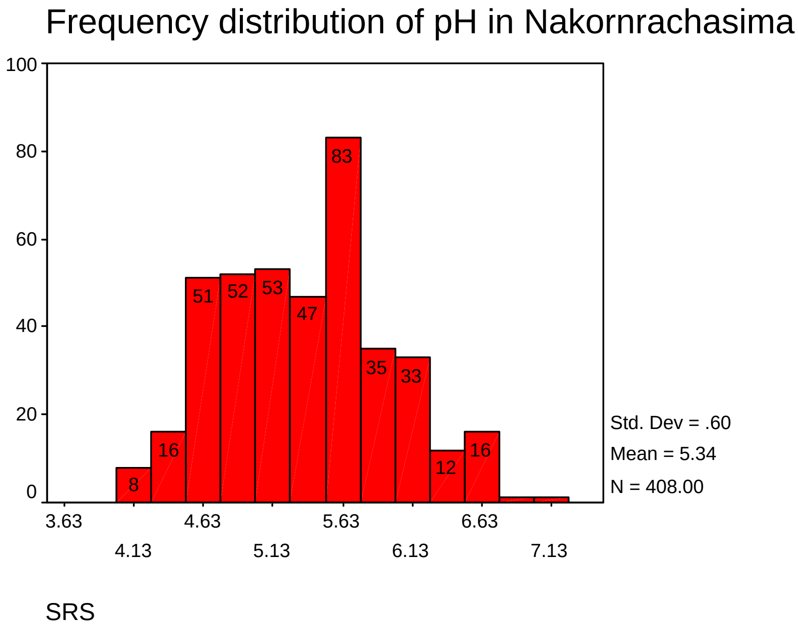


Figure 12.2.7. Frequency distribution of pH during 2005-2009 at remote sites.

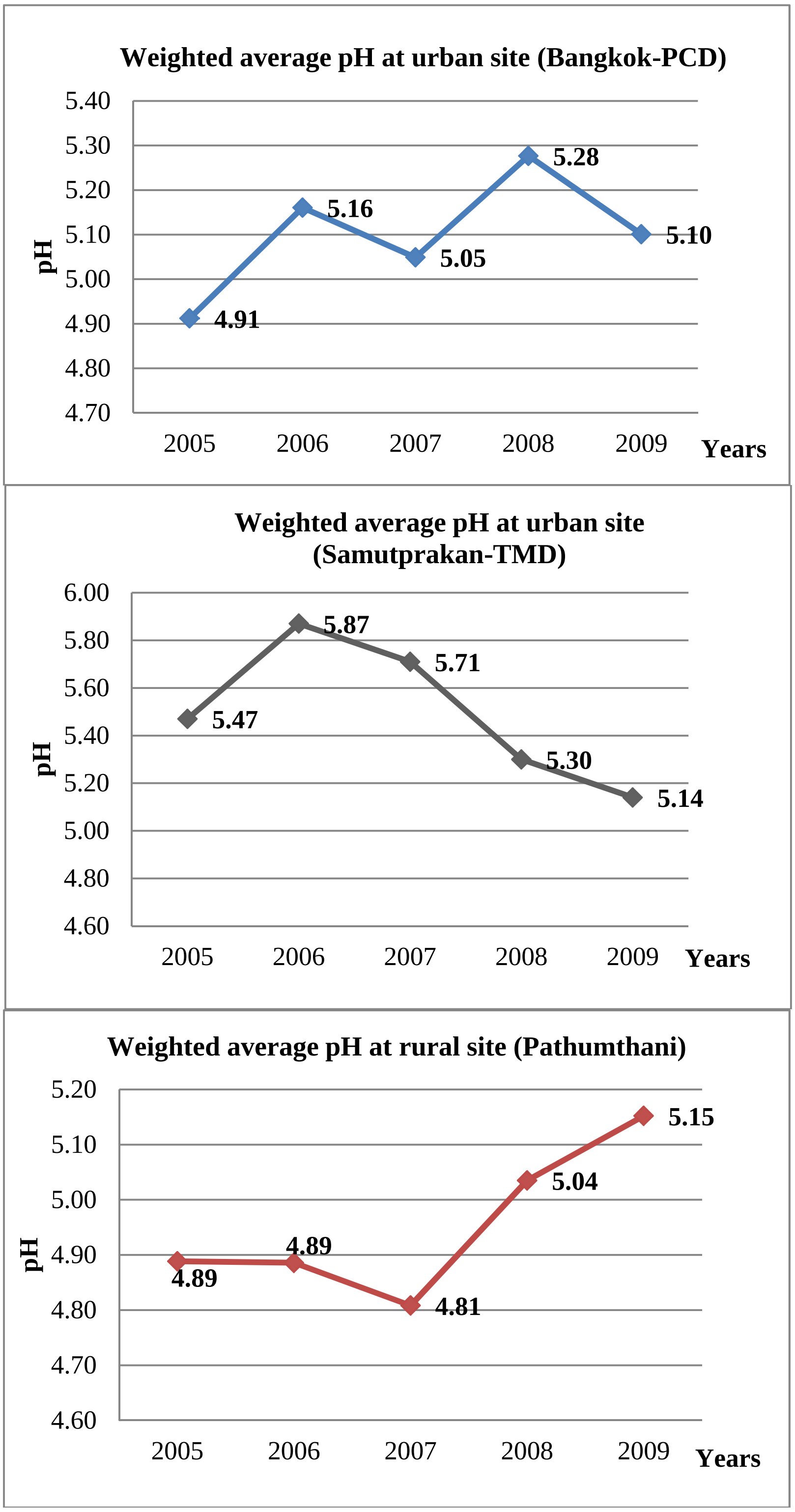


Figure 12.2.8. Volume weighted average pH during 2005-2009 at different monitoring sites.

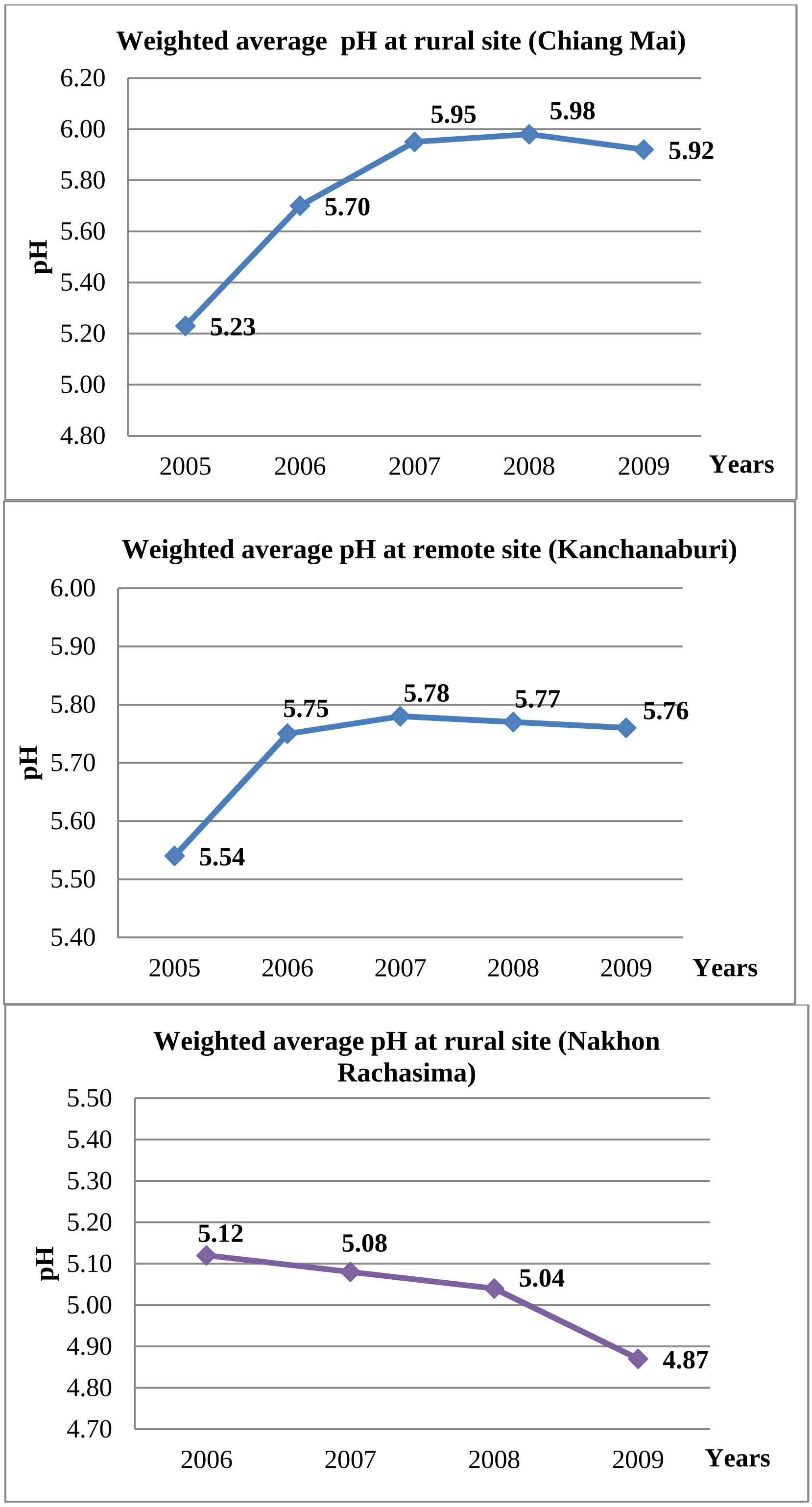


Figure 12.2.9. Volume weighted average pH during 2005-2009 at different monitoring sites (continued).

(3) Chemical composition of precipitation

The yearly variation of volume-weighted average (VWA) concentration of major ions in rainfall at different sampling sites is shown in Figures 12.2.10-12.2.12. The yearly variation of VWA concentration varied within the range of 0.03-2.3 mg.l^{-1}, 0.02-1.41 mg.l^{-1} and 0.01-0.80 mg.l^{-1} for the urban, rural and remote areas, respectively. The ionic abundance in precipitation (mg.l^{-1}) showed the general trend $SO_4^{2-} > NO_3^- > NH_4^+ > Ca^{2+} > Cl^- > Na^+ > Mg^{2+} > K^+$. Decreasing tendency of weighted average concentration SO_4^{2-} was observed at all sites. Concentration and deposition of NO_3^- were almost stable and or showed a slight upward trend in the inner city site. Concentration and deposition of NH_4^+ were nearly stable or showed a slight upward trend. In overall, the variation of VWA concentration illustrated the effect of rainfall amount to the amount of chemical composition in the rainwater. Higher concentrations were generally associated with lower precipitation amounts.

Table 12.2.2. and Figures 12.2.13-12.2.15 showed the average total deposition (mmol.m^{-2}) of major ions in precipitation during 2005-2009. At all monitoring sites the precipitation contains about 60% of total cations and about 40% of total anions. Deposition of NH_4^+ was found the most prevail and ranged from 27-30 % of the total ions in the precipitation from remote through urban sites. SO_4^{2-} was found 6-10% of the total ions in the precipitation samples for remote through urban sites. NO_3^- was found also prevailing in the precipitation samples with more fluctuation between different sampling areas, i.e., 11% and 16% in urban areas, 14% and 17% in rural areas and 8% and 16% in remote areas.

Table 12.2.2. Average total deposition (mmol.m^{-2}) of major ions in precipitation at different monitoring sites during 2005-2009.

Monitoring site	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}	H^+	nss-SO_4^{2-}	nss-Ca^{2+}
Urban (Bangkok-PCD)	*31.7*	*50.9*	*17.9*	*98.5*	*17.4*	*3.8*	*27.2*	*4.2*	*15.1*	*30.6*	*26.8*
Urban (Samutprakan-TMD)	*27.0*	*27.8*	*20.2*	*73.9*	*22.8*	*6.7*	*20.0*	*5.5*	*6.6*	*25.6*	*19.5*
Rural (Pathumthani)	*16.8*	*29.7*	*9.6*	*46.5*	*9.1*	*2.2*	*14.8*	*2.1*	*16.6*	*16.2*	*14.6*
Rural (Chiang Mai)	*6.3*	*10.2*	*5.6*	*23.2*	*3.0*	*2.2*	*6.8*	*2.2*	*3.0*	*6.1*	*6.8*
Remote (Kanchanaburi)	*5.0*	*6.3*	*12.2*	*21.9*	*12.0*	*1.8*	*5.4*	*1.9*	*3.2*	*4.3*	*5.2*
Rural (Nakhon Ratchasima)	*9.8*	*16.1*	*7.4*	*29.2*	*5.5*	*1.6*	*6.3*	*2.1*	*13.2*	*9.4*	*6.2*

Note: PCD = Pollution Control Department station, TMD = Thai Meteorological Department station

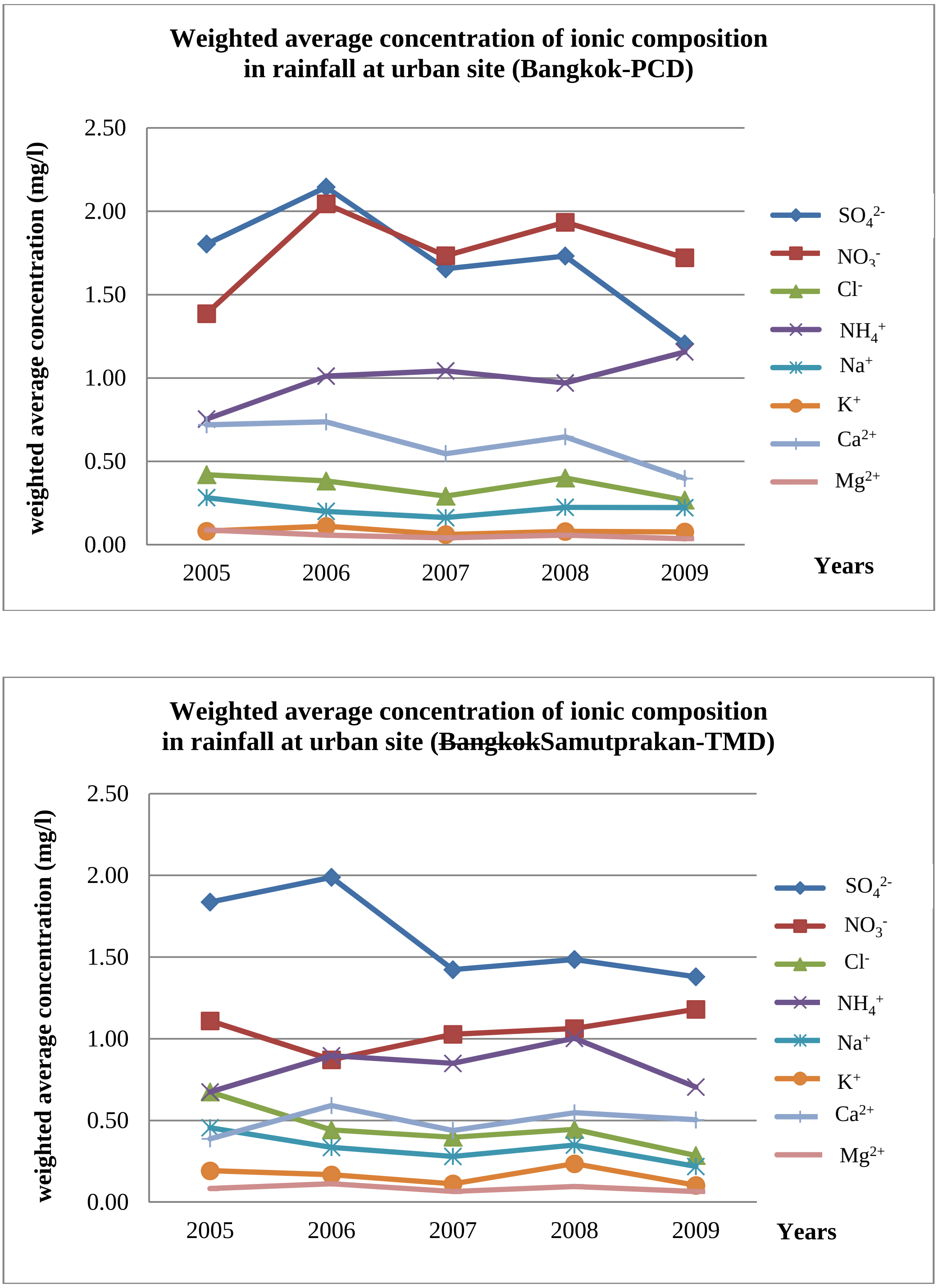
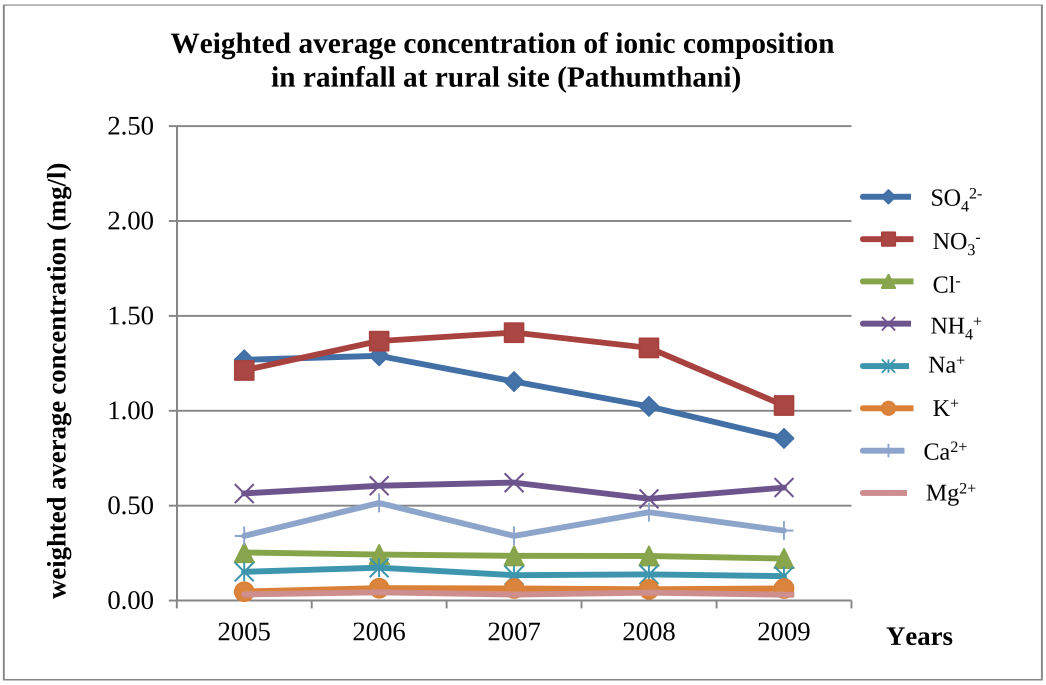


Figure 12.2.10. Yearly variation of volume-weighted average (VWA) concentration of major ions in precipitation at urban sampling sites.



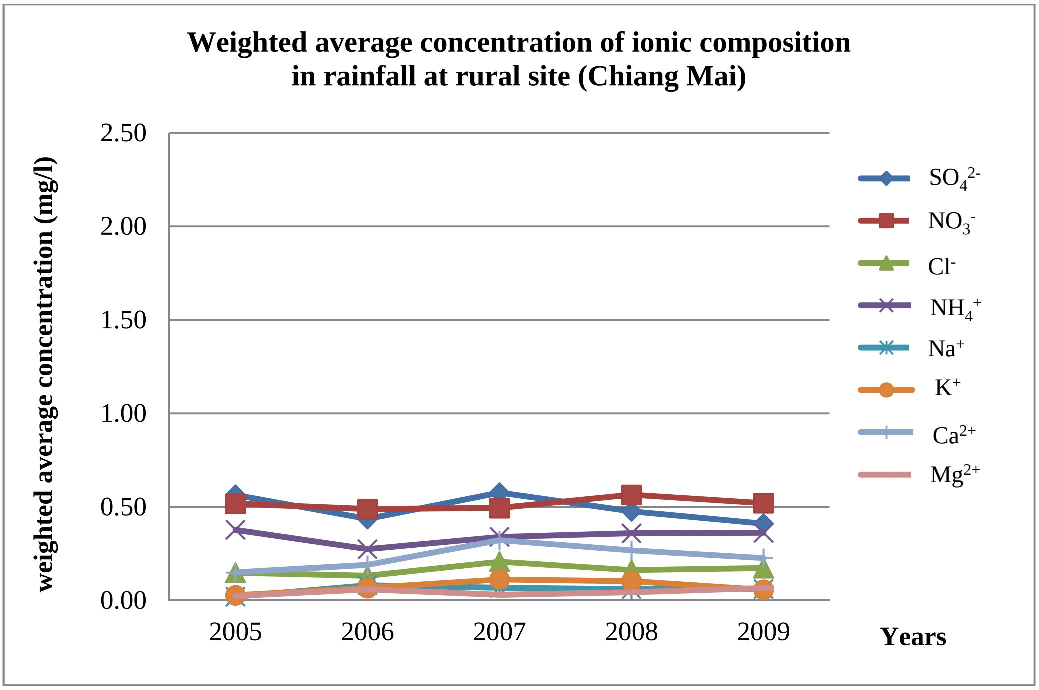
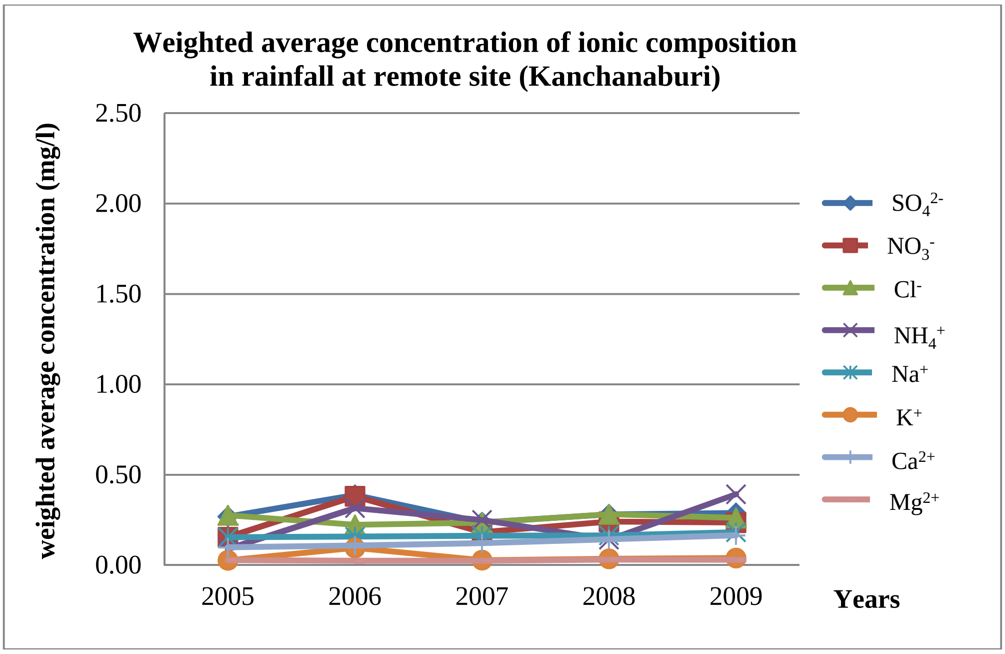


Figure 12.2.11. Yearly variation of volume-weighted average (VWA) concentration of major ions in precipitation at rural sampling sites.



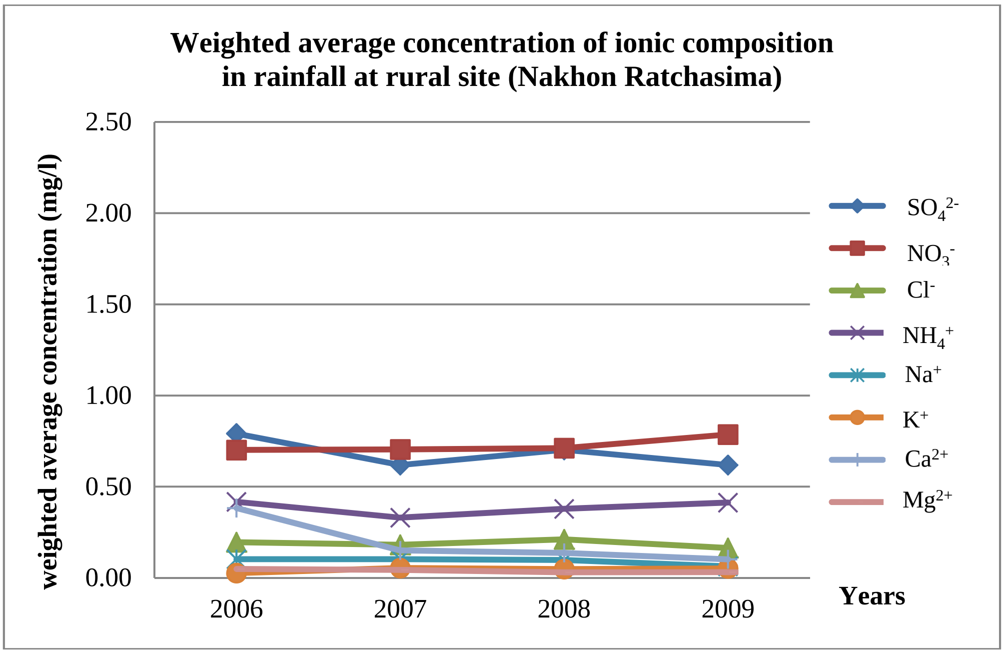


Figure 12.2.12. Yearly variation of volume-weighted average (VWA) concentration of major ions in precipitation at remote sampling sites.

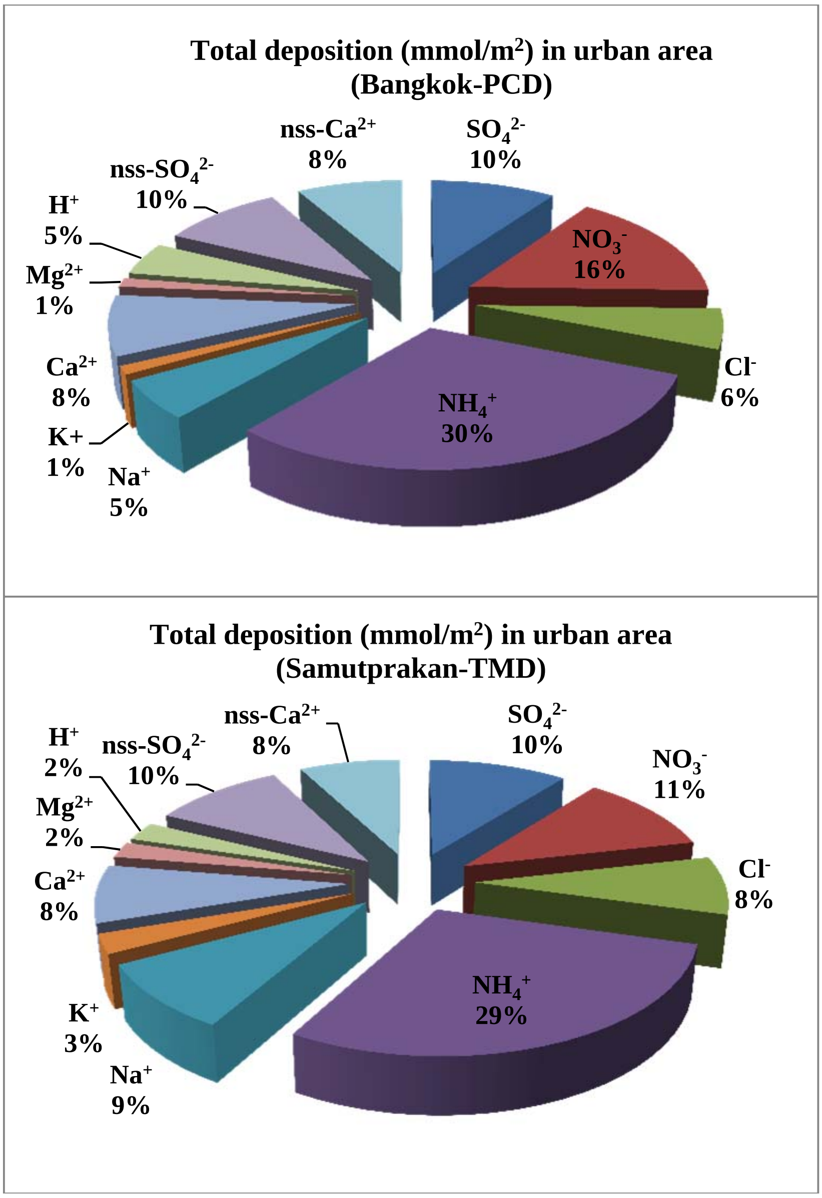


Figure 12.2.13. The average total deposition (mmol.m^{-2}) of major ions in precipitation in urban areas during 2005-2009.

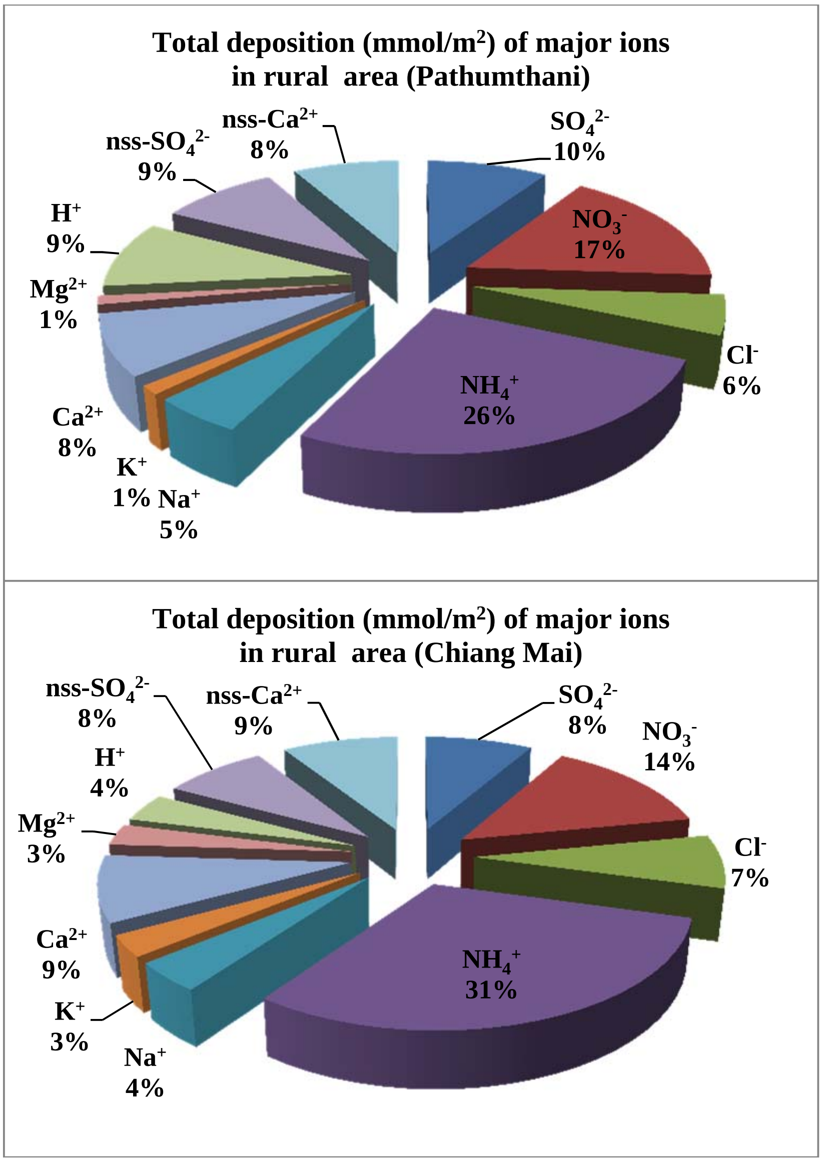


Figure 12.2.14. **The average total deposition (mmol.m^{-2}) of major ions in precipitation in rural areas during 2005-2009.**

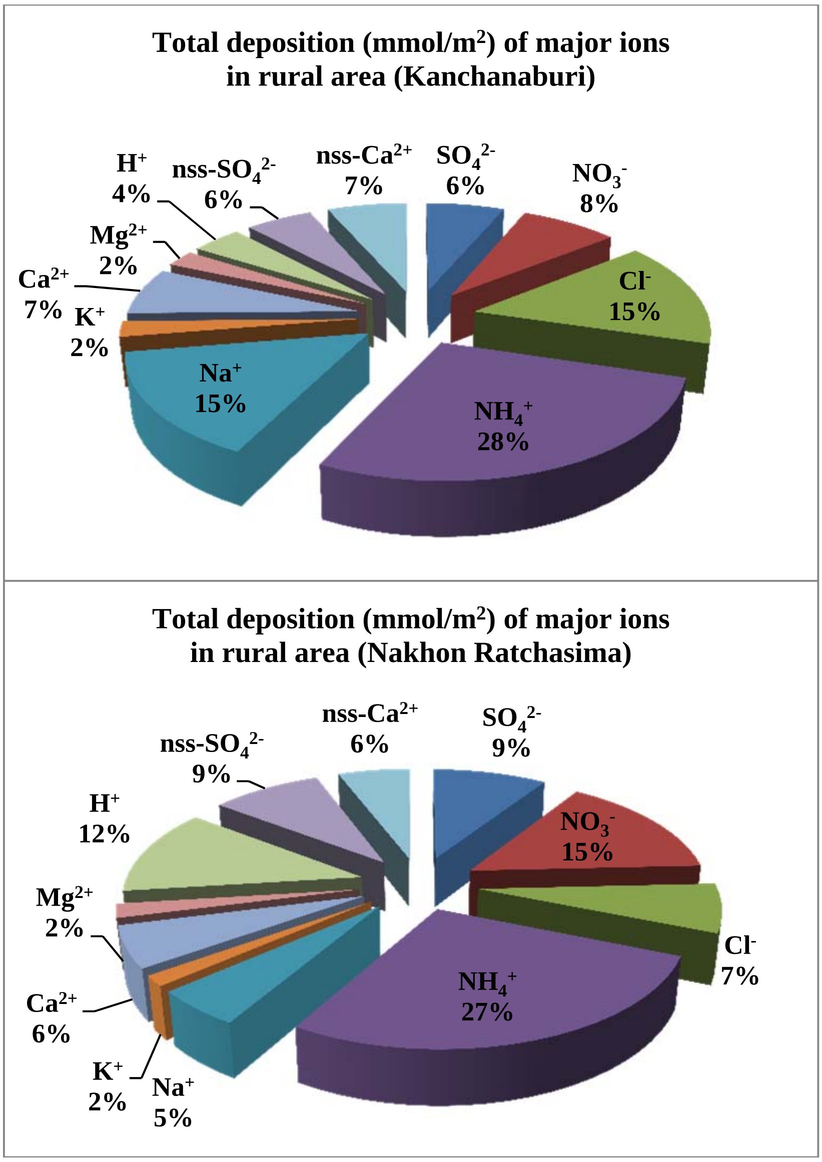


Figure 12.2.15. The average total deposition (mmol.m^{-2}) of major ions in precipitation in remote areas during 2005-2009.

12.2.1.2 State of dry deposition

To assess total acid deposition, dry deposition follows the wet deposition criterion in which 5-year data (2005–2009) of EANET are assessed. Dry monitoring sites are established within the vicinity of wet monitoring sites. The analyses will be presented in terms of monthly concentration variation and topographical differences (urban, rural and remote sites). The principal acid chemicals for analyses consist of the gas components: SO_2, HNO_3,NH_3 and aerosol components: SO_4^{2-}, NO_3^- and NH_4^+.

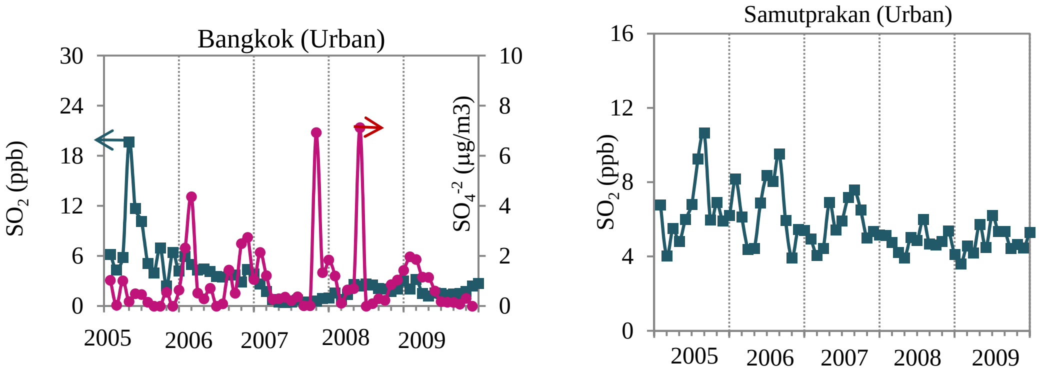
Gas and aerosol concentrations of sulphur

The gaseous SO_2 and aerosol SO_4^{2-} are the principal man-made acid species affecting neutrality of the atmosphere. The status trends of these acid concentrations during 2005-2009 in the urban, rural and remote areas are presented in Figure 12.2.16(a). The yearly SO_2 concentrations are found in the ranges of 0.8–7.3 ppb at the urban sites in Bangkok and 4.8–6.6 ppb in Samutprakan. High concentration occurs in the dry season (September–February) and low in the wet season (June–August). The low concentration is believed to be affected by atmospheric wash-off by heavy rainfall in the tropical climate. The figure also shows a significant decrease of SO_2 after the year 2005. It is considered a successful implementation of policy limiting sulphur content in vehicle and industrial fuels. The SO_4^{2-} concentration follows the same decreasing trend as SO_2. SO_4^{2-} concentrations are high in the dry season and low in the wet season. The yearly concentrations of SO_4^{2-} in Bangkok are in the range of 2.13–4.71 µg.m^{-3}. Data for SO_4^{2-} concentrations in Samutprakan were not reported.

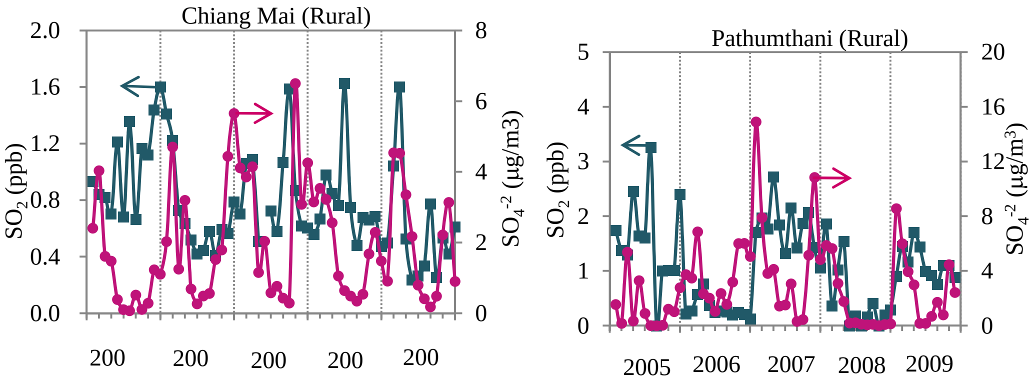
The monthly variation of SO_2 concentration in the rural sites of Chiang Mai and Pathumthani are shown in Figure 12.2.16(b). The yearly concentrations lie within ranges of 0.6–1.0 ppb and 0.3–1.8 ppb in Chiang Mai and Pathumthani, respectively. The observed values of SO_4^{2-} concentrations are in ranges 1.11–2.60 µg.m^{-3} and 1.39–4.69 µg.m^{-3} in Chiang Mai and Pathumthani, respectively.

The yearly concentration of SO_2 in the remote site, Figure 12.2.16(c) are observed in ranges of 1.2–1.6 ppb and 0.2–2.7 ppb in Kanchanaburi and Nakhon Ratchasima, respectively. The SO_4^{2-} concentrations are found in ranges of 0.15–3.24 µg.m^{-3} and 3.14–4.80 µg.m^{-3} in Kanchanaburi and Nakhon Ratchasima, respectively.

All observed acid gas and aerosol concentrations demonstrate the same pattern of seasonal variation between the high and low concentrations during the 5-year monitoring period (2005–2009). Urban concentrations of SO_2 are reported to be 3–5 times higher than the concentrations in remote areas**.** However, SO_4^{2-} concentrations are not likely to differ among urban, rural and remote areas. Aerosol components are secondary pollutants that can be chemically formed at a distance from the emission sources.



(a)



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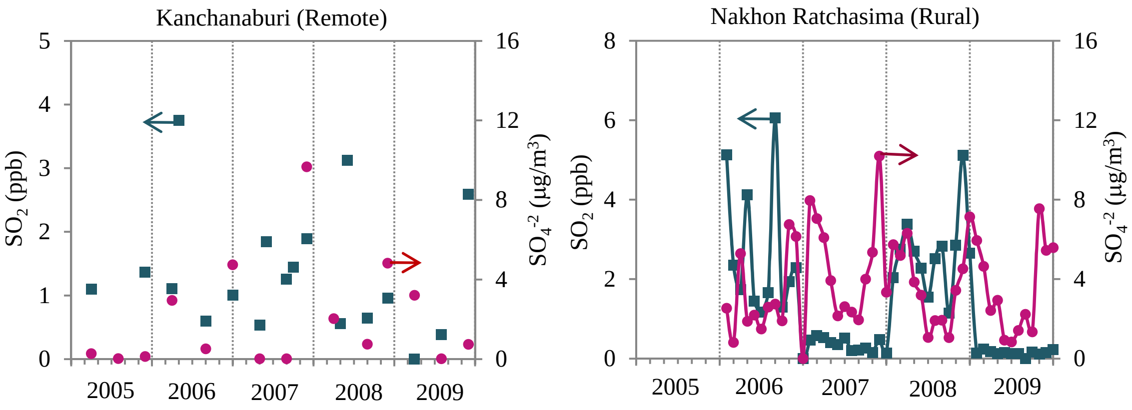


(c)

Figure 12.2.16. The monthly variation in concentrations of gaseous SO_2 and aerosol during the 5-year monitoring period (2005–2009), (a) Bangkok and Samutprakan sites (urban), (b) Chiang Mai and Pathumthani sites (rural) and (c) Kanchanaburi and Nakhon Ratchasima sites (remote and rural).

Gas and aerosol concentrations of nitrogen

The principal chemical species of nitrogen, due to their acidic nature, are composed of the gases, HNO_3 and NH_3 and aerosols, NO_3^- and NH_4+. The observed values of these chemicals show distinguishable trends of high and low concentrations in the dry and the wet season. The ratio of concentrations between dry/wet seasons is approximately 3 to 10.

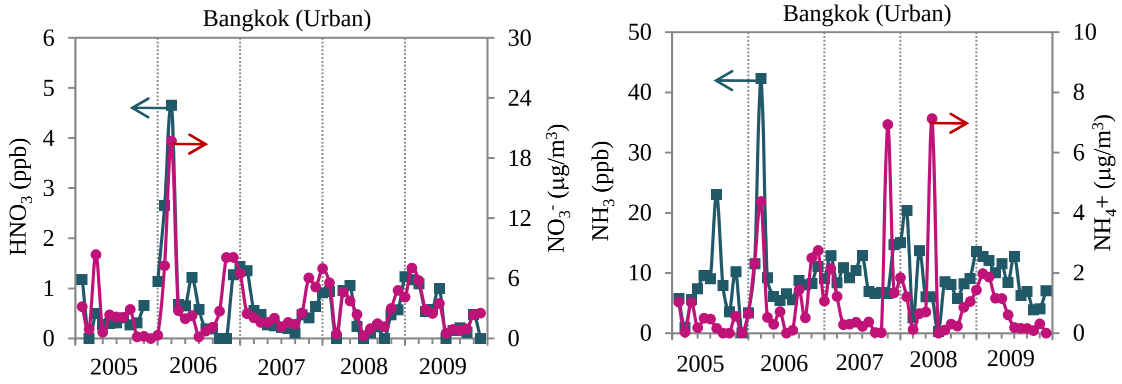
The yearly concentrations of gaseous HNO_3 and NH_3 in the urban city of Bangkok lie in ranges of 0.5–1.0 ppb and 7.8–10.2 ppb, respectively. See Figure 12.2.17(a). The concentration of NH_3 is significantly 10 folds higher than HNO_3. The sources of NH_3 emission in the urban area are envisaged to derive from nearby industrial waste water and sewage treatments and agriculture utilizing fertilizers. The yearly concentrations of aerosol NO_3^- and NH_4^+ in the urban city of Bangkok are measured in ranges of 1.44–2.83 µg.m^{-3} and 0.42–1.30 µg.m^{-3}, respectively (Figure 12.2.17(b)). The trend of both gases appears stable during the past 5 years and reaches the maximum value in the dry season and the minimum value in the wet season. The observed low concentration is caused by the atmospheric wash out by heavy rainfall.

In the rural areas of Chiang Mai, the concentration of gaseous HNO_3 and NH_3 are found in ranges of 0.2–0.7 ppb and 3.0–5.8 ppb, respectively. The concentration of aerosol NO_3^- and NH_4^+ lie in ranges of 0.33–0.67 µg.m^{-3} and 0.49–0.74 µg.m^{-3}, respectively (Figure 12.2.17(b)).

In the rural areas of Pathumthani, the concentration of gaseous HNO_3 and NH_3 lie in ranges of 0.3–0.8 ppb and 2.8–9.2 µg.m^{-3}, respectively. The concentration of aerosol NO_3^- and NH_4^+ lie in ranges of 0.52–2.02 µg.m^{-3} and 0.38–1.50 µg.m^{-3}, respectively. These observed data also show significant trend of high NH_3 concentration in the rural areas (Figure 12.2.17(c)).

In the remote areas of Kanchanaburi, the concentration of gaseous HNO_3 and NH_3 are found in ranges of 0.2–0.5 ppb and 1.9–3.2 ppb, respectively. The concentration of aerosol NO_3^- and NH_4^+ lie in ranges of 0.06–3.55 µg.m^{-3} and 0.04–1.1 µg.m^{-3}, respectively (Figure 12.2.17(d)).

In the rural areas of Nakhon Ratchasima, the concentration of gaseous HNO_3 and NH_3 are found in ranges of 0.2–0.6 ppb and 2.3–7.0 ppb, respectively. The concentration of aerosol NO_3^- and NH_4^+ lie in ranges of and 0.34–0.81 µg.m^{-3} and 0.86–1.37 µg.m^{-3}, respectively. The rural site also observes high values of NH_3. It should be noted that the existence of high NH_3 in the atmosphere can be a normal occurrence in the agricultural country (Figure 12.2.17(e)).



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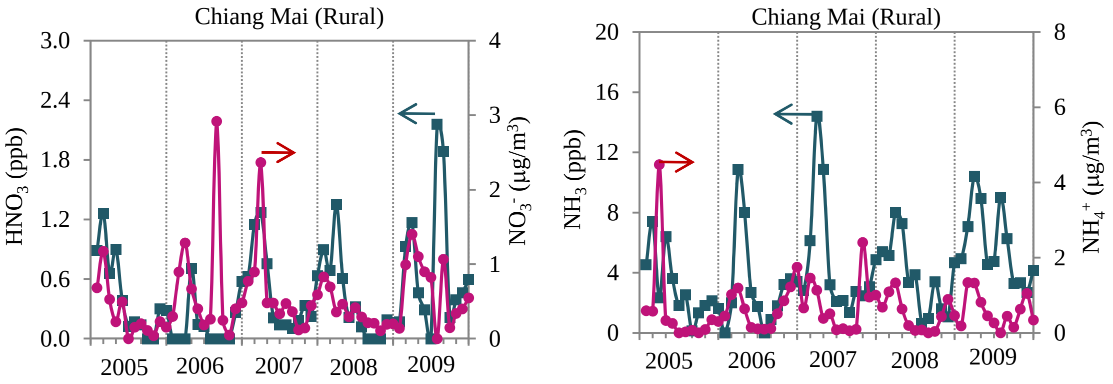

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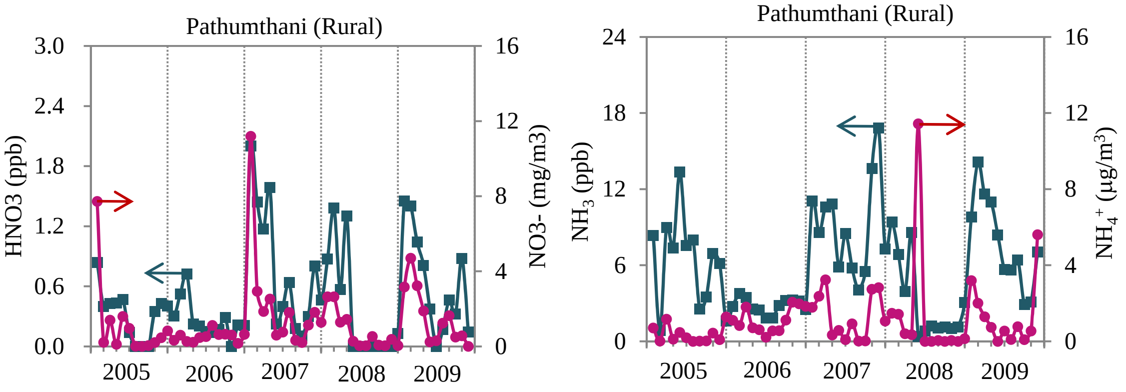

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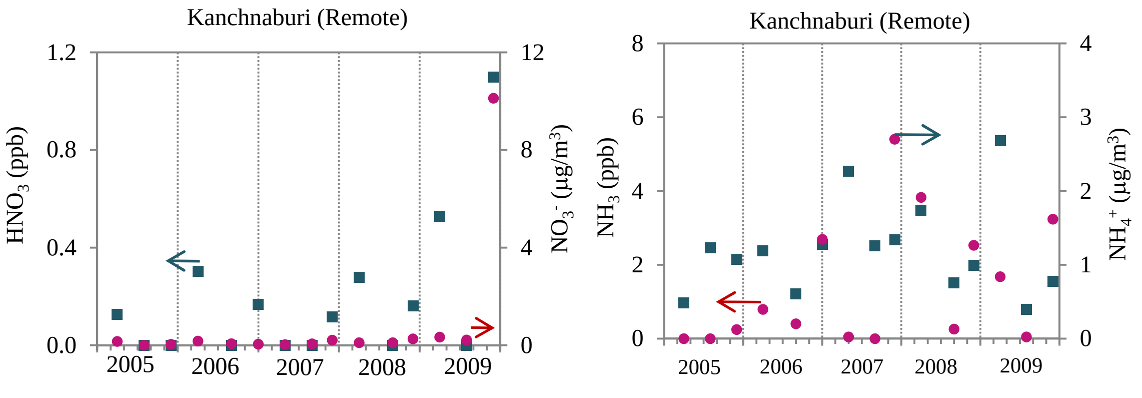

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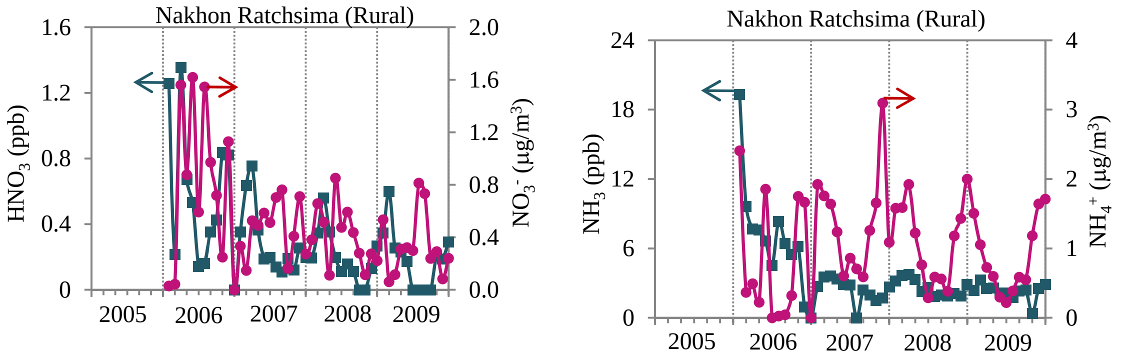


(e)

Figure 12.2.2.17. The monthly variation in the concentrations of gaseous HNO_3, NH_3 and aerosol $NO_3^-$and NH_4^+ during 5-year monitoring (2005–2009), (a) Bangkok site (urban), (b) Chiang Mai site (rural) (c) Pathumthani site (rural), (d) Kanchanaburi site (remote) and (e) Nakhon Ratchasima site (rural).

Dry Deposition

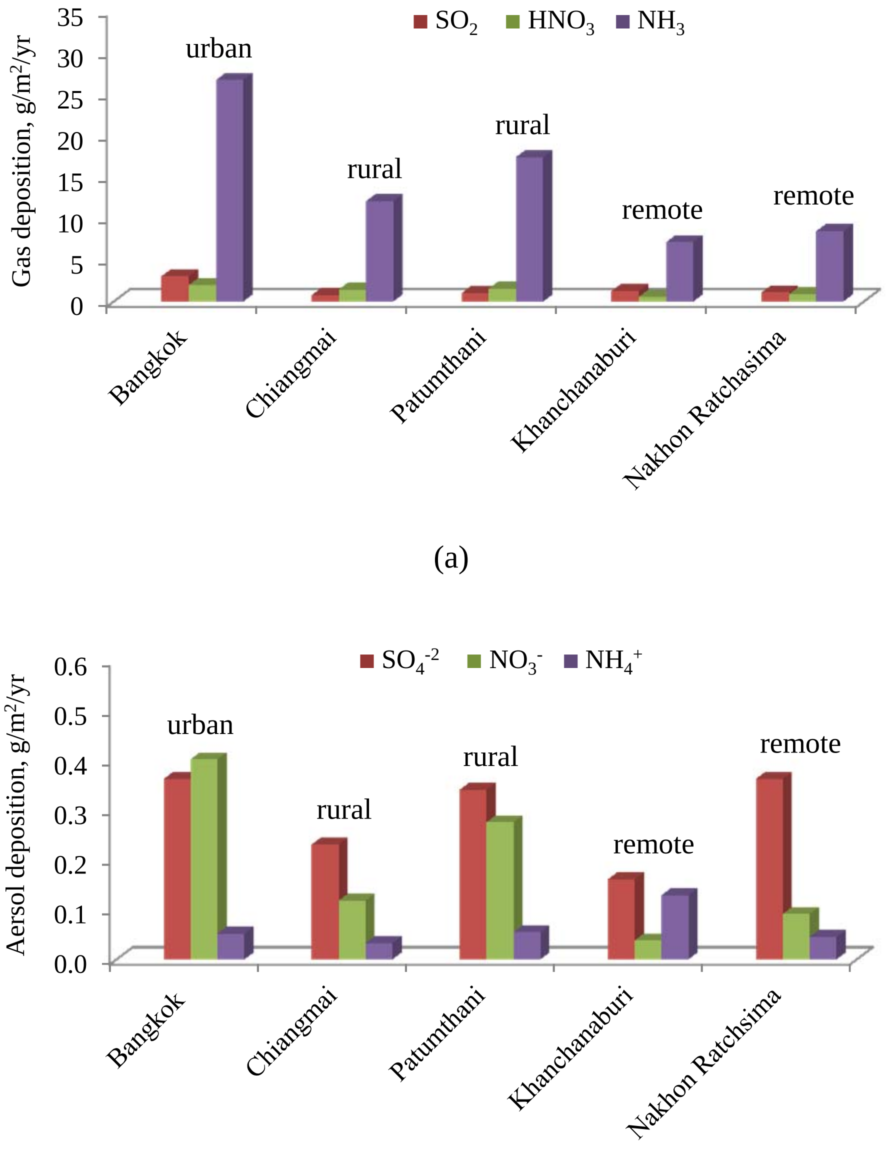
The average dry deposition of acid species, in $g.m^{-2}.yr^{-1}$, during 2005–2009 is shown in Figure 12.2.18. The deposition is calculated by a general deposition equation, $F_d = v_d C_{ave}$ where F_d is the amount of acid deposition ($g.m^{-2}.yr^{-1}$), v_d is a deposition velocity ($m.s^{-1}$) and C is an average measured concentration at the monitoring sites. Table 12.2.3 lists values of deposition velocities for different chemical species.

Table 12.2.3. Deposition velocity of chemical species.

Species	v_d ($cm.s^{-1}$)	References
SO_2	1.14	Jitto&Khummongkol (2007)
HNO_3	4.0	Hauglustaine *et al.* (1994)
NH_3	3.6	Duyzer *et al.* (2003)
SO_4^{2-}	0.38	Khoomsab&Khummongkol (2010)
NO_3^-	0.71	Khoomsab&Khummongkol (2010)
NH_4^+	0.17	Duyzer (1994)

The average dry deposition rate of SO_2 are quantified to be 3.06, 0.77, 1.00, 1.26 and 1.10 g.m^{-2}.yr^{-1} at Bangkok (urban), Chiang Mai (rural). Pathumthani (rural), Kanchanaburi (remote) and Nakhon Ratchasima (rural), respectively. The Bangkok site provides a significant SO_2 deposition which is 3 times higher than other sites.

The average HNO_3 dry deposition at Bangkok, Chiang Mai, Pathumthani, Kanchanaburi and Nakhon Ratchasima are evaluated to be 1.98, 1.46, 1.57, 0.56 and 0.87 g.m^{-2}.yr^{-1}, respectively and the average dry deposition of NH_3 are observed to be 26.74, 12.11, 17.44, 7.16 and 8.48 g.m^{-2}.yr^{-1}, respectively. The deposition trend of all acid gases are much higher in the urban than the rural and the remote areas. It should be noted that the deposition of NH_3 is very large compared with the observed values of other acid gases. Figure 12.2.18(a) shows comparative quantities of SO_2, HNO_3 and NH_3 depositions over the urban, rural and remote areas.



(a)

(b)

Figure 12.2.18. Average dry deposition rate (g.m^{-2}.yr^{-1}) at EANET urban, rural and remote sites during 2005–2009. (a) gas deposition and (b) aerosol deposition.

The average dry deposition rate of aerosols, i.e. SO_4^{2-}, NO_3^- and NH_4^+ are shown in Figure 12.2.18(b). The dry deposition rates of SO_4^{2-} are evaluated at Bangkok (urban), Chiang Mai (rural), Pathumthani (rural), Kanchanaburi (remote) and Nakhon Ratchasima (rural) to be 0.36, 0.23, 0.34, 0.16 and 0.36 $g.m^{-2}.yr^{-1}$, respectively. The deposition rates of NO_3^- and NH_4^+ are 0.40, 0.12, 0.28, 0.04 and 0.09 $g.m^{-2}.yr^{-1}$ and 0.05, 0.03, 0.05, 0.13 and 0.05 $g.m^{-2}.yr^{-1}$, respectively evaluated at the same sites mentioned above. The monitoring data during 2005–2009 show that the Bangkok urban area generally contributes the greatest rate of all types acid gas deposition. The deposition rate can be as much as three times higher than the deposition rate in the rural and remote areas. However, in the case of aerosol deposition, the amount of depositions are very small compared with acid gas deposition. The amount is smaller by 4 to 15 times. The large difference is accounted for by the deposition velocity of different gas species as listed in Table 12.2.3.

12.2.2 State of inland aquatic environment

Vachiralongkorn Dam has been selected for the inland aquatic environment monitoring proposes since 2000. Vachiralongkorn Dam is a rock filled dam covering the area of 388 km^2. The watershed area is 3,720 km^2 with an average inflow of 5,500 million m^3. The maximum water storage volume is 8,860 million m^3. The average water depth is 115.0 m with the maximum depth of 153.2 m. The annual water level fluctuated between 0-18 meters (average 9 m.) The residence time of water is 165 days. One river stream flows into the dam. Main bed rock type is lime stone. The drainage area is covered by forest. The dam is highly utilized for electric power generation, irrigation, fish culture and recreation.

The water quality during 2005-2009 was examined four times per years at the two selected monitoring sites. The measured parameters for acidification of the inland aquatic water are reported as follow: The pH varies within 6.8-8.0, alkalinity average value of 1.10 ± 0.08 $meq.l^{-1}$ and EC average value of 107.20 ± 6.60 $\mu S.cm^{-1}$. Composition ratio of the major ions is presented in Figure 12.2.19. The main dominated ions are bicarbonate (74%) and calcium (18%). Composition ratio of the major ions is quite stable. According to the monitoring results, there were no clear seasonal and yearly trends for pH and acidification of water. Meanwhile, the data showed that the high pH and alkalinity values are associated with the lime stone rock type of the reservoir basin.

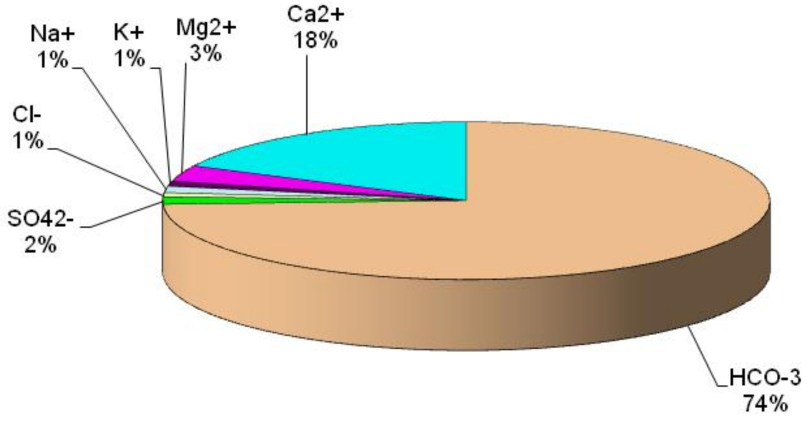


Figure 12.2.19. Composition ratio of the major ions in dam water ($mg.l^{-1}$).

12.2.3 State of soil and vegetation

Soil sampling was carried out in the year 2006 and 2008 at two sampling locations in Vachiralongkorn area; Vachiralongkorn Dam and Vachiralongkorn-Puye. The results of pH analysis are shown in Table 12.2.4.

Table 12.2.4. Results of soil sampling at the depth level of 0-20 cm.

Sampling Sites	Soil type	pH (H₂O)	
		2000-2004	2005-2009
Vachiralongkorn Dam location	Ferric acrisols	5.21-8.40	6.00-7.30
Vachiralongkorn-Puye location	Luvisols	3.9-5.06	4.80-6.10

The pH of soil measured at Vachiralongkorn Dam during 2005-2009 was in a range of 6.00-7.30 while Vachiralongkorn-Puye was in a range of 4.80-6.10 which are in the range of measurement during 2000-2004. There was no noticeable change in the soil pH comparing to the year 2000-2004.

Vegetation monitoring plot related to the impact of acid deposition in Thailand is located in Kanchanaburi, the western region. Tree height and DBH are essential parameters in the estimation of growth and yield of the stand for observation impact of acid deposition on growth and yield of tree stand. The monitoring area is located in the mixed deciduous forest, Vachiralongkorn Dam and dry evergreen forest, Puye. The dominant forestry species in Vachiralongkorn Dam are *Xylia xylocarpa, Lagerstroemia tomentosa* and *Millettia branbisiana* and in Puye is *Dipterocarpus turbinatus.*

In Vachiralongkorn Dam monitoring plot, most of the tree with 200 m^2 plot in 2006 and 2009, higher than 1.30 m., was Bamboo species and understory plants. The number of measurable tree depends on seasonal difference. During wet season, the understory plants were found more than those investigated in the dry season. There was no evident of acid condition or acid rainfall effect. In 400 m^2 plot, the number of trees which DBH 4-18 cm. found in 2006 were not different from those found in 2009. In 1,000 m^2 plot, the number of trees which DBH more than 18 cm found in 2006 were not different from those found in 2009. The maximum DBHs was 142 cm. (2006) and 147.5 cm. (2009) in *Lagerstroemia tomentosa* and the maximum heights was 47.90 m. (2006) and 52.60 m. (2009) in *Lagerstroemia tomentosa*. The study of understory vegetation in 2006 and 2009 found that the number of species and population of understory plants depended on surveying time. In 2006, the surveying started in May which was the beginning of wet season. It was founded that *Aglaomema simplex* distributed more than other species. During the survey in 2009, it was found that the number of *Aglaomema simplex* was decreased while other species were increased. The survey started in April, 2009 which was the dry season.

Table 12.2.5. Tree species and measurements at the Vachiralongkorn Dam.

No	Species Name	2006		2009	
		DBH	Height	DBH	Height
	Plot Radius 7.98 m.				
1	Tree (none)	-	-	-	-
2	Bamboo species	-	-	-	-
	Plot Radius 11.28 m.				
1	*Heteropanax fragrans* (Aoi chang)	4.40	3.90	9.80	7.70
2	*Sterculia guttata* (Por daeng)	5.20	6.40	10.70	15.50
3	*Oroxylum indicum* (Pe ka)	9.00	8.90	-	-
4	Climber (Khruea chan)	-	-	9.00	18.30
5	Ni	4.20	3.40	-	-
6	*Dendrocalamus membranaceus* (Pai sang nuan)	38 clumps	-	17 clumps	75 culms
	Plot Radius 17.85 m.				
1	*Lagerstroemia tomentosa* (Sa lao)	142.00	47.90	147.50	52.60
2	*Xylia xylocarpa* (Daeng)	45.00	27.45	47.00	27.45
3	*Xylia xylocarpa* (Daeng)	49.00	29.20	49.40	30.50
5	*Glochidion assamicum* (Khae mod)	24.00	20.80	-	-

6	*Heteropanax fragrans* (Aoi chang)	36.00	23.50	-	-
7	*Millettia branbisiana* (Kra pi jan)	33.00	27.10	33.00	27.10
8	*Vitex limonifolia* (Sawong)	71.30	41.20	82.00	44.30
10	Ni	-	-	31.20	19.50
	Understory Vegetation Survey	Dominance			
1	*Aglaomema simplex* (Waan khan mak)	4		2	
2	*Ampelocissus malinii* (Som kung)	3		-	
3	*Pterocymbium malayanum* (Po I keng)	3		-	
4	*Dendrocalamus membranaceus* (Pai sang nuan)	+		-	
5	*Stebhania peticulata* (Tub tao)	+		-	
6	*Ammania villosum* (Rew, wan)	+		-	
7	*Alocasia everardii* (Bon pa)	-		2	
8	*Alocasia cucullta* (Waan nok khum))	-		2	
9	*Smithatris supraneanae* (Waan dok kao phansa)	-		+	
10	*Begonia inflata* (Som kung)	-		+	
11	*Amorphophallus bulbifer* (Buk kliang)	-		2	
12	*Millettia branbisiana* (Kra pi jan)	-		2	
13	*Schleichera oleosa* (Tra kro)	-		2	
14	*Amorphophallus aberrans* (Buk)	-		+	
15	*Hibiscus* spp. (Kra chiap pa)	-		2	
16	*Tetrastigma* spp. (A-ngun pa)	+		-	
17	Climber (Khruea chan)	-		2	
18	Climber (Herb)	-		+	
19	Ni (Annonaceae) (Pum luey)	+		-	
20	Ni (Wan ngam bai)	+		-	

In Puye monitoring plot, there were two species of trees which 200 m^2 plot and higher than 1.30 m. found in 2006. Later in 2009 it was found that four species of trees are higher than those in 2006. In 400 m^2 plot most of the tree was bamboo species. During the survey in 2006, it was found that two trees had DBH between 4-18 cm. In 2009, six trees were found with DBH between 4-18 cm. However, the species of trees found in 2006 were different from that in 2009. In 1,000 m^2 plot, the DBH and height of all trees in 2009 increased from 2006, but the number of trees decreased. It because some trees were died or falling by wind. The maximum DBH of tree in this plot was 84 cm. in *Aphanamixis polystachya* and the maximum height was 46.40 m. in *Artocarpus kemando* (2006) and 40 m. in Ni species (2009). The study in 2006 and 2009 found that the numbers of species and population of understory plants were seasonal dependence. It is similar to the survey result in Vachiralongkorn Dam. The understory plants were increased in wet season but decreased in dry season.

Table 12.2.6. Tree species and measurements at the Vachiralongkorn dam (Puye).

No	Species Name	2006		2009	
		DBH	Height	DBH	Height
	Plot Radius 7.98 m.				
1	*Baccaurea ramiflora* (Ma fai)	2.30	2.80	2.70	3.80
2	*Microcos tomentosa* (Plub pla)	2.50	4.90	-	-
3	*Dipterocarpus turbinatus* (Yang dang)	-	-	2.10	2.60
4	*Dipterocarpus turbinatus* (Yang dang)	-	-	2.60	3.00
5	Ni	-	-	3.30	3.60
	Plot Radius 11.28 m.				
1	*Dioscorea alata* (Mun chang)	17.40	17.90	-	-
2	*Combretum punctatum* (Sakaewan)	4.80	4.80	-	-
3	*Fraxinus chinensis* (Khae)	-	-	7.00	5.20

4	*Millettia brandisiana* (Kra pi jan)	-	-	12.20	11.30
5	*Caryota bacsonensis* (Tao rang)	-	-	10.00	5.70
6	*Fraxinus chinensis* (Khae)	-	-	5.00	4.40
7	Ni	-	-	5.60	5.60
8	Ni	-	-	6.00	5.80
9	*Gigantochloa hasskarliana* (Pai park)	10 clumps	51 culms	2 clumps	10 culms
10	*Bambusa longispiculata* (Pai ta yai)	1 clumps	3 culms	10 clumps	46 culms
	Plot Radius 17.85 m.				
1	*Pterocymbium tinctorium* (Po I keng)	36.20	23.50	-	-
2	*Dipterocarpus turbinatus* (Yang dang)	33.10	24.10	-	-
3	*Vitex limonifolia* (Sawong)	21.70	13.20	23.20	13.50
4	*Pterocymbium tinctorium* (Po I keng)	22.00	19.20	-	-
5	*Microcos tomentosa* (Plub pla)	21.00	19.00	25.10	22.80
6	*Dipterocarpus turbinatus* (Yang dang)	71.00	32.00	-	-
7	*Aphanamixis polystachya* (Tasuea)	84.00	33.90	84.00	33.90
8	*Strychnos nux-blanda* (Tumka khao)	77.50	35.80	78.10	35.80
9	*Artocarpus kemando* (Khanun pa)	76.50	46.40	-	-
10	*Paranepelium xestophyllum* (Lum yai pa)	-	-	26.00	18.90
11	Ni (*Kamindum*)	52.30	38.70	-	-
12	Ni (Kanieng)	41.70	23.50	-	-
13	Ni	-	-	18.00	19.10
14	Ni	-	-	50.80	40.00
15	Ni	-	-	60.90	28.00
16	Ni	-	-	28.20	21.20
	Understory Vegetation Survey	Dominance			
1	*Sterculia guttata* (Por daeng)	+		-	
2	*Tetrastigma quadrangulatum* (A-ngun pa)	4		-	
3	*Bauhimia integrifolia* (Tao fai)	+		-	
4	*Pterolobium micranthum* (Ta kaom ta noo)	4		-	
5	*Ammannia villosum* (Rew, wan)	5		-	
6	*Mollig cordifolia* (Po liang)	4		-	
7	*Persea kurzii* (Yang bong)	+		-	
8	*Crotalaria sanica* (Rang jued, annual)	+		-	
9	*Thunbergia laurifolia* (Rang jued, climber)	+		-	
10	*Combretum punctatum* (Sakaewan)	4		-	
11	*Terminalia myriocarpa* (Sang)	+		-	
12	*Gigantochloa hasskarliana* (Pai park)	+		4 clumps	32 culms
13	*Endospermum peltatum* (Klai)	+		-	
14	*Cantharellus cidarius* (Hed man poo)	+		-	
15	*Paederia linearis* (Tao tod maa)	+		-	
16	*Heteropogon contortus* (Nuad ru si)	+		-	
17	*Stephonia pierrei* (Kling glang dong)	+		-	
18	*Millettia leucantha* (Kra pi khoa kai)	+		+	
19	*Eupatorium odoratum* (Sab sue)	+		-	
20	*Grewia paniculata* (Plub pla)	+		-	
21	*Dioscorea alata* (Mun sao)	+		-	
22	*Dioscorea burmanica* (Mun nok)	+		-	
23	*Habenaria rhodocheila* (Fern)	+		-	
24	*Barringtonia macrocarpa* (Jig nom yang)	+		-	
25	*Erythring subumbrans* (Tong lang paa)	+		-	
26	*Maranta arundinacea* (Sa koo)	+		-	
27	*Microcos tomentosa* (Plub pla)	-		2	

28	*Amomum xanthioides* (Rew)	-	4
29	*Glochidion wallichianum* (Mun poo)	-	+
30	Ni (Cham chuang)	+	-
31	Ni (Nuad pa kao)	+	-
32	Ni (Keeb lab)	+	-
33	Ni (Nam khae nak)	+	-
34	Ni (Tao maa noi)	+	-
25	Ni (Tao kru ru)	+	-
36	Ni (Kanieng)	+	-
37	Ni (Mun nan)	+	-
38	Ni (Herb)	-	2
39	Bamboo (Pai ta yai)	-	4 clumps 28 culms

In general, it was found that two parameters, DBH and height for all trees enumerate are increase at both sites. There are some changes on the other stand parameters such as indicative of growth and yield of trees in both monitoring sites. At Vachiralongkorn Dam plot there were increasing numbers in all parameters, maximum height, maximum DBH, mean height, mean DBH, basal area and total volume. But in Puye plot there were decreasing number in all the parameters, because of lost some big trees in the second enumeration in 2009. Those trees were falling by wind and some died in natural.

Table 12.2.7. Change in stand parameters at the monitoring site in Vachiralongkorn dam.

PARAMETERS	MEASUREMENTS	
	2006	2009
Maximum DBH	142.00 cm.	147.50 cm.
Minimum DBH	24.00 cm.	31.20 cm.
Mean DBH	57.19 cm.	65.02 cm.
Maximum Height	47.90 m.	52.60 m.
Minimum Height	20.80 m.	19.50 m.
Mean Height	31.02 m.	33.58 m.
Basal area	25.62 $m^2.ha^{-1}$	27.63 $m^2.ha^{-1}$
Total volume	37.79 m^3	42.54 m^3

Table 12.2.8. Change in stand parameters at the monitoring site in Vachiralongkorn dam (Puye).

Parameters	Measurements	
	2006	2009
Maximum DBH	84.00 cm.	84.00 cm.
Minimum DBH	21.00 cm.	18.00 cm.
Mean DBH	48.82 cm.	43.81 cm.
Maximum Height	46.40 m.	40.00 m.
Minimum Height	13.20 m.	13.50 m.
Mean Height	28.12 m.	25.91 m.
Basal area	25.30 $m^2.ha^{-1}$	17.59 $m^2.ha^{-1}$
Total volume	29.17 m^3	18.89 m^3

In both monitoring sites some species were lose, but there were new species recorded. It could be part of the regeneration dynamics on the natural forest. The monitoring result has confirmed no effects caused by the acid deposition on vegetation in Thailand.

12.3. Review of National Measures Against Acid Deposition

In Thailand, air pollution problems are significantly related to meteorological conditions. Elevated of air pollution concentrations are usually occur during dry season. Then, almost of these pollutants are decreased rapidly in wet season. However, the use of command and control principle is always being a foundation of national policy to protect human health and environment. Consequently, it is the responsibility of government to enact and update environmental control registrations. In fact, it is necessary to establish regulatory strategies, in order to implement objectives of those registrations. PCD should continue its aggressive program already underway to the future improve national air quality.

The ultimate goal of PCD is that air quality levels in Thailand are below the National Air Quality Standards, both ambient air quality standard and emission standard. This is needed measures to control, prevent, and remedy air quality problems caused by air pollution. Based on the current knowledge and technology, pollution situation, economic and social, PCD has developed strategy for air quality conservation and promotion, regarding acid deposition problem as following:

SO_2 mitigation

The mitigation of SO_2 is consistent with national policy to enhance the use of natural gas in transport and manufacturing sector. Since natural gas is recognized as domestic energy in Thailand, it could be introduced by economic mechanisms without any new stringent regulation. Moreover, the uses of natural gas also benefit to the environment because of less quantity of dust, black smoke, and SOx emissions.

Thailand has been very pro-active in developing cleaner fuel specifications for over a decade. Under PCD’s recommend the RTG to improve fuel quality such as lower the sulphur content in diesel fuel to be 50 ppm in 2010. Other kind of alternative fuels such as gasohol, biodiesel, and CNG, with non-toxic, biodegradable and renewable, have been introduced to Thai people over 10 years.

NOx mitigation

NOx control is still being a challenge to urban air quality management. Motor vehicles are the major contributors to its air pollution problem. Therefore, one of the most important efforts in NOx control is to enhance the Real-EURO standard. Thailand has adopted emission standards for new vehicles in 1995, follow the European emission standard. However, implementing dates are generally 2 years after the standards is being enforced in Europe.

Other measures, namely Inspection and Maintenance Program and Ecology car (Eco car) are also launched along with the Real-Euro for additional NOx reduction measures. However, their additional effects were estimated relatively small. The over aged vehicles (over 7 years) are required to pass the emission inspection annually prior to the annual renewal of the license. The Eco car has recently been promoted due to fuel saving policy. Moreover, it is one of the environmentally friendly measures.

The major focus on accessible public transportation is one of the changes discussed in the current Bangkok’s transportation plan. It widely believes that there will be an effort to redesign city’s traffic plan in order to promote the use of public transportations and reduce air pollution caused by traffic congestion.

PM_{10} mitigation

In recent years, Haze episodes have caused a major attention on air pollution problem in the northern part of Thailand. The attention has originated from two major areas of concern. First, open burning is the greatest source of PM_{10}. Dominate factors of PM_{10} emission include forest fires, municipal waste and agricultural waste burning. Second, PM_{10} typically exposes to the largest population every summer. This realization is the starting point of ASEAN Agreement on Transboundary Haze and National Master Plan on Open Burning Control. The National Master Plan tends to focus on forest fires prevention and rehabilitation of traditional crops land preparation rather than on establishment of new stringent regulation. Consequently, the following implementation programs are mainly based on preserve and protect nature. These programs have been made possible through the joint efforts of various ministries, including Ministry of Natural Resources and Environment, Ministry of Agriculture and Cooperatives, Ministry of Interior, Ministry of Public Health, Ministry of Transport, and Ministry of Foreign Affairs.

O_3 mitigation

Results of ambient air quality monitoring indicate that Ground-level Ozone (O_3) concentration is increasing in all urban background areas. It is assumed that the increases in NOx, VOCs, and CO concentrations are responsible for O_3 concentration increase in the ambient. Unfortunately, there is no direct measure to reduce O_3 concentration. Every current environmental control registrations have concentrated on the primary pollutant rather than on the secondary pollutant. However, it is hoped that the benefit of integrating particular adopted measures with Volatile Organic compound (VOC) control measure will bring O_3 concentration below the air quality standard level. Thailand has adopted VOC emission standards for both vehicles and industrials. In addition, Gasoline Vapor Recovery Unit (VRU) is required as one of the control technologies in the gasoline distribution system to control Hydro Carbon evaporative emissions.

12.4 References

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Acid Deposition Assessment in Vietnam:

National Report Period II (2005 – 2009)

13.1. Basic information on National Monitoring Activities

13.1.1. Outline of the activities on acid deposition and national monitoring plan

There are 2 networks of environmental monitoring stations in operation. Networks of environmental background and impacts stations are all under Ministry of Natural Resources and Environment. Network of environmental background includes 24 rain-water chemistry monitoring stations (10 automatic stations), 1 background air monitoring station, 51 river water quality stations, 10 reservoir monitoring stations, 1 experimental station for reservoir environment, and 6 sea water monitoring stations. These stations take on-site measurements and samples taken are delivered to 3 laboratories in the North, Central and South of Vietnam to analyze.

In this network, 23 rain-water chemistry monitoring stations have been operated since 1987 and located in Thai Nguyen, Viet Tri, Bac Giang, Bai Chay, Phu Lien, Hai Duong, Ha Noi, Ninh Binh, Cuc Phuong in the North of Vietnam; Thanh Hoa, Vinh, Hue, Da Nang, Qui Nhon, Nha Trang, Phan Thiet in the Central part of Vietnam; Pleiku, Buon Me Thuot, Da Lat in the Central High Land of Vietnam; Nha Be, Tan Son Hoa, Tay Ninh, Can Tho, Ca Mau in the South of Vietnam. In these stations, rain water samples are collected semi-automatically, and pH and EC are measured on site. In addition, in 2008 Hanoi has 01 more automatic air monitoring station was brought into operation.

Monitoring parameters and interval are as following:

- Wet deposition: In order to observe wet deposition, samples are taken in every precipitation event. Beside these samples, ten day-mixed samples are also analyzed with parameter of pH, EC, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Na^+, Mg^{2+}, K^+ and HCO_3^-. In these stations, rain water samples are collected semi-automatically, and pH are measured on site.

- River and reservoir quality monitoring stations: Every month, water samples are taken. The monitoring parameters compose of pH, EC, alkalinity, SO_4^{2-}, COD, Cl^-, Ca^{2+}, Na^+, NH_4^+, NO_3^-, Mg^{2+}, and K^+.

Since 2002, 6 Micro Computer Systems for Air Monitoring stations (KIMOTO Brand from Japan) with high-volume sampler and acid rain monitor have been set up and operated in Ha Noi (Lang), Phu Lien, Cuc Phuong, Da Nang, Pleiku, Nha Be stations. *Monitoring parameters and interval are as following*:

- Meteorology: wind direction, wind velocity, air temperature, air humidity, air pressure, solar radiation, rainfall and ultra-violet;

- Air quality: SO_2, NO, NO_2, NH_3, CO, O_3 in surface, CH_4, OBC, TSP, PM_{10};

- Wet deposition: pH, EC was measured for each mm of rainfall. Rainfall water samples were transferred to the laboratory for analysis. These samles is the combination of 10-day with measure parameters pH, EC, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Na^+, Mg^{2+}, K^+ and HCO_3^-.

All real-time data of automatic stations are online transferred to a data-sever in Ha Noi Network Center of Hydrometeorology and Environment to analyze.

Up to now, there are 4 automatic stations including: Long Bien station (Ha Noi) and 3 additional stations are Son La station, Vinh station and Can Tho station but these stations do not have equipments to measure parameters such as: O_3, dust and THC.

Vietnam has taken a part in EANET since August 1999 and Institute of Hydrology- Meteorology and Environment (belonging to Ministry of Natural resouse and Environment) is representative as the National Center for Vietnam. Currently, there are 13 members officially to join in the EANET network such as: Cambodia, China, Indonesia, Japan, Malaysia, Myanmar, Mongolia, Phillipines, Korea, Russia, Thailand and Vietnam.

In 1999, With the support of equipments and machines (two wet only samplers and two filter packs) from Japan Government, 2 monitoring stations based in Lang (Hanoi) and Hoa Binh Hoa Binh province have been set up and operated since then.

Vietnam spreads over 14° N of latitude, EANET Monitoring Network Center proposed that Vietnam encrease monitoring stations to provide and measure a fully of acid deposition data on the whole country. At the end of 2008, with the agreement of Vietnam Government, Ministry of Natural Resource and Environment added 3 air environmental monitoring stations: Cuc Phuong station (Ninh Binh), Da Nang station and Nha Be station (HCM city) to take part in EANET network.

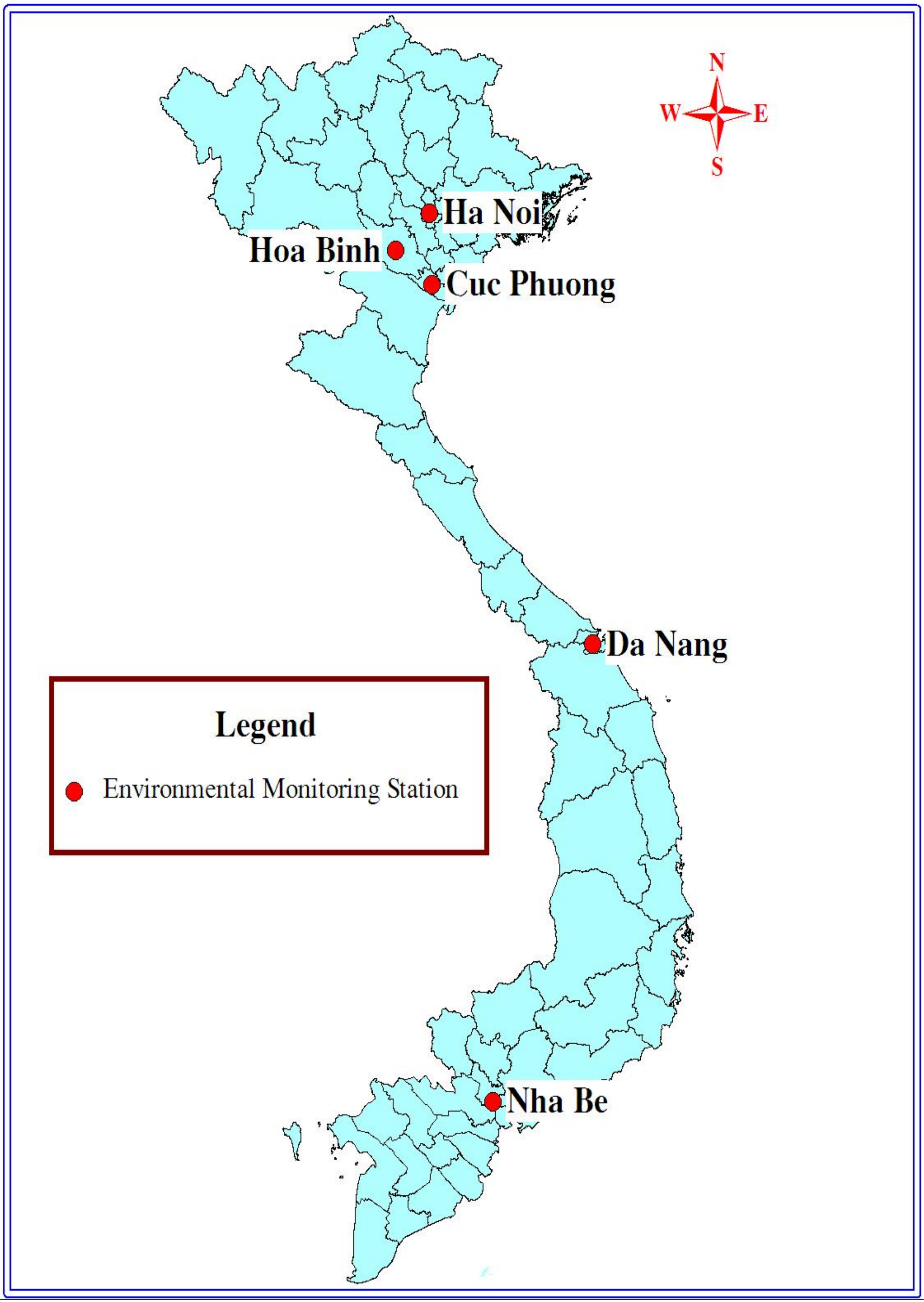


Figure 13.1.1. Location of Vietnam EANET monitoring stations.

13.1.2. National monitoring plan from 2005 to 2009:

Acid deposition monitoring stations in Ha Noi, Hoa Binh were operated till 1998, while in Cuc Phuong (Ninh Binh) and Da Nang started providing wet deposition data only from 2009.

- *Wet deposition:* With monitoring frequency is 24 hours from 9:00 am to 9:00 pm next day and sampling interval: seven days composite samples can be analyzed and measured parameters including: pH, EC, Cl^-, NO_3^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+; meteorological parameters (temperature, humidity, wind velocity, wind direction, rainfall, ultra-violet). Particularly, in Da Nang and Cuc Phuong stations, analysis sample is ten days composite.
- *Dry deposition:* Monitoring frequency is seven days, from 9:00 am, Monday this week to 9:00 am, Monday next week, and parameters including: SO_2, HCl, HNO_3, NH_3 and ions Cl^-, NO_3^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, K^+, Na^+, and NH_4^+ in the aerosol.
- *Inland aquatic environment:* Monitoring frequency is 4 times/year, parameters including: pH, EC, Cl^-, NO_3^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+, alkalinity and COD, NO_2^-, clarity.
- *Soil and vegetation environment:* Since location of Hoa Binh station does not meet the technical requirements of the station's acid deposition assessment in period 2005-2009, so this station was conducted measurements. Recommend to the support of EANET Network Center to select new monitoring station.

The monitoring data are transferred to the network center placed in Niigata in order to processed and stored.

12.1.3. Monitoring stations

Ha Noi station is an urban acid deposition station where both wet and dry deposition samples are collected and analyzed. Wet deposition samples were collected using wet only sampler and dry deposition using Filter Pack following technical guidelines of EANET.

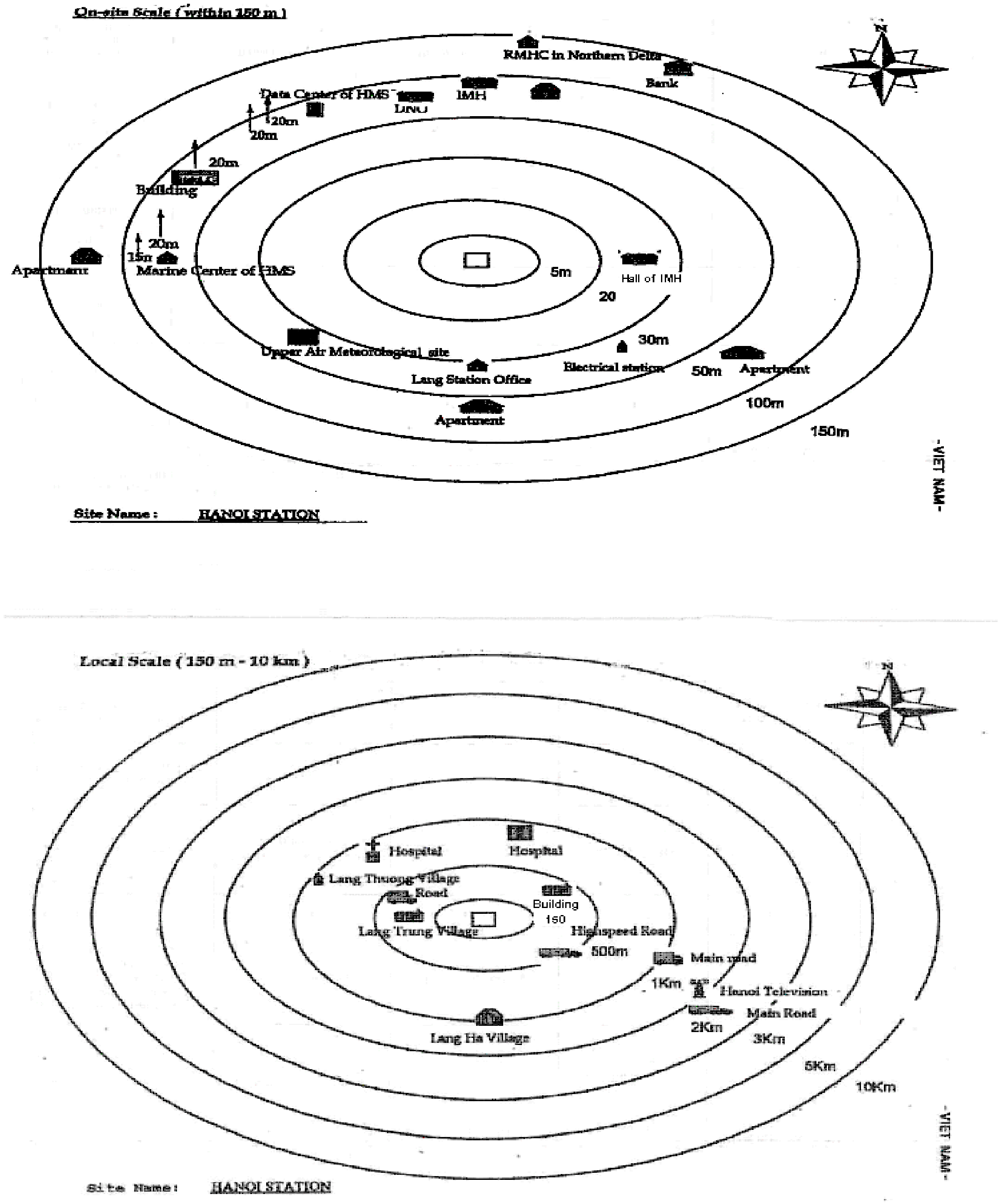
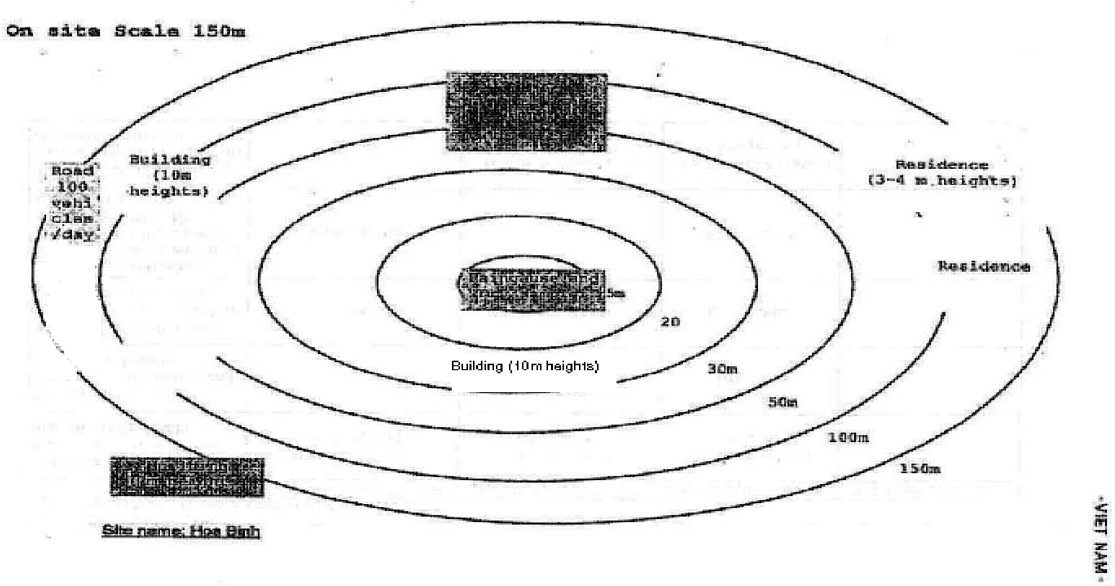


Figure 13.1.2. Outline of Hanoi monitoring site.

Hoa Binh site is a rural and ecological acid deposition station. In Hoa Binh site wet deposition, dry deposition and inland aquatic environment samplers are collected. However, Hoa Binh site is not suitable to monitor inland aquatic environment due to high alkalinity.



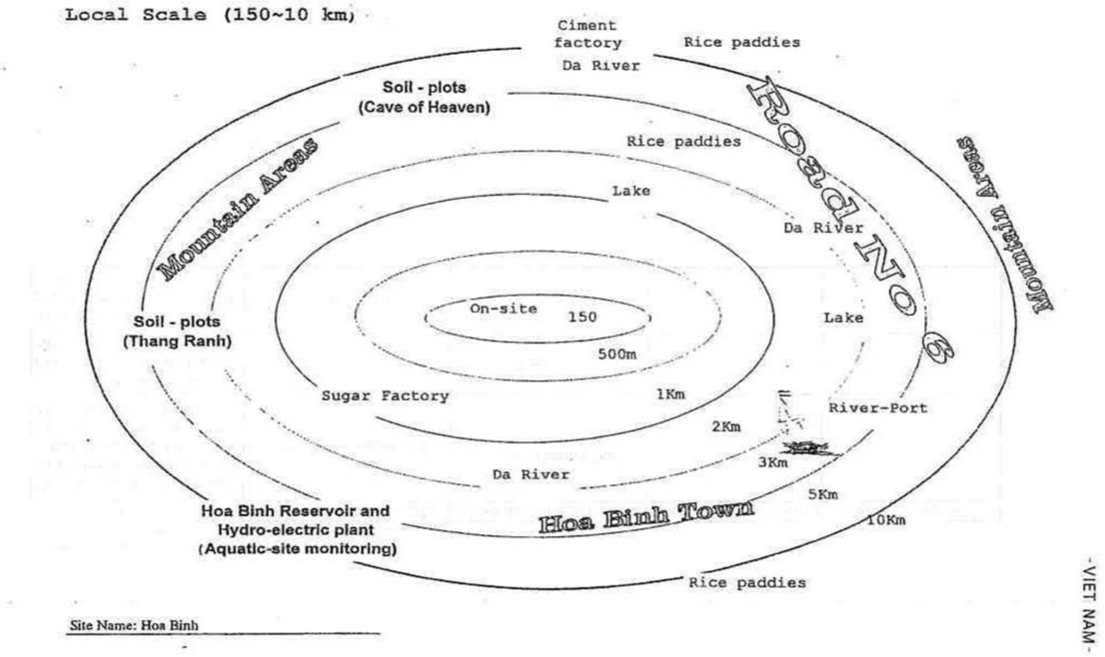


Figure 13.1.3. Outline of Hoa Binh monitoring site.

In Da Nang and Cuc Phuong sites, data of wet deposition monitoring have been transferred to Network Center since 2009.

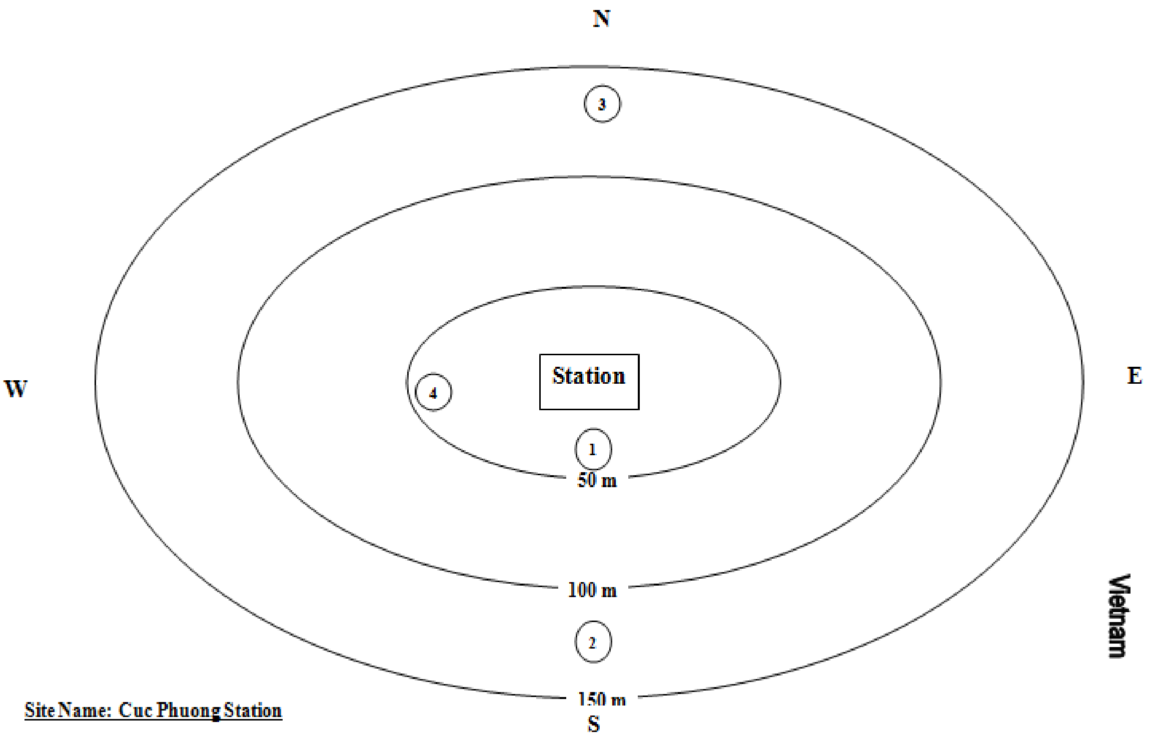


Figure 13.1.4. Outline of Cuc Phuong monitoring site.

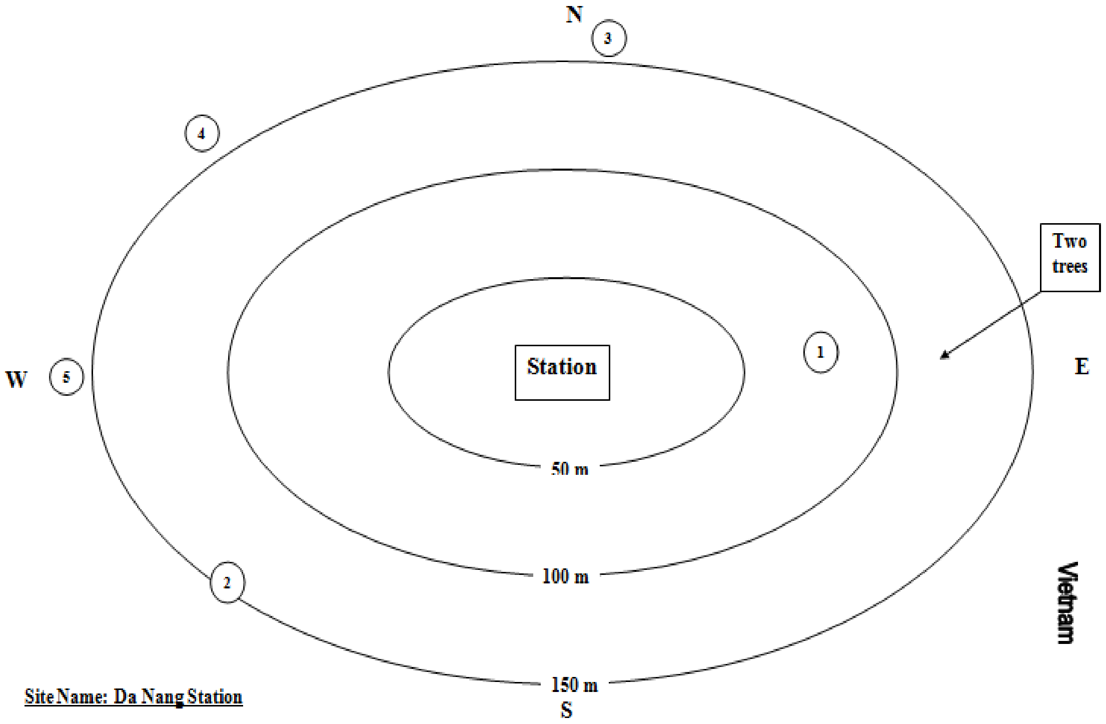


Figure 13.1.5. Outline of Da Nang monitoring site.

13.1.4. Quality assurance and quality control (QA/QC)

QA/QC programs are conducted at all stages of monitoring activities. Regularly calibrate analyzers, use certified standard materials and samples in analysis. A quality of the analytical results was regularly controlled by the balance of cations and anions in each sample examined and by comparison of the measured and the calculated electrical conductivity as well.

The laboratories, where analyses were made, involved in the Network Center's inter-laboratory comparison projects on wet deposition, soil and inland aquatic environment monitoring**.**

13.2. Results of Acid Deposition Monitoring in Vietnam During the Period From 2005 to 2009

13.2.1. Atmosphere deposition

13.2.1.1. Wet deposition

a. pH in precipitation

The annual average pH in Hanoi site (urban area) and Hoa Binh site (rural area) in survey period (2005-2009) is shown on Figure 13.2.1.

In Hoa Binh site, the highest pH value was measured in 2005 (pH = 5.69). Whereas the remaining years, pH value was lower than 5.6. These show that Acid rain has appeared regularly in Hoa Binh province since 2006. In Ha Noi site, the lowest pH value was measured in 2007 (pH = 5.58), but annual average pH value is always higher than in Hoa Binh site. In Hoa Binh and Ha Noi sites, pH value in precipitation tends to decrease with time.

Thus, compared with the previous 5-years period, pH in Hoa Binh has subsequently increased, while in Hanoi there is no significant variation (Figure 13.2.2).

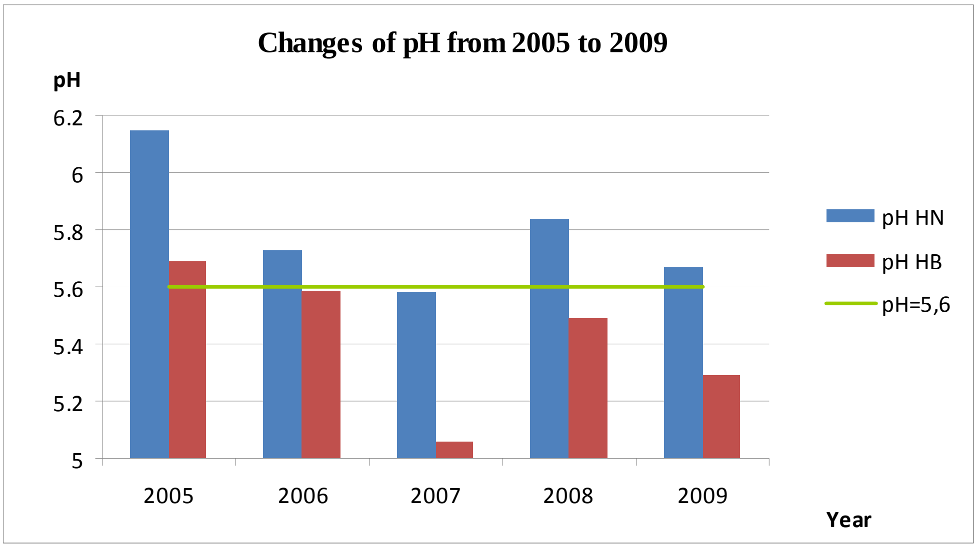


Figure 13.2.1. Average pH value in precipitation in Hanoi and Hoa Binh sites (2005-2009).

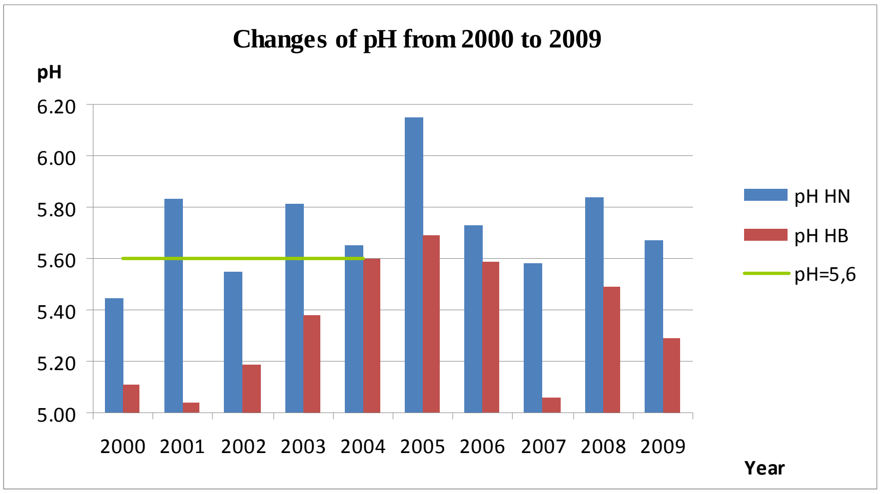
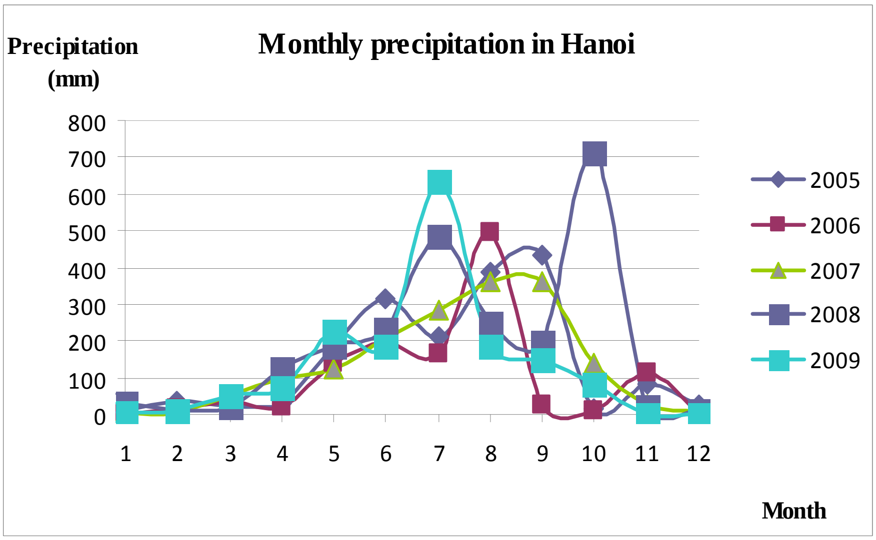


Figure 13.2.2. Average pH value in precipitation in Ha Noi and Hoa Binh sites (2000-2009).



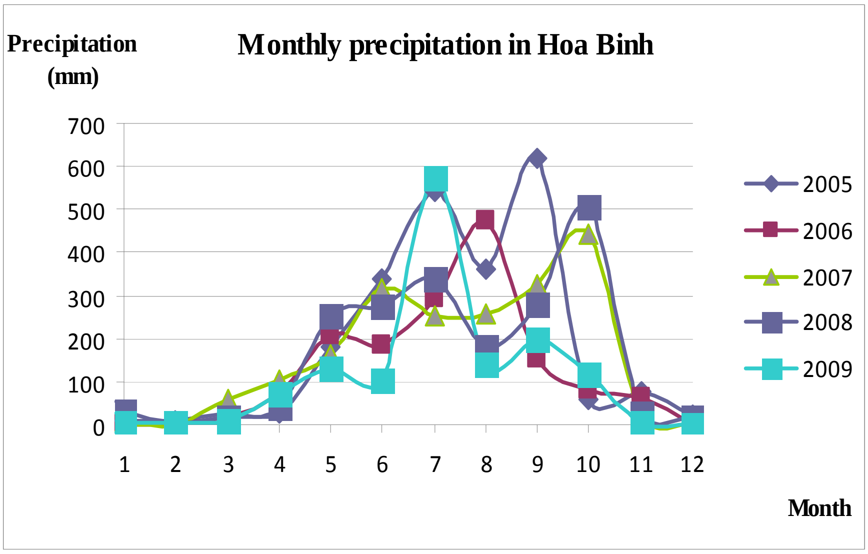


Figure 13.2.3. Monthly precipitation in Ha Noi and Hoa Binh sites (2005-2009).

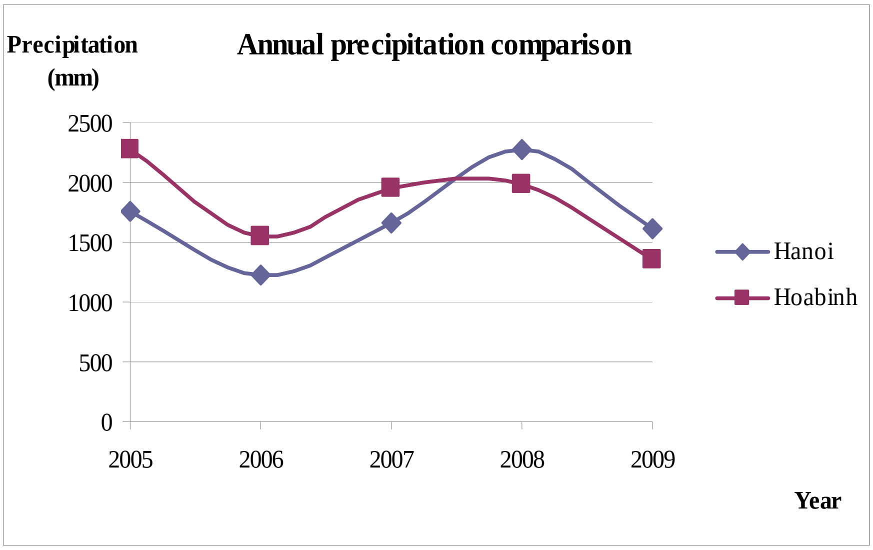


Figure 13.2.4. Annual average rainfall in Ha Noi and Hoa Binh sites during the period from 2005–2009.

In Ha Noi and Hoa Binh sites, the annual average rainfall decreased in 2006 and then increased with the highest value in 2008 and then has decreased since 2009. The lowest pH values were found in precipitation collected in Hoa Binh and Ha Noi sites in 2007. So, this reason of reduction does not depend on rainfall. Variation of pH values at 4 stations in precipitation are shown on Figure 13.2.5. In Northland, rainy season is the period from May to October and dry season is the period from November to April. In Central Coast, rainy season is from July to November. However, according to Figure 13.2.3 and 13.2.5, pH value is higher in dry season in Hoa Binh site.

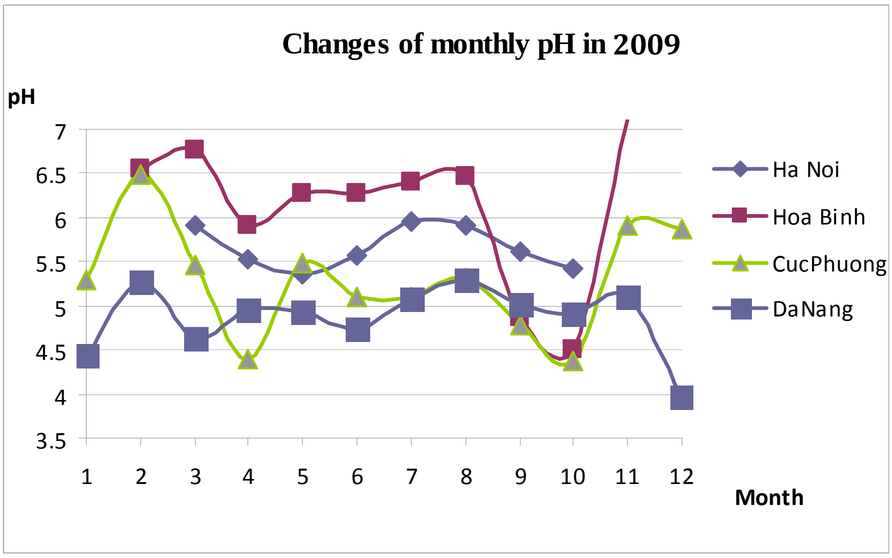


Figure 13.2.5. Monthly average pH value in precipitation at 4 stations in 2009.

b. Ion components of precipitation:

Figure 13.2.6 shows average concentration of major ion and cation in precipitation in Hanoi and Hoa Binh sites. Major anions in precipitation at 2 sites are SO_4^{2-} (~50%) and NO_3^- (~35%), and cations NH_4^+ (~50%) and Ca^{2+} (~20%).

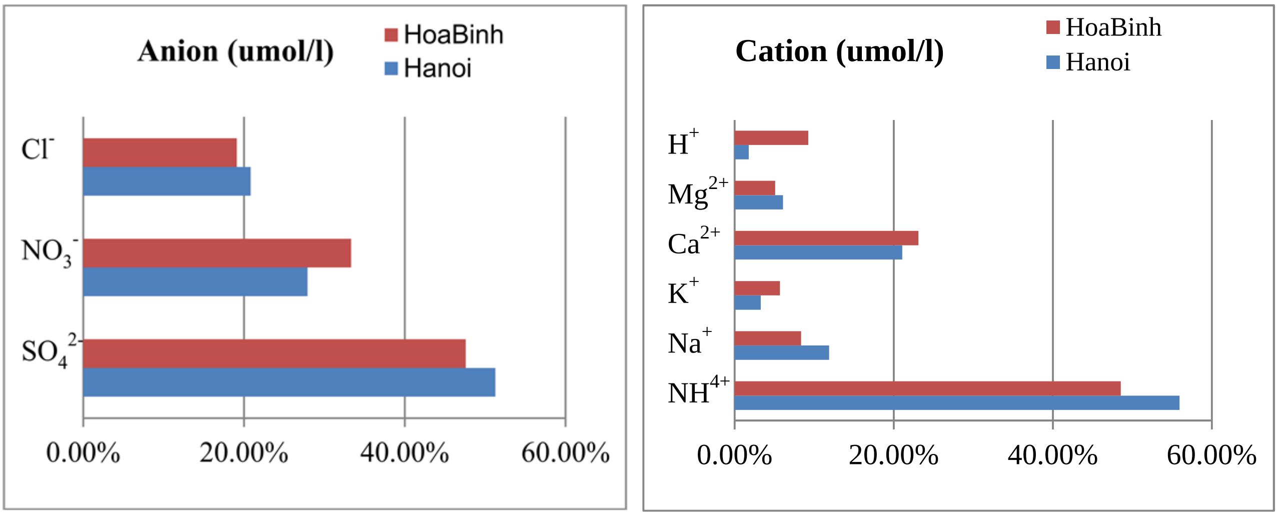
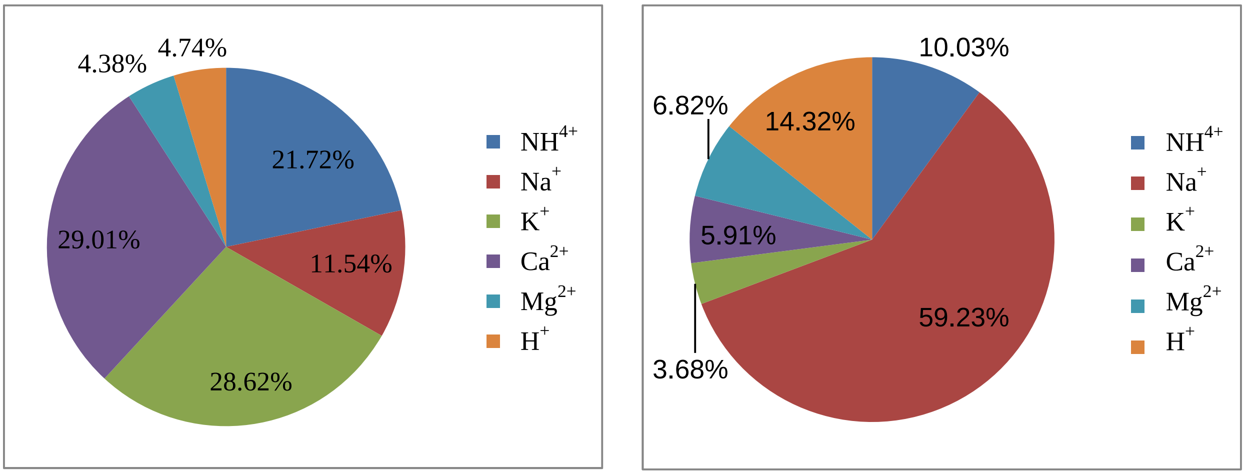


Figure 13.2.6. Percentage of anion and cation in precipitation in Ha Noi and Hoa Binh sites in the period 2005 – 2009.

In Cuc Phuong and Da Nang stations are only have data in 2009. Thus, ratios of cation and anion in precipitation (in 2009) are compared in Figure 13.2.7 and Figure 13.2.8.

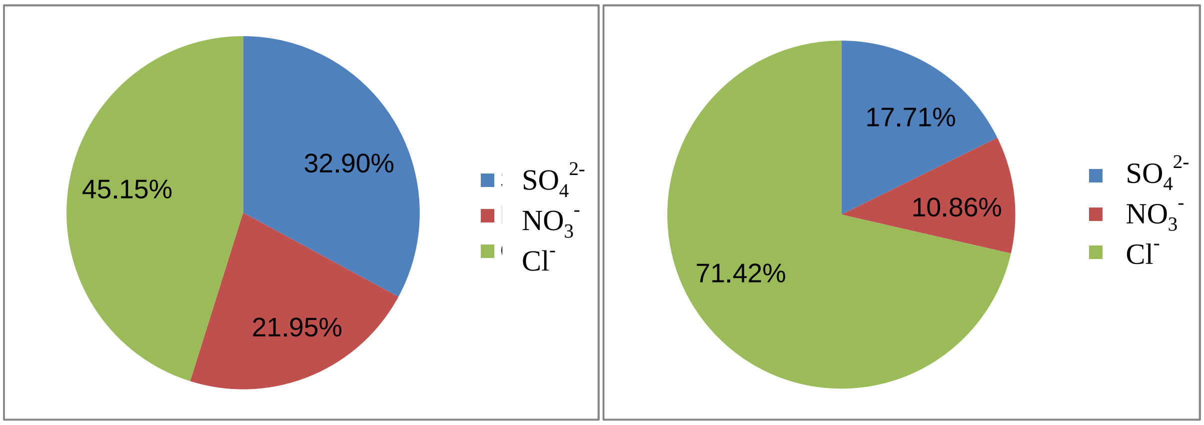


Cuc Phuong

Da Nang

Figure 13.2.7. Percentage of cation in precipitation at 4 stations in 2009.

In Cuc Phuong site, ratios of cation are equal or majority 80% in precipitation. But, in Da Nang site, Na^+ cation occupies 60%, and then H^+ and NH_4^+ cations with each of type is 10%.



Cuc Phuong

Da Nang

Figure 13.2.8. Percentage of anion in precipitation at 4 stations in 2009.

In Cuc Phuong site, Cl^- anion in precipitation is majority (45%) and in Da Nang site is 71%. Next is SO_4^{2-} with 32% and 18% respectively.

c. The status of acid rain

At 4 stations, ratios of acid rain ($pH < 5.6$) are shown on Figure 13.2.9. According to the analysis results in the period of 2005-2009 acid rains were detected in Hanoi and Hoa Binh with approximately 20%.

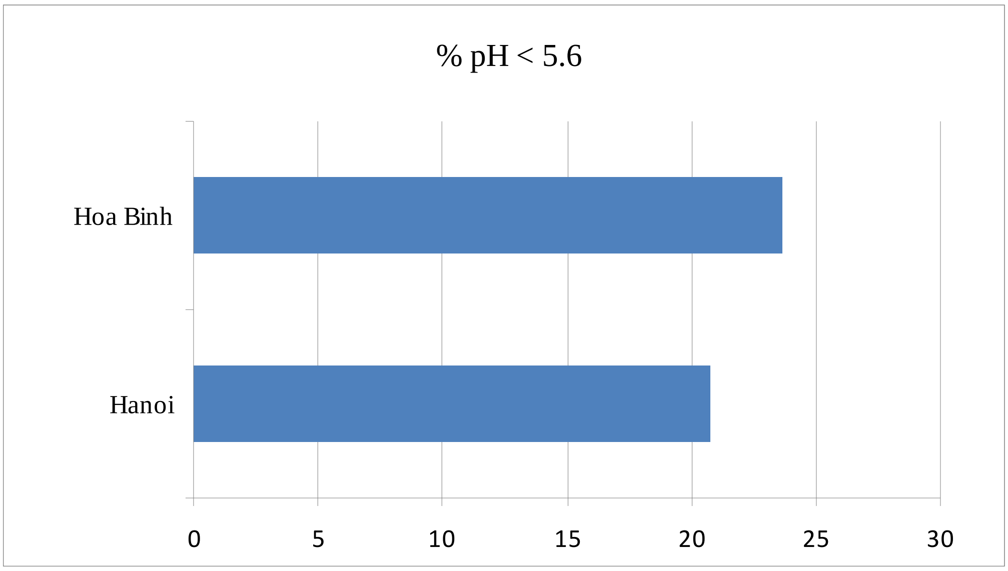


Figure 13.2.9. Percentage of pH in precipitation <5.6 at 2 stations during the period 2005 – 2009.

At Cuc Phuong and Da Nang sites, there were only monthly mean pH data in 2009 so they cannot perform the whole period. Particularly in 2009, all monthly average pHs of 12 months in Danang are below 5.6, while in Cuc Phuong from January to October (rainy season) monthly average pH are below 5.6 and was increasing in the last 2 months (dry season).

Two major ions cause acidity in precipitation: SO_4^{2-} and NO_3^-. These ions combined with H^+ ion into H_2SO_4 and HNO_3 acidities. pA_i index is used to calculate concentration of these 2 ions in precipitation, pAi is defined by the same way as pH and calculated using the following formula:$pA_i = -\log([nss\text{-}SO_4^{2-}] + [NO_3^-])$

pA_i will equal with pH if there is no neutralization appears.

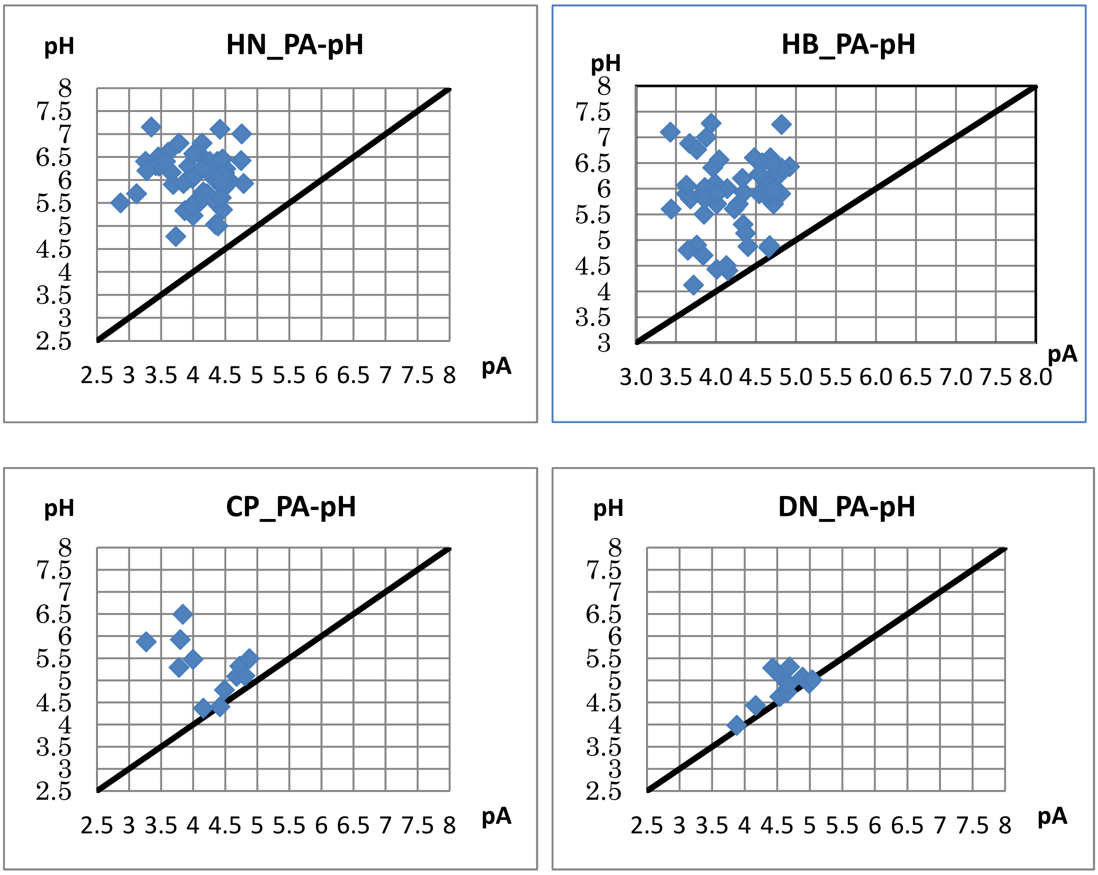
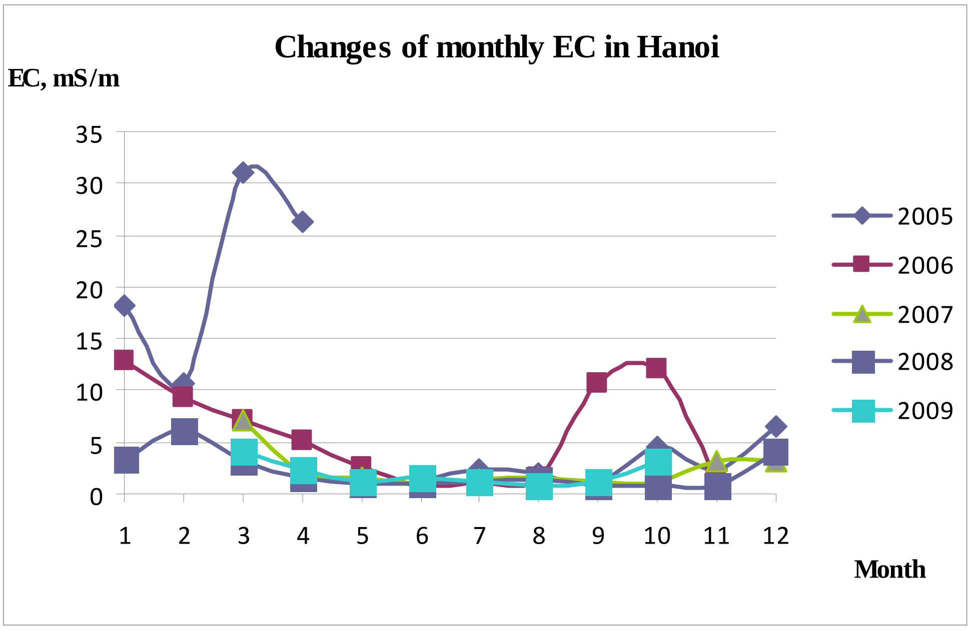


Figure 13.2.10. Comparison of pH and pAi values at four stations.

At stations: Ha Noi, Hoa Binh and Cuc Phuong, pH value is always higher than pA_i value. It results in the greater impact of Ca^{2+} and NH_4^+ ions in precipitaion. In Da Nang site, pH value approximately equals with pA value. Thus, In Da Nang site, Ca^{2+} and NH_4^+ cations in precipitation are not enough to neutralize, led to acid rain tend to permanent.

d. Electrical Conductivity (EC)

From Figure 13.2.11 and Figure 13.2.12, at 4 stations EC in dry season is always higher than in rainy season.



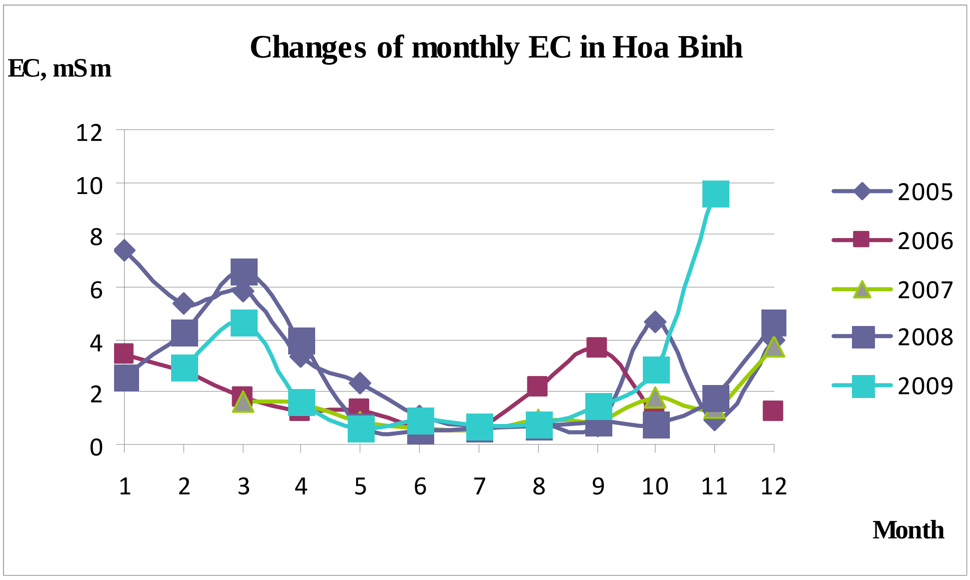


Figure 13.2.11. Monthly EC value in Ha Noi and Hoa Binh sites during the period 2005-2009.

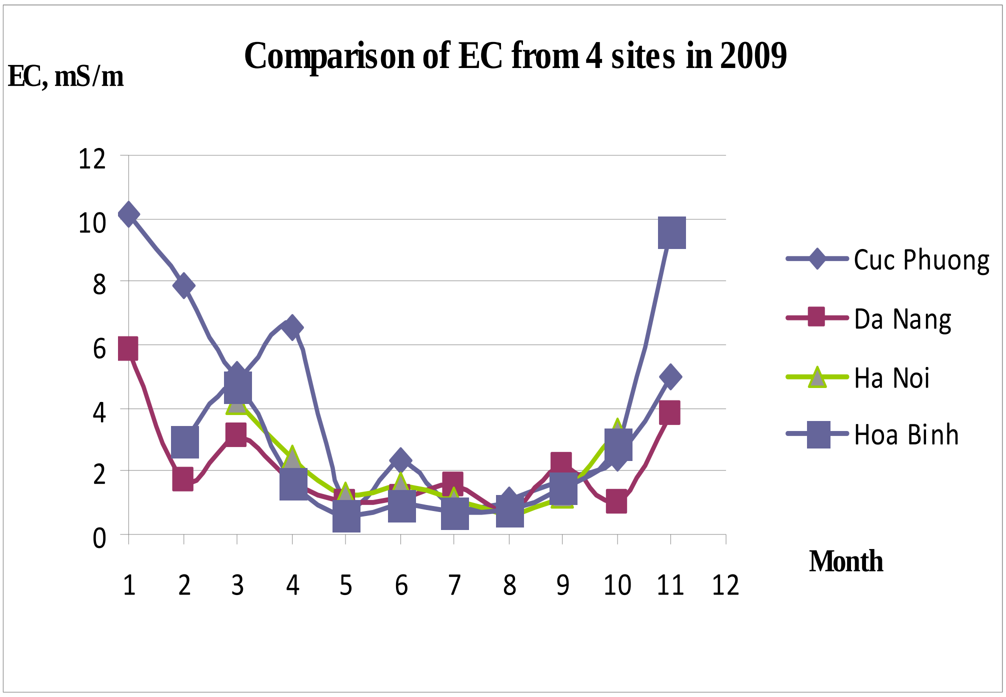
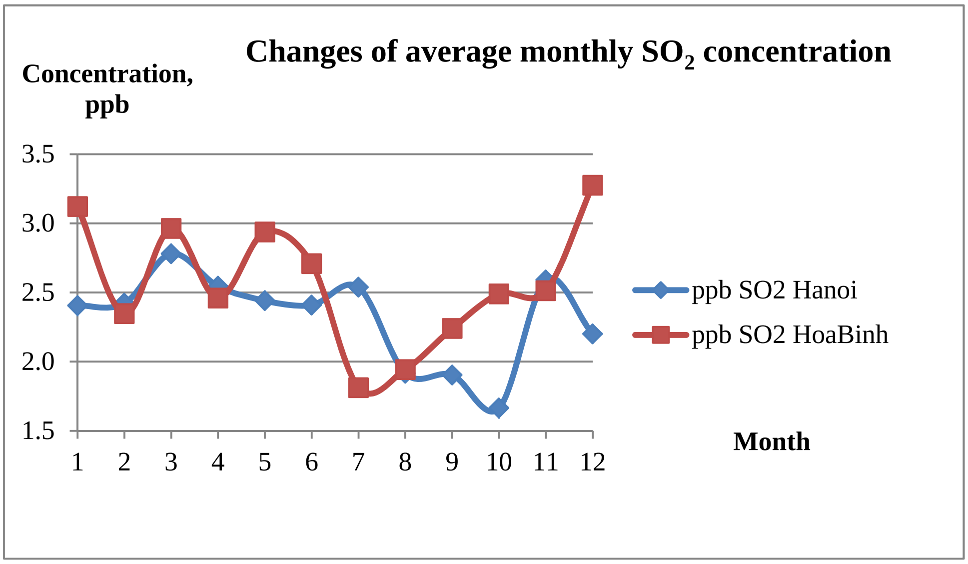


Figure 13.2.12. EC value at 4 stations in 2009.

13.2.1.2. Dry deposition

At all observation sites, SO_2 concentration is major. In Ha Noi and Hoa Binh sites, variation of monthly SO_2 concentration and annual SO_2 concentration during the period 2005 - 2009 are presented at Figure 13.2.13. The highest concentration was observed in dry season when amount of rainfall decreases. During the period 2005 – 2009, SO_2 concentration development in Ha Noi site (urban area) and Hoa Binh site (rural area) are similar with the exception in 2006.



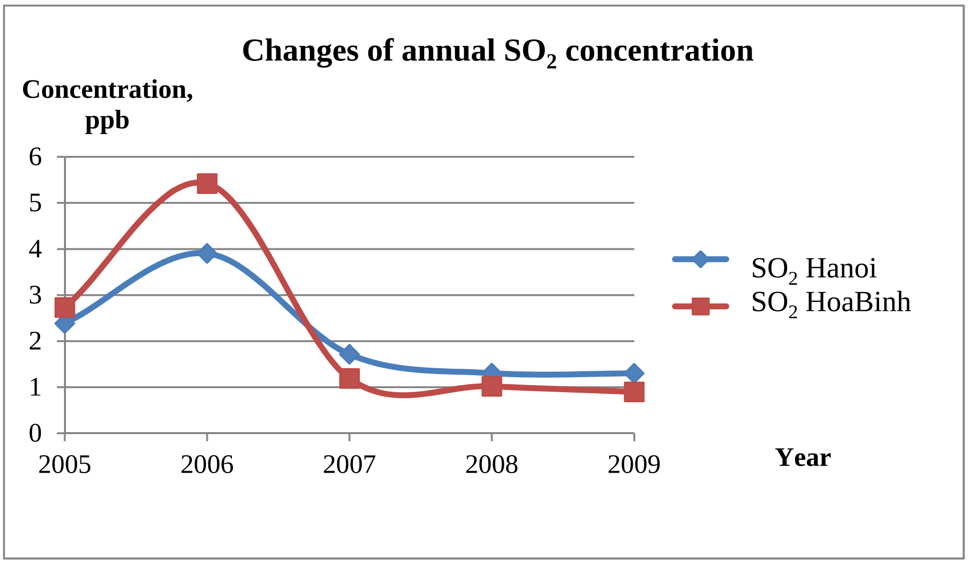
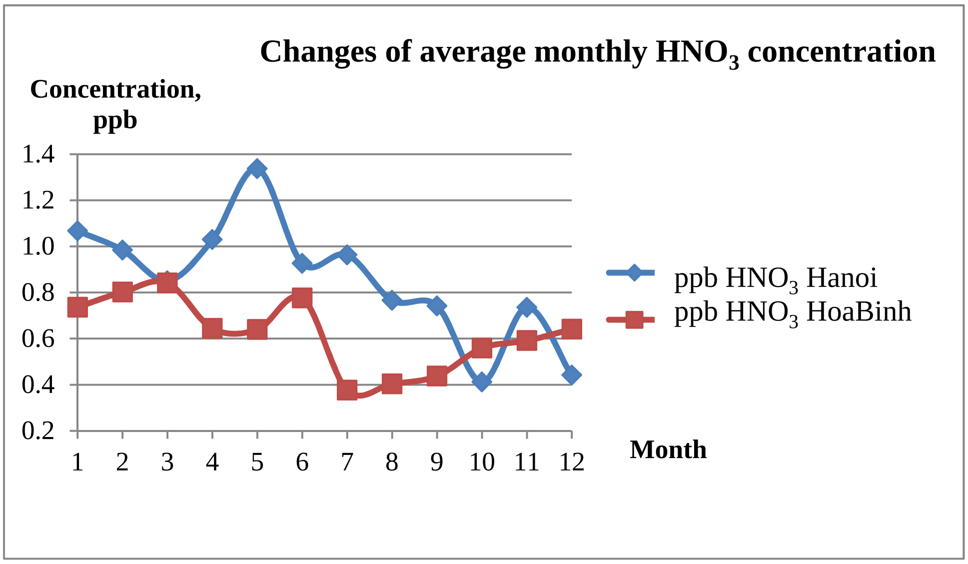


Figure 13.2.13. Variation of SO_2 concentration in Ha Noi and Hoa Binh sites (2005-2009).

The level of air pollution by gaseous nitrogen compounds in Hanoi was higher than in Hoa Binh and higher in rainy season (Figure 13.2.14). Variation of HNO_3 concentrations in Hoa Binh has tended to decrease significantly. In 2009, its value was ½ compared with in 2005. But in Ha Noi, variation of HNO_3 concentrations was not clearly, in 2008, it decreased and in 2009, it increased.



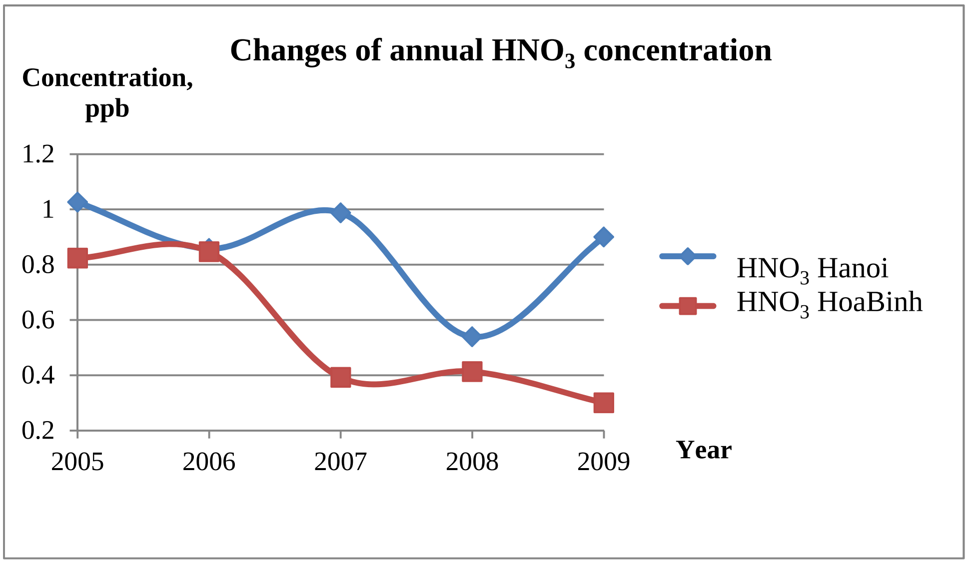
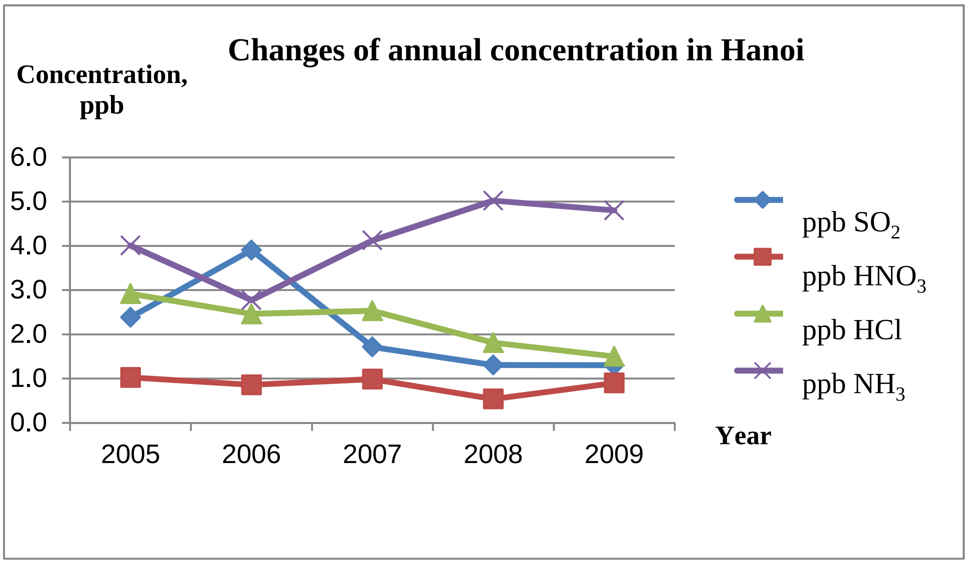


Figure 13.2.14. Variation of HNO_3 concentration in Ha Noi and Hoa Binh sites (2005-2009).

During the period 2005 – 2009, concentrated variation of other air pollution substances in Ha Noi and Hoa Binh are presented at Figure 13.2.15.



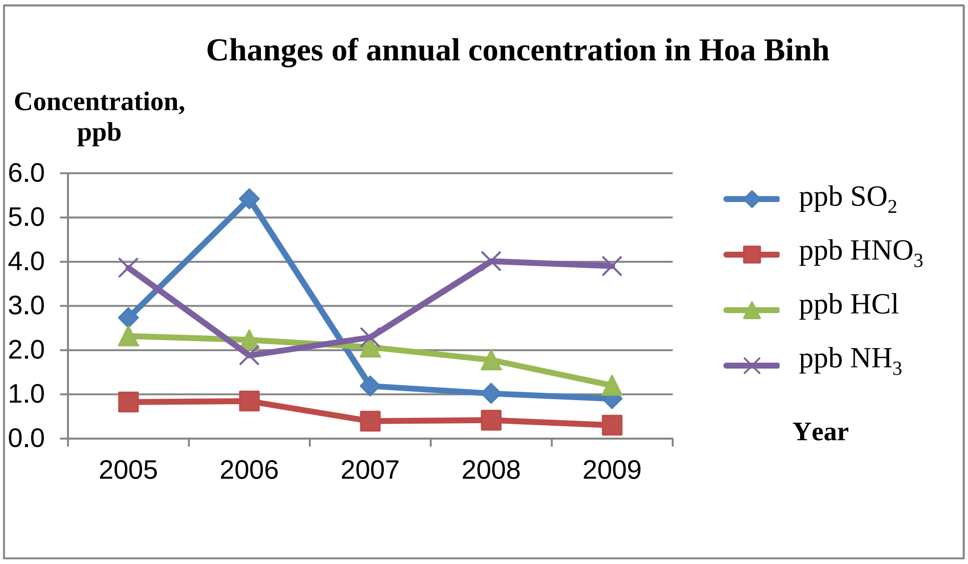


Figure 13.2.15. Concentrated variations of other air pollution substances in Ha Noi and Hoa Binh (2005-2009).

In Ha Noi and Hoa Binh, SO_2 and HCl concentrations tended to decrease and are almost similar; in particular SO_2 concentration has decreased strongly from 2007. In these 2 areas, NH_3 gases were major and tended to increase strongly from 2006. However, these gases have decreased significantly compared to the previous 2000-2004 period. A comparison of long-term data on ions concentrations in aerosols obtained at Hanoi and Hoa Binh site during monitoring period 2005-2009 is shown that ratio of SO_4^{2-}, NO_3^- anions and NH_4^+, K^+ and Ca^{2+} cations were predominant (Figure 13.2.16). This ratio has not changed much compared with the previous 2000-2004 period.

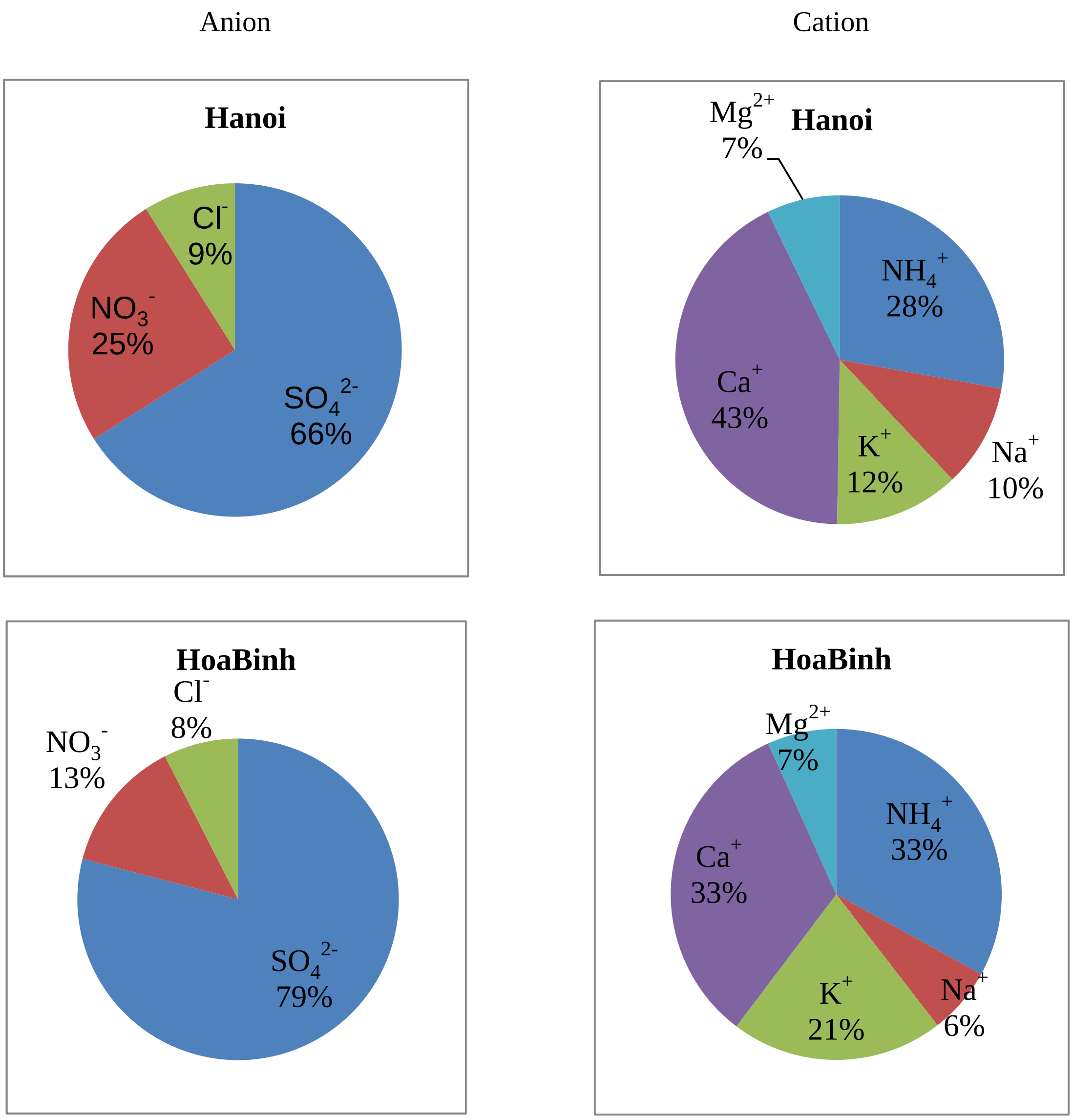


Figure 13.2.16. Percentage of major ions in aerosol (2005-2009).

13.2.2. State of inland aquatic environment

During the period 2005 – 2009, in Hoa Binh reservoir pH value of all samples are higher than 7.0. The results show that surface water has not acidified yet. EC value is from 14.00 to 21.95 mS/m. Maximum EC value is in June (at the beginning of rainy season) and the lowest EC value is in September (at the end of rainy season). It shows that in the beginning of the season metal salts dissolve in water are greater than other ions. Observation results (Table 13.2.1.) showed that up and down of EC was insignificant over the years (from 2005 to 2009) in Hoa Binh station. Concentration of all ions was analyzed in surface water samples to meet surface water standards.

Table 13.2.1. Analytical results of inland aquatic samples in Hoa Binh reservoir in the period 2005-2009.

Time	Temp (°C)	pH	EC (mS/m)	Alkalinity (meq/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	Cl^- (mg/l)	NH_4^+ (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)
15-03-05	22.5	7.63	19.26	1.58	8.52	1.35	1.89	0.15	3.41	0.89	24.96	5.11
15-06-05	29.0	7.36	21.95	1.84	4.21	0.48	2.02	0.13	5.27	1.28	24.88	6.50
15-09-05	27.0	8.40	16.00	1.40	3.98	0.96	1.04	0.19	3.39	0.84	19.97	3.63
15-12-05	17.0	7.46	18.83	1.60	5.76	1.38	1.52	0.16	5.54	2.23	22.67	3.84
15-03-06	20.0	7.02	20.42	1.72	7.40	1.00	1.67	0.10	4.20	1.52	26.74	5.26
15-06-06	27.8	7.28	21.45	1.78	10.85	0.78	1.75	0.18	4.38	1.73	28.01	5.40
15-09-06	29.8	7.15	16.58	1.44	5.35	0.23	0.84	0.09	2.51	1.22	21.62	4.25
15-12-06	24.9	7.66	17.86	1.48	7.23	1.46	1.36	0.11	3.37	1.38	24.49	4.55
15-03-07	21.0	7.56	20.53	1.70	9.12	0.84	1.85	0.15	4.45	1.31	27.65	4.85
15-06-07	28.2	7.43	21.01	1.65	11.45	2.64	2.28	0.04	4.49	1.81	25.29	5.16
15-09-07	28.5	7.83	15.36	1.40	5.45	0.52	0.99	0.14	2.49	1.27	20.95	3.54
15-12-07	24.0	7.77	19.45	1.70	6.53	1.76	1.05	0.12	2.68	1.52	25.70	4.99
15-03-08	21.0	8.12	19.67	1.65	8.96	0.53	1.80	0.05	3.49	1.06	24.33	5.23
15-06-08	28.2	7.50	21.15	1.68	10.69	1.91	2.70	0.01	0.81	0.42	28.92	4.95
15-09-08	28.5	8.19	14.92	1.32	4.43	0.13	0.90	0.04	2.30	1.25	16.92	4.81
15-12-08	24.0	7.53	17.30	1.48	5.36	1.57	1.19	0.04	2.72	0.91	21.43	5.03
15-03-09	21.5	8.10	19.40	1.68	5.68	0.29	2.52	0.01	3.18	0.93	23.79	5.26
15-06-09	31.0	7.82	15.19	1.04	10.07	1.21	3.05	0.05	4.30	0.78	15.47	4.47
15-09-09	31.0	8.08	14.00	1.24	4.28	0.15	1.56	0.01	2.37	0.66	18.37	3.73
15-12-09	25.0	7.96	18.01	1.60	6.18	1.01	1.07	0.01	2.54	0.97	25.65	4.50

13.2.3. Overall analysis

In the period 2005 – 2009, results showed that precipitation is tending to acidify in Ha Noi and Hoa Binh. According to the observation data in 2009 showed that monthly average pH lower than 5.6 occupied more than 60% in Cuc Phuong and 100% in Da Nang. Inland aquatic environment: In this period, there is no acidification in reservoir. However, according to the EANET assessment, Hoa Binh reservoir has not met standards. Thus, request the technical assistance of Network Center to select new inland aquatic environment station. Similar request of soil and vegetation environmental monitoring station (as Hoa Binh station did not meet the technical requirements of acid deposition impact assessment station during the period 2005 – 2009 so in this station was not conducted measurement).

13.3. Review of National Measures Against Acid Deposition in Vietnam

Acid deposition (acid rain in particular) is a very difficult problem solving and control. In Vietnam, the current amount of acid rain accounts for 30% of rainfall and a growing tendency to increase. Rainwater contaminated acid is dangerous to health if water is put to use.

To be able to limit the harmful effects of acid deposition, the problem of air pollution must be addressed by general measures. Emissions of air pollution in Vietnam are primarily from industrial sources like power plants, factories and cement factories, producing construction materials, metallurgy and chemicals. To solve these problems, the Government of Vietnam has promulgated policies and action plans for environmental protection such as clean air Ordinance, environmental impact assessments for all projects, check Effective control of pollution at factories all serious pollution emissions, using clean production technologies, unleaded gasoline, reducing substances that cause the greenhouse effect, enhanced automatic air monitoring stations etc. Vietnam gradually applies the system of national standards on a uniform environment, access to international standards, to ensure management objectives for environmental management and sustainable development. Ministry of Natural Resources and Environment) is responsible for promulgating the environmental standard sets. The following environmental standards of Vietnam will be strictly adhered to carry out the environmental assessment study, including:

- QCVN 05: National Technical Regulation on ambient air quality;
- QCVN 06: National Technical Regulation on hazardous substances in ambient air;
- QCVN 08:2008/BTNMT: National technical regulation on Surface water quality.
- QCVN 09:2008/BTNMT: National technical regulation on Ground water quality.
- QCVN 10:2008/BTNMT: National technical regulation on Coastal water quality.

Besides, other technical standard were also applied.

Vietnam has committed to implement Agenda 21, "For life on earth". Vietnam is one of the first countries which have developed “Strategic Orientation for Sustainable Development” and efforts to implement the national plans, especially:

- Program to prevent industrial pollution and urbanization.
- Education, training and raising awareness of the community on environmental protection.
- A national program to implement the United Nations Framework Convention on Climate Change.
- National Program phasing out ozone destroying substances.
- The changing consumption patterns in ways that are beneficial to the environment.
- Program to ensure clean water and sanitation in rural areas.

Vietnam, as in many other countries in the world, environmental issues in general, the atmosphere in particular is a problem of strategic importance in economic development – social, national security. Without investment in pollution control adequately, then this will have huge cost to the Environmental cost of remediation. Thus, environmental protection, "home" of the whole human race is that of all the people and industries, all countries in the world.

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