

THIRD PERIODIC REPORT ON ACID DEPOSITION ASSESSMENT IN VIETNAM (2010- 2014)

Chapter 1. Basic Information on National Monitoring Activities

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 5 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, seven 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 Automatic Air quality Monitoring stations (KIMOTO Brand from Japan) with 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: SO₂, NO, NO₂, NH₃, CO, O₃ in surface, CH₄, OBC, TSP, PM10;
- Wet deposition: pH, EC was measured for each mm of rainfall. Rainfall water samples were transferred to the laboratory for analysis. These samples is the combination of 10-day from 2010 to 2012) and 7-day from 2013 to now with measure parameters pH, EC, SO₄²⁻, NO₃⁻, NH₄⁺, Cl⁻, Ca²⁺, Na⁺, Mg²⁺, K⁺ and HCO₃⁻.

All real-time data of automatic stations are online transferred to a data-server 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 equipment to measure parameters such as: O₃, dust and THC.

Vietnam has taken a part in EANET since August 1999 and Institute of Hydrology-Meteorology and Climate Change (IMHEN) belonging to Ministry of Natural Resource and Environment (MONRE) is representative as the National Center for Vietnam.

In 1999, with the support of equipment 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. In the end of 2008, with the agreement of Vietnam Government, Ministry of Natural Resource and Environment added 3 sites: Cuc Phuong station (Ninh Binh), Da Nang station (Da Nang city); and In 2014 added 2 sites Ho Chi Minh station (HCM city) and Can Tho station (Can Tho province) to take part in EANET network.

Table 1. EANET acid deposition monitoring sites in Vietnam

Items	Before 2015			From 2015		
	Urban sites	Rural sites	Remote sites	Urban sites	Rural sites	Remote sites
Wet deposition	3 (Ha Noi, Da Nang, Ho Chi Minh city)	2 (Hoa Binh, Can Tho)	1 (Cuc Phuong)	3 (Ha Noi, Da Nang, Ho Chi Minh city)	3 (Hoa Binh, Can Tho)	1 (Cuc Phuong)
Dry deposition	2 (Ha Noi, Ho Chi Minh city)	2 (Hoa Binh, Can Tho)		3 (Hanoi, Ho Chi Minh city, Da Nang)	3 (Hoa Binh, Can Tho)	
Soil & vegetation			1 (Cuc Phuong)			
Inland aquatic environment		1 (Hoa Binh)			1 (Hoa Binh)	



Hình 1.1: Monitoring stations

1.2. Monitoring plan from 2010 to 2014

Items	Sites classify	Place	Sampler	Analytical offices
Wet deposition	Urban sites (3 sites)	Ha Noi	Wet only sampler	Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE
		Da Nang	Wet sampler with pH, EC automatic measurement each	Environmental analysis laboratory II area- Mid-central regional hydro meteorological center – National

Items	Sites classify	Place	Sampler	Analytical offices
			mm of rainfall	Hydro-meteorological Service (NHMS) – MONRE
		Ho Chi Minh city	Wet only sampler	Environmental Laboratory - Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) – IMHEN- MONRE
	Rural sites (2 sites)	Hoa Binh	Wet only sampler	Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE
		Can Tho*	Wet only sampler	Environmental Laboratory - Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) – IMHEN- MONRE
	Remote sites (1 site)	Cuc Phuong	Wet sampler with pH, EC automatic measurement each mm of rainfall	Environmental analysis laboratory I area - Center for Hydro-Meteorological and Environmental Networks - National Hydro-meteorological Service (NHMS) – MONRE
Dry deposition	Urban sites (2 sites)	Ha Noi,	Fiter Pack	Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE
		Ho Chi Minh*	Fiter Pack	Environmental Laboratory - Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) – IMHEN- MONRE
	Rural sites (2 sites)	Hoa Binh	Fiter Pack	Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE
		Can Tho*	Fiter Pack	Environmental Laboratory - Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC) –

Items	Sites classify	Place	Sampler	Analytical offices
				IMHEN- MONRE
Inland aquatic environment	Rural sites (1 sites)	Hoa Binh		Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE

Note: *Ho Chi Minh and Can Tho sites have just started providing wet and dry monitoring data since 2014.

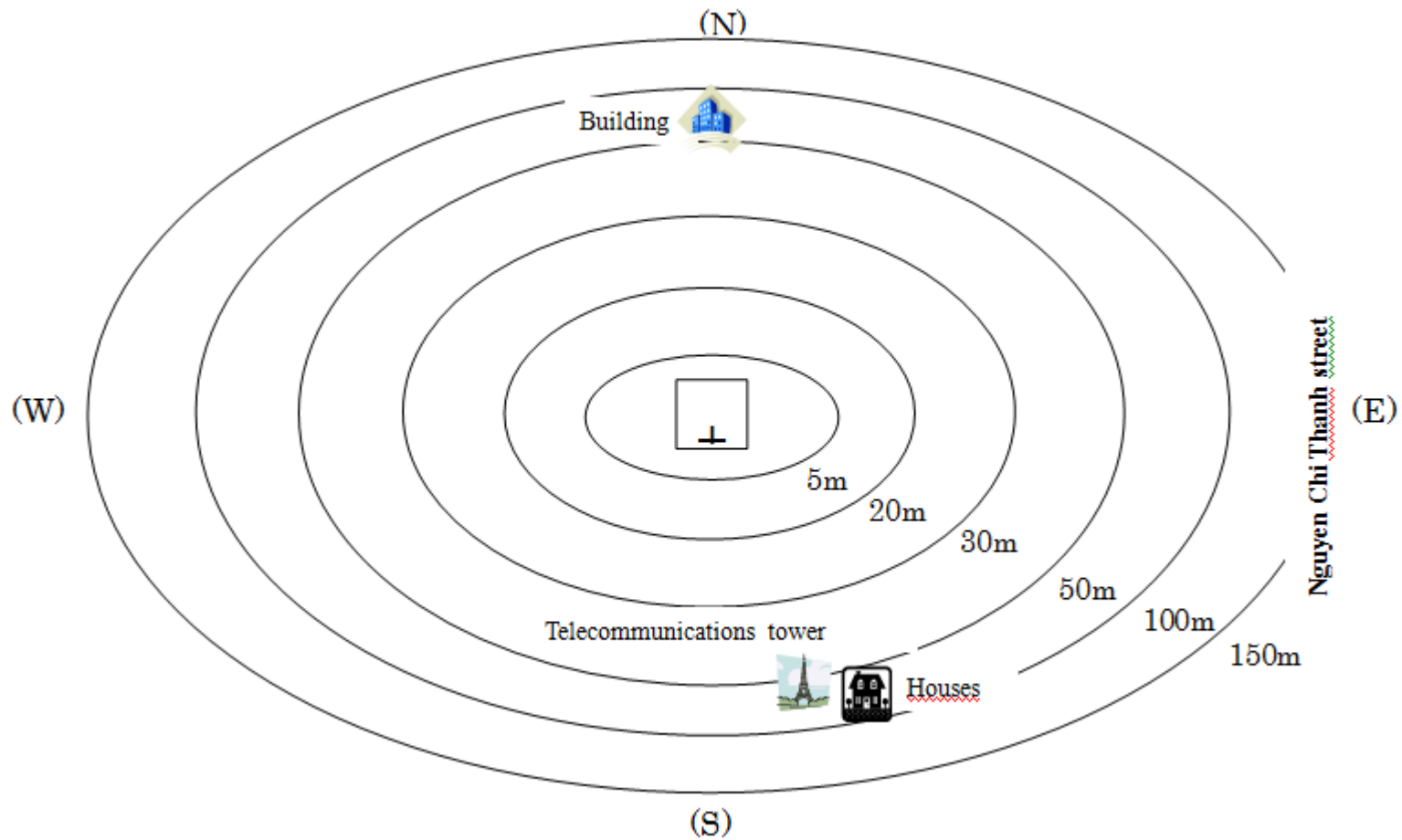




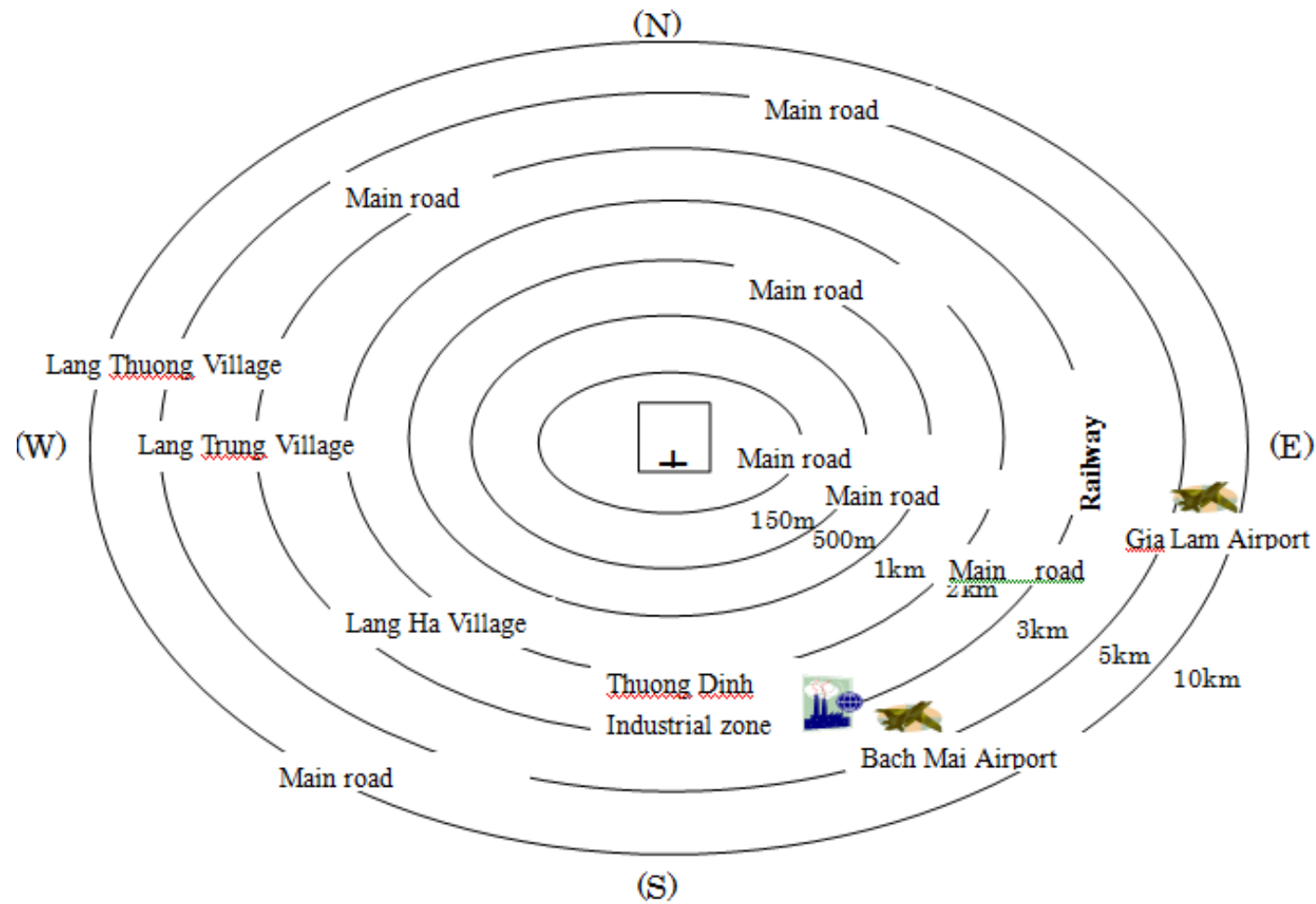
1.3. Location of monitoring sites

a. Ha Noi station

Outline of monitoring site: On-site scale (distance within 150 m)

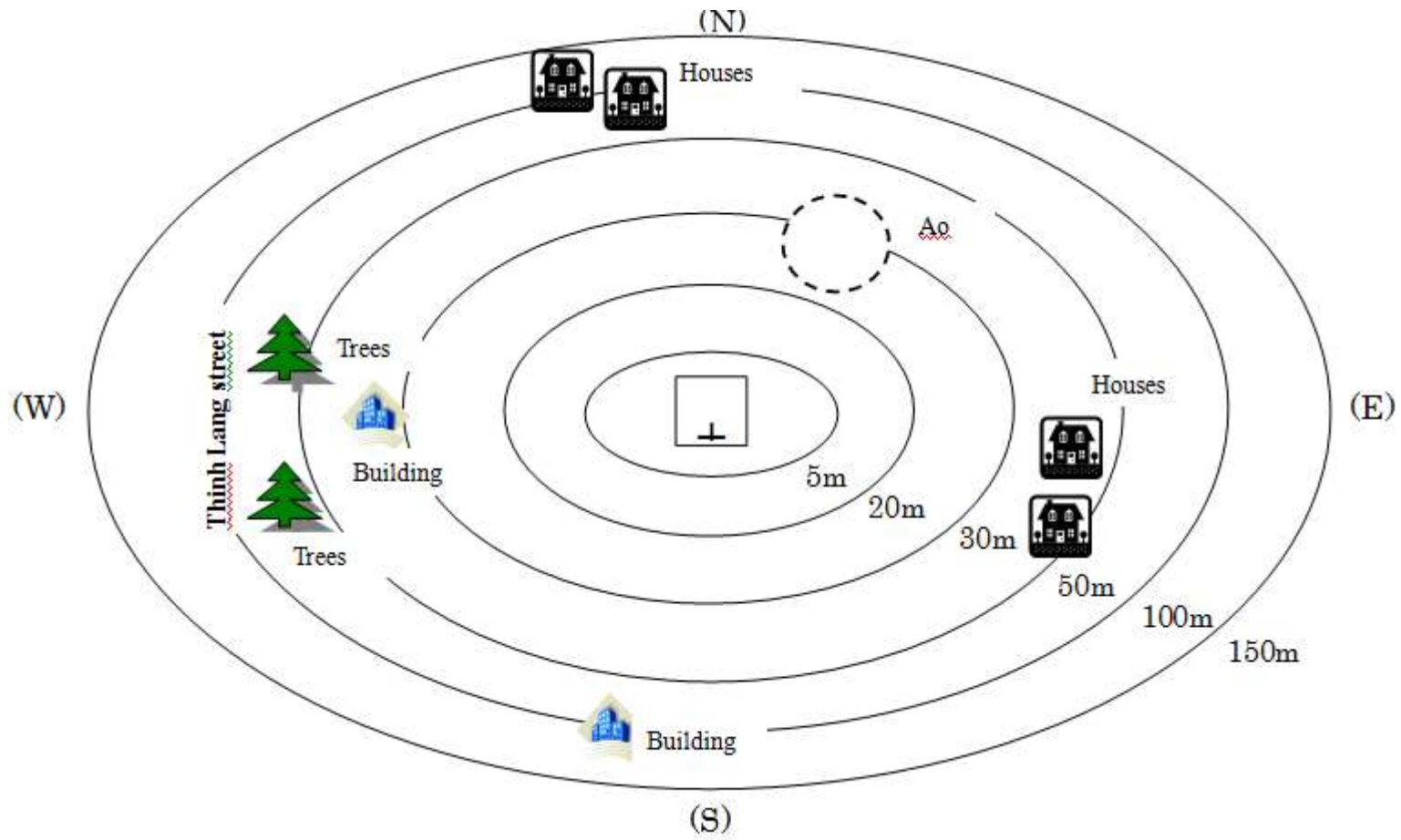


Outline of monitoring site: Local scale (distance 150 m – 10 km)

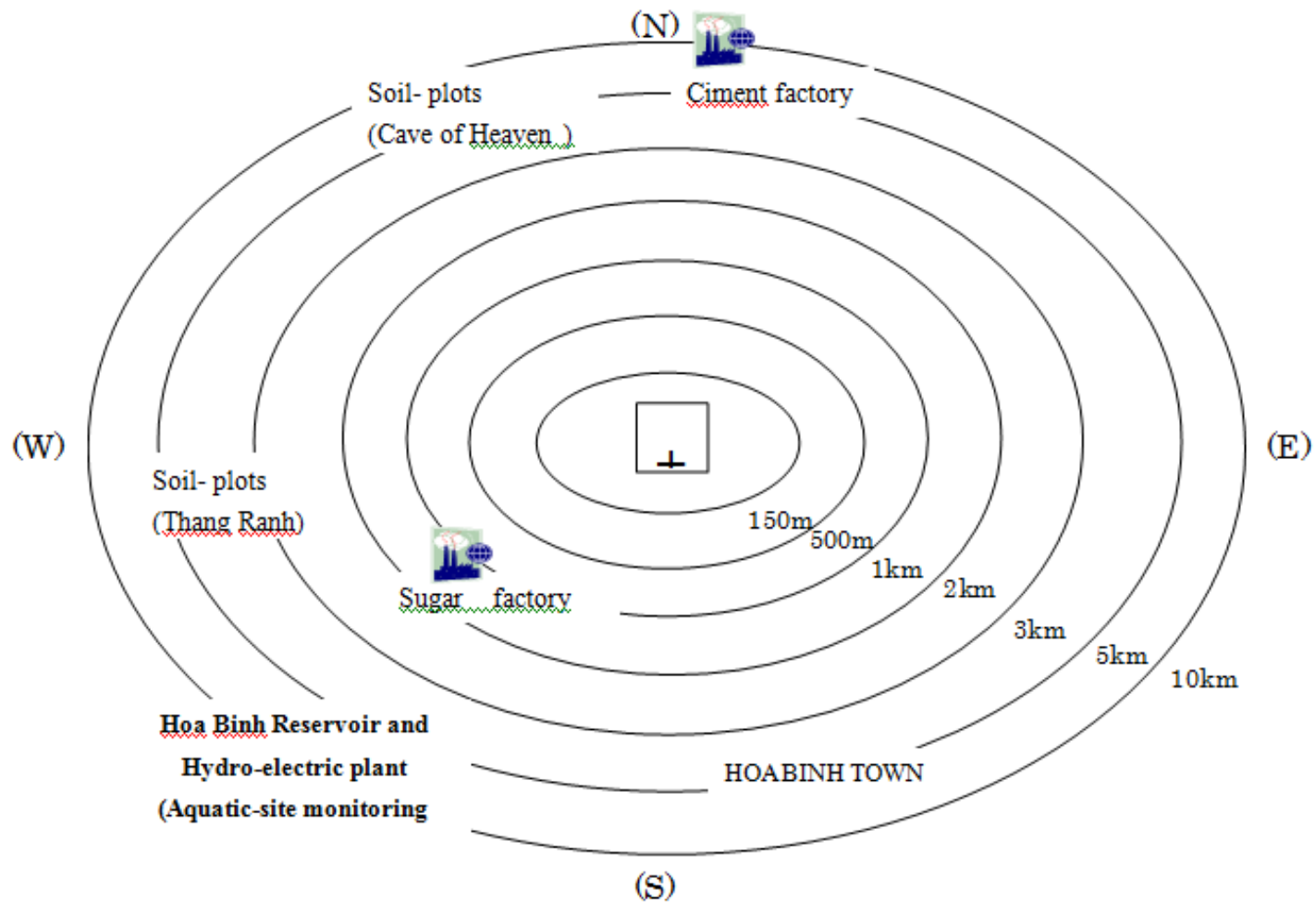


b. Hoa Binh station

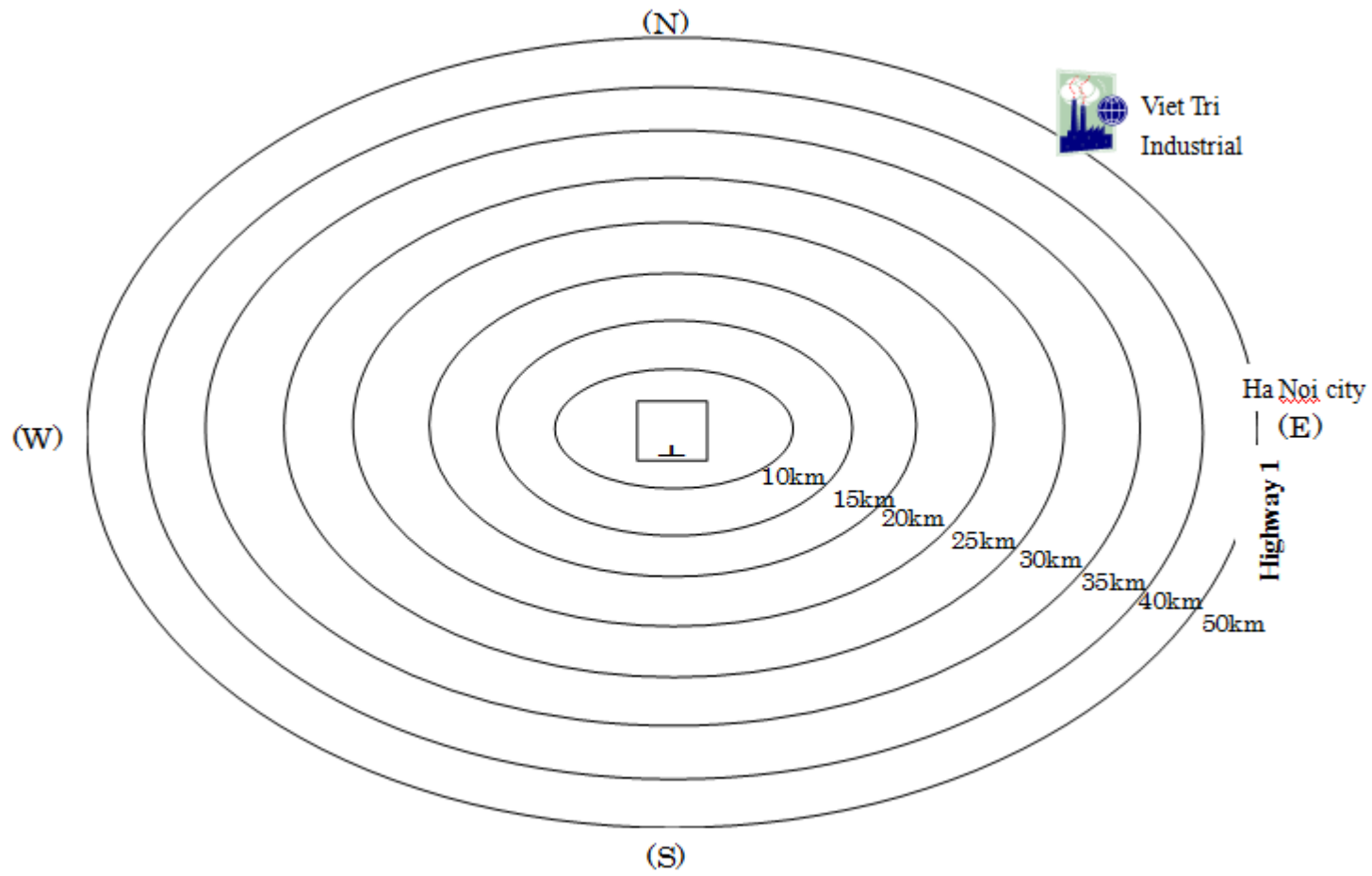
Outline of monitoring site: On-site scale (distance within 150 m)



Outline of monitoring site: Local scale (distance 150 m – 10 km)

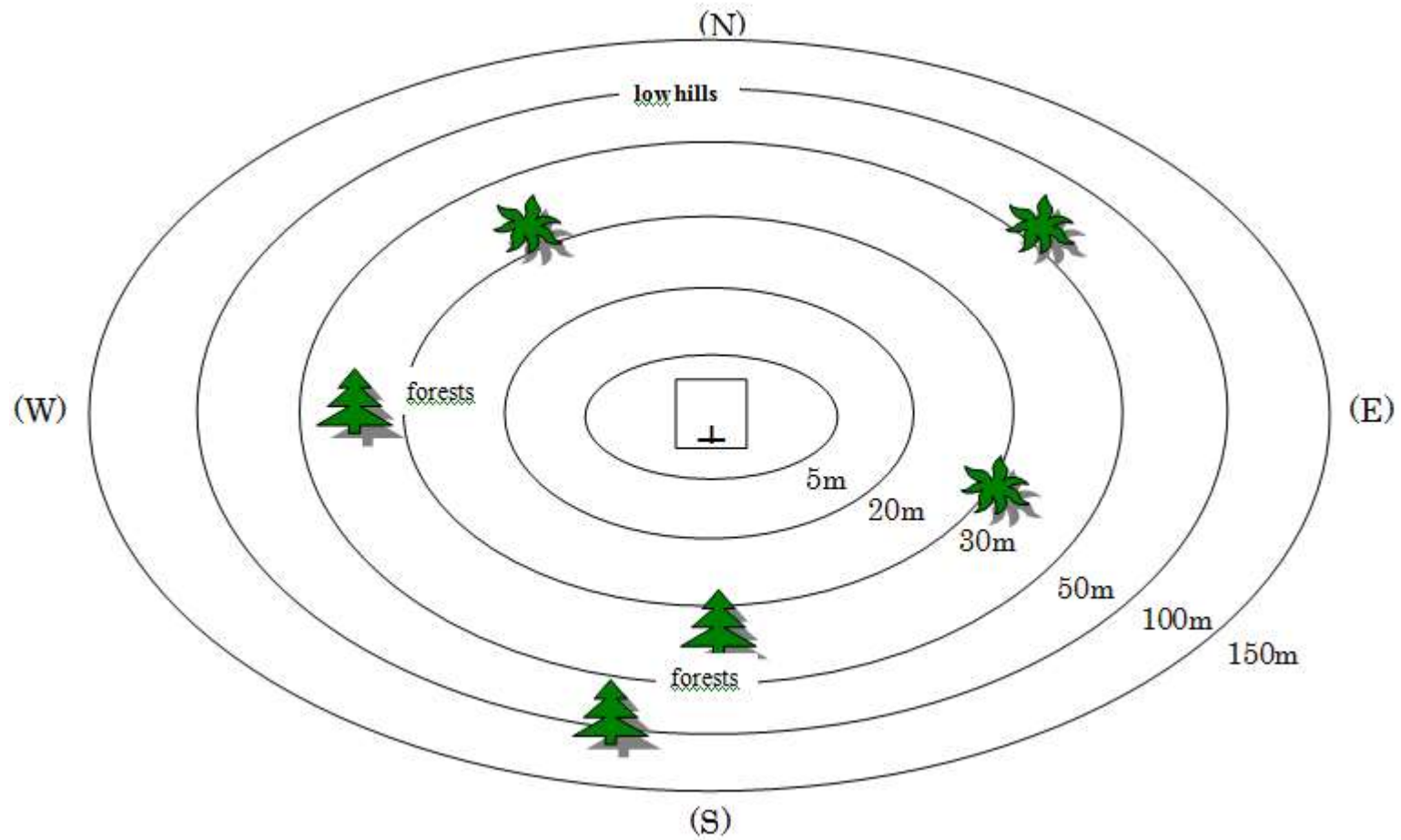


Outline of monitoring site: Regional scale (distance 10 km – 50 km)

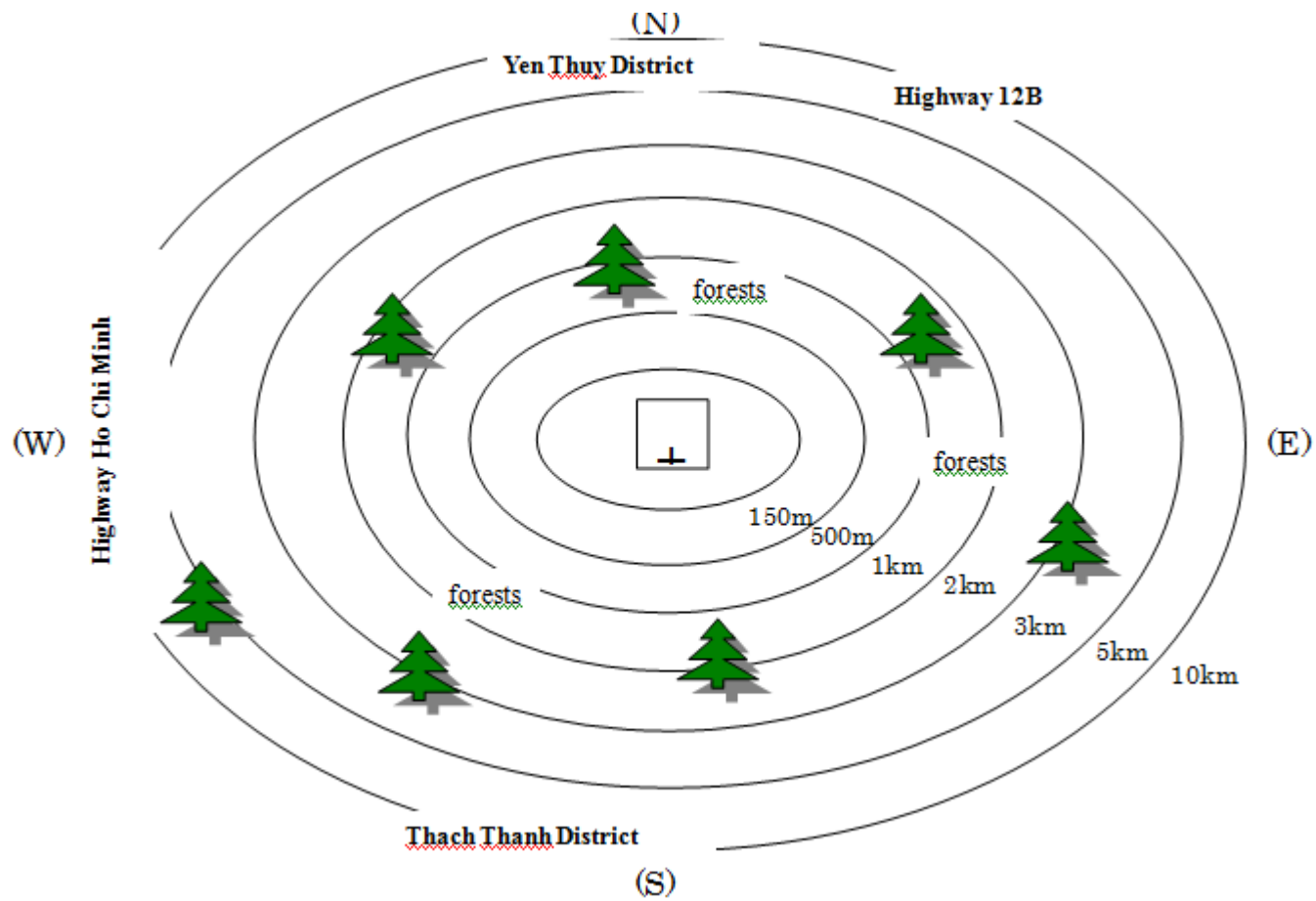


c. Cuc Phuong station

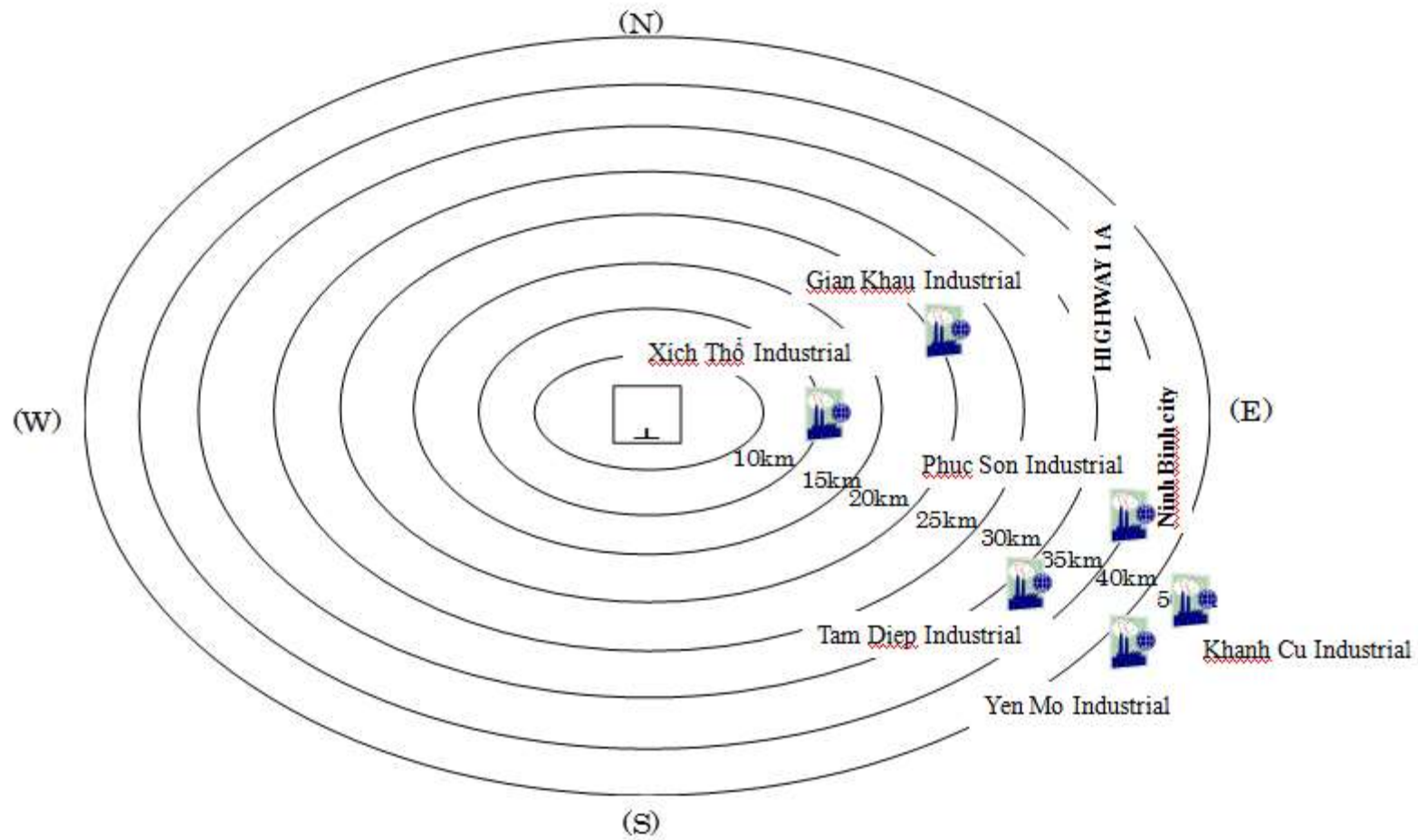
Outline of monitoring site: On-site scale (distance within 150 m)



Outline of monitoring site: Local scale (distance 150 m – 10 km)

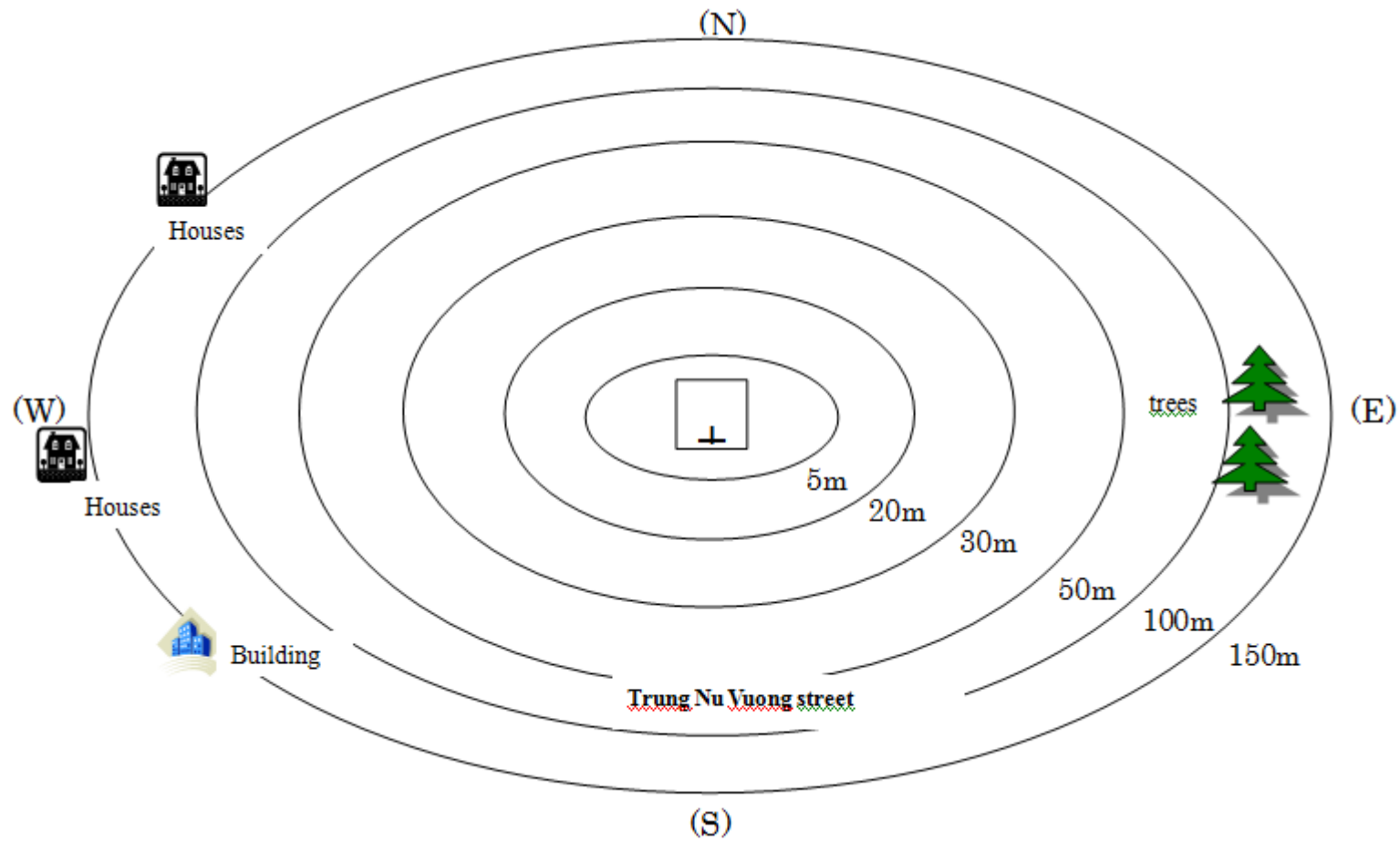


Outline of monitoring site: Regional scale (distance 10 km – 50 km)

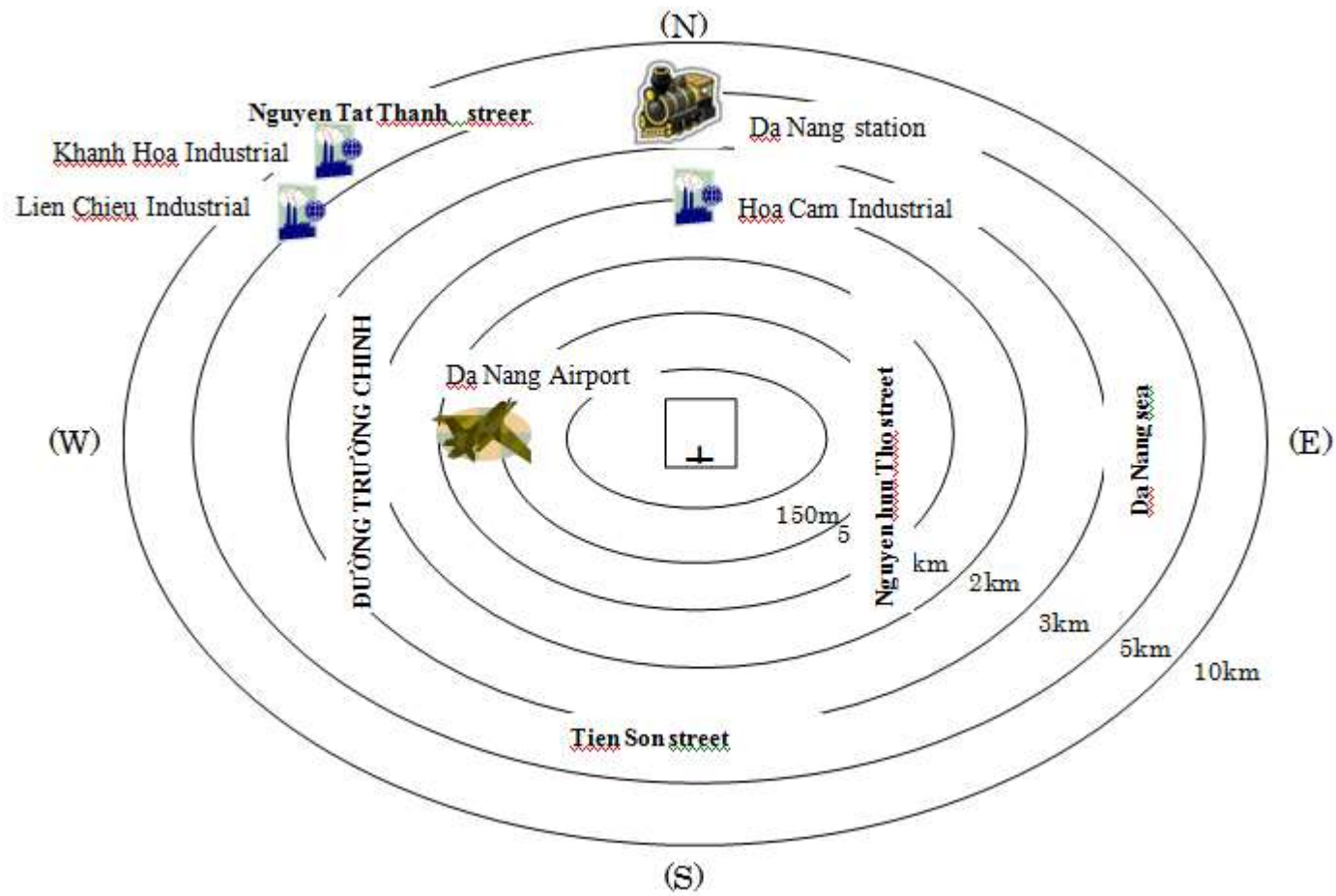


d. Da Nang station

Outline of monitoring site: On-site scale (distance within 150 m)

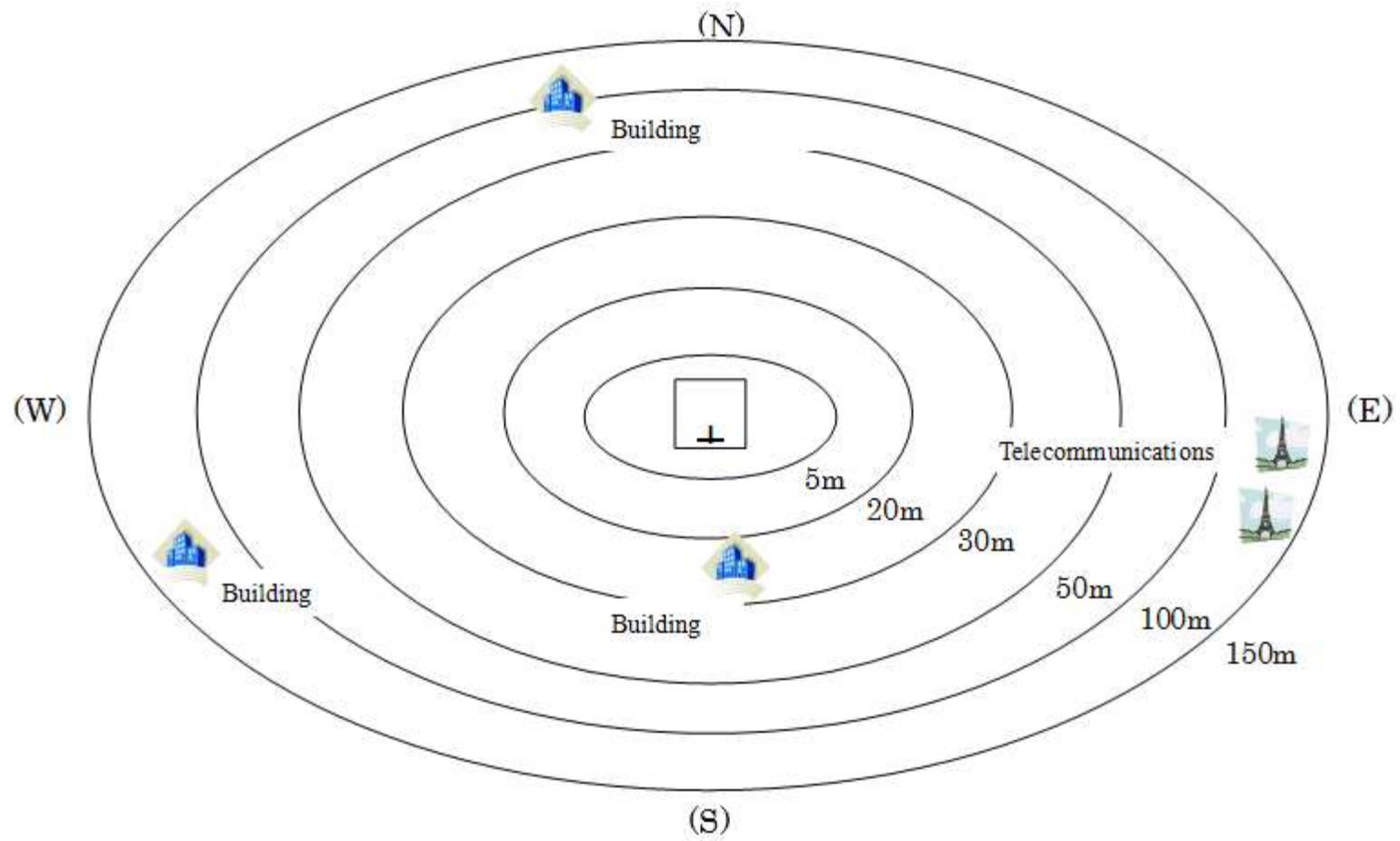


Outline of monitoring site: Local scale (distance 150 m – 10 km)

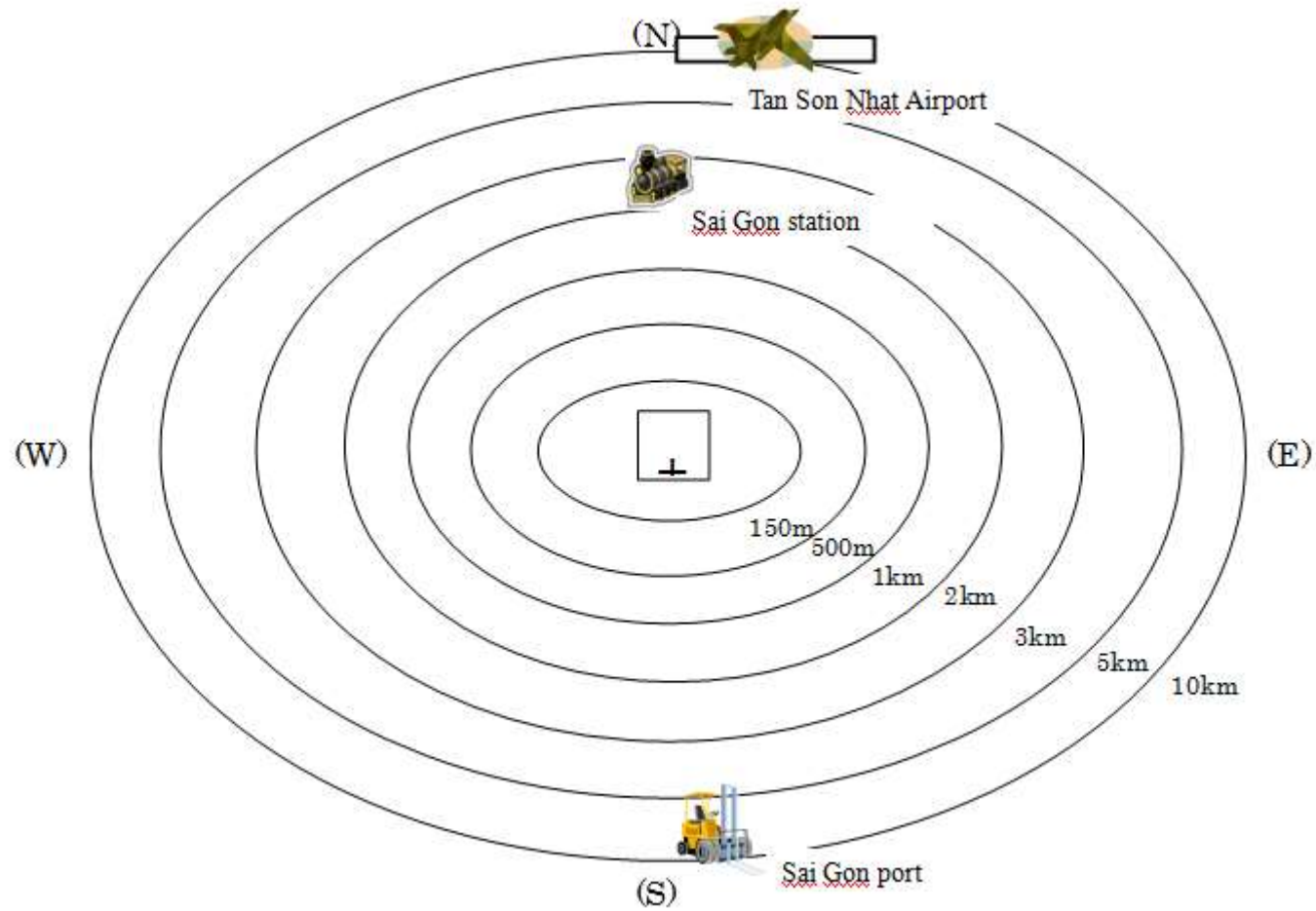


e. Ho Chi Minh city station

Outline of monitoring site: On-site scale (distance within 150 m)

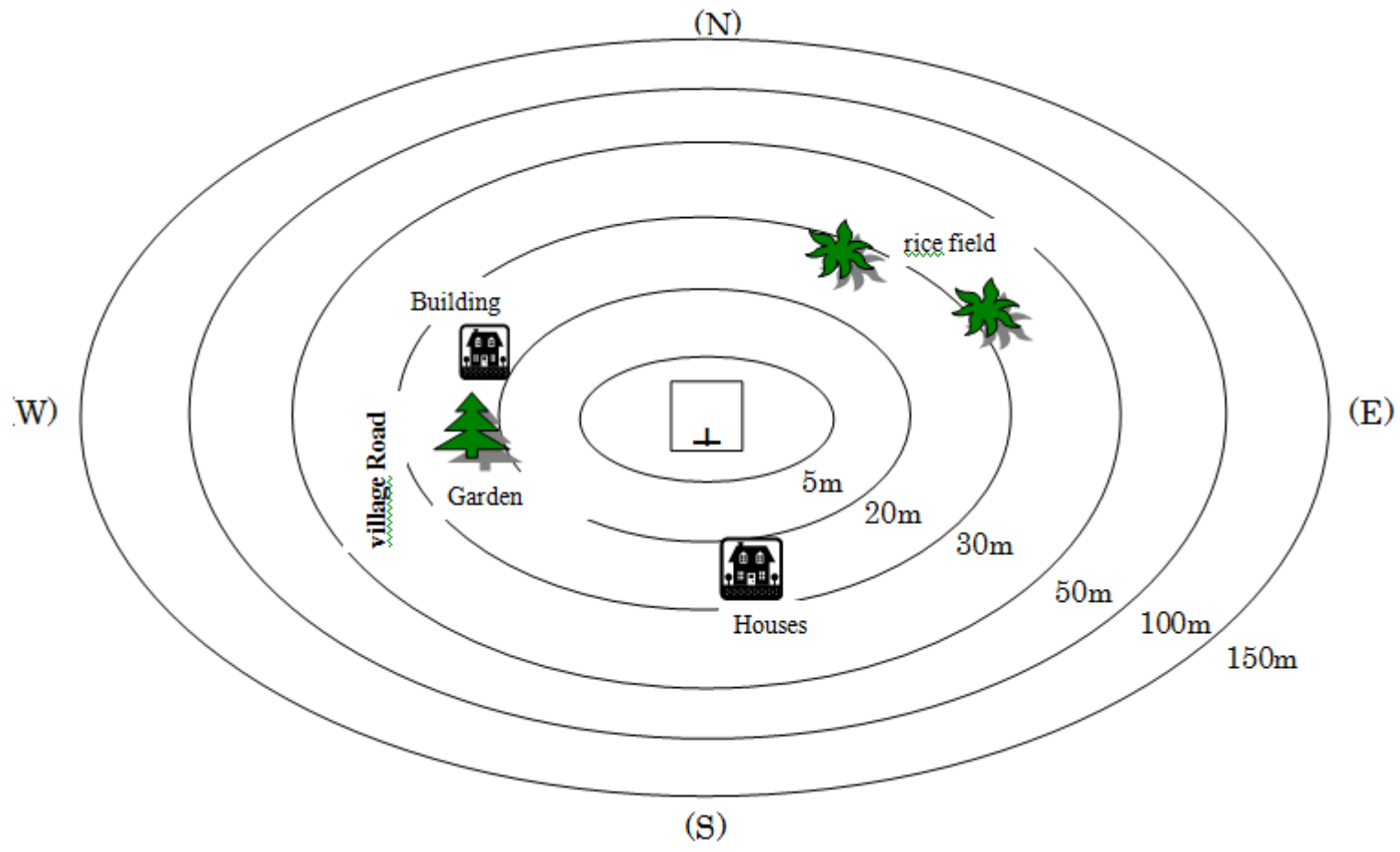


Outline of monitoring site: Local scale (distance 150 m – 10 km)

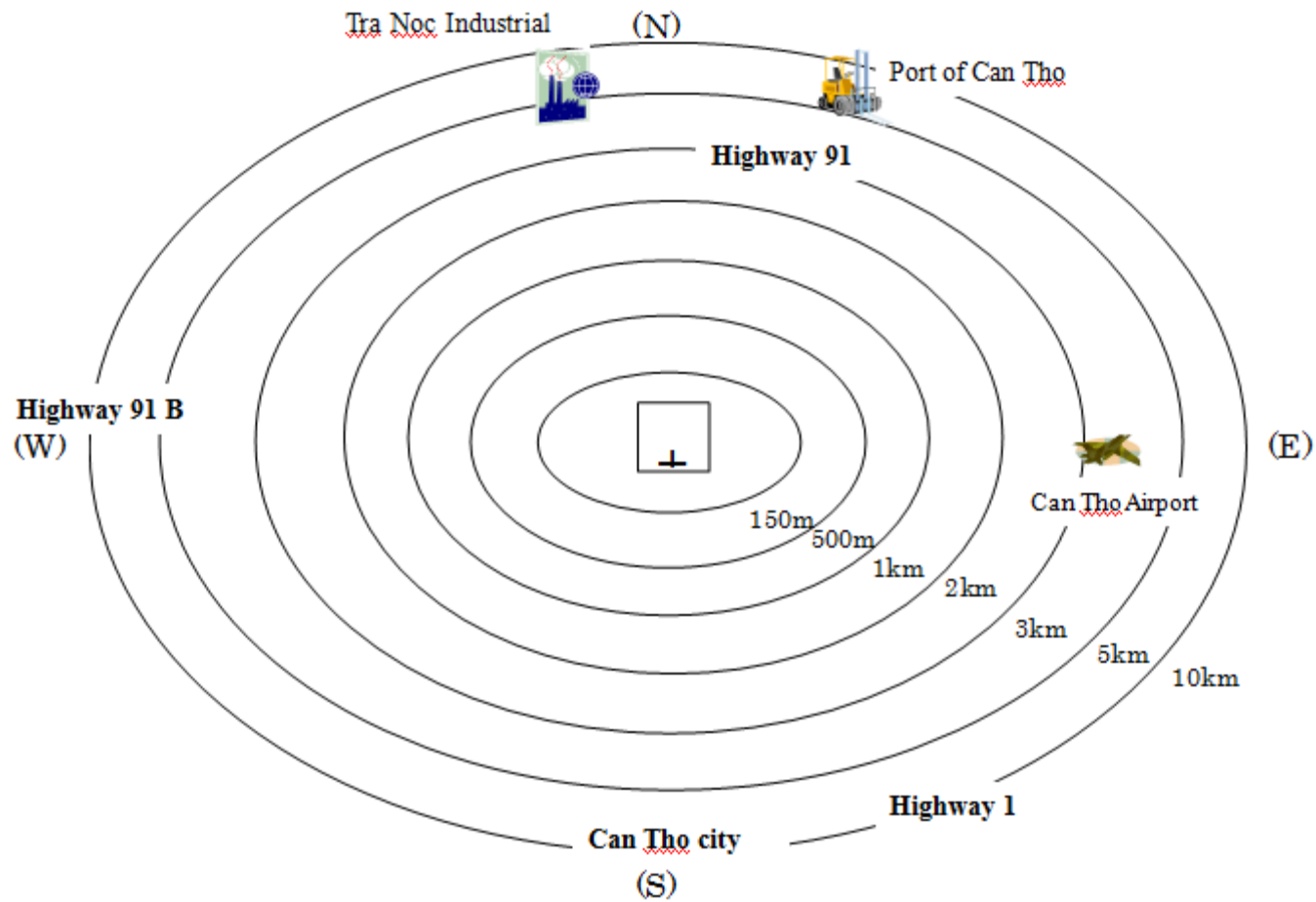


e. Can Tho station

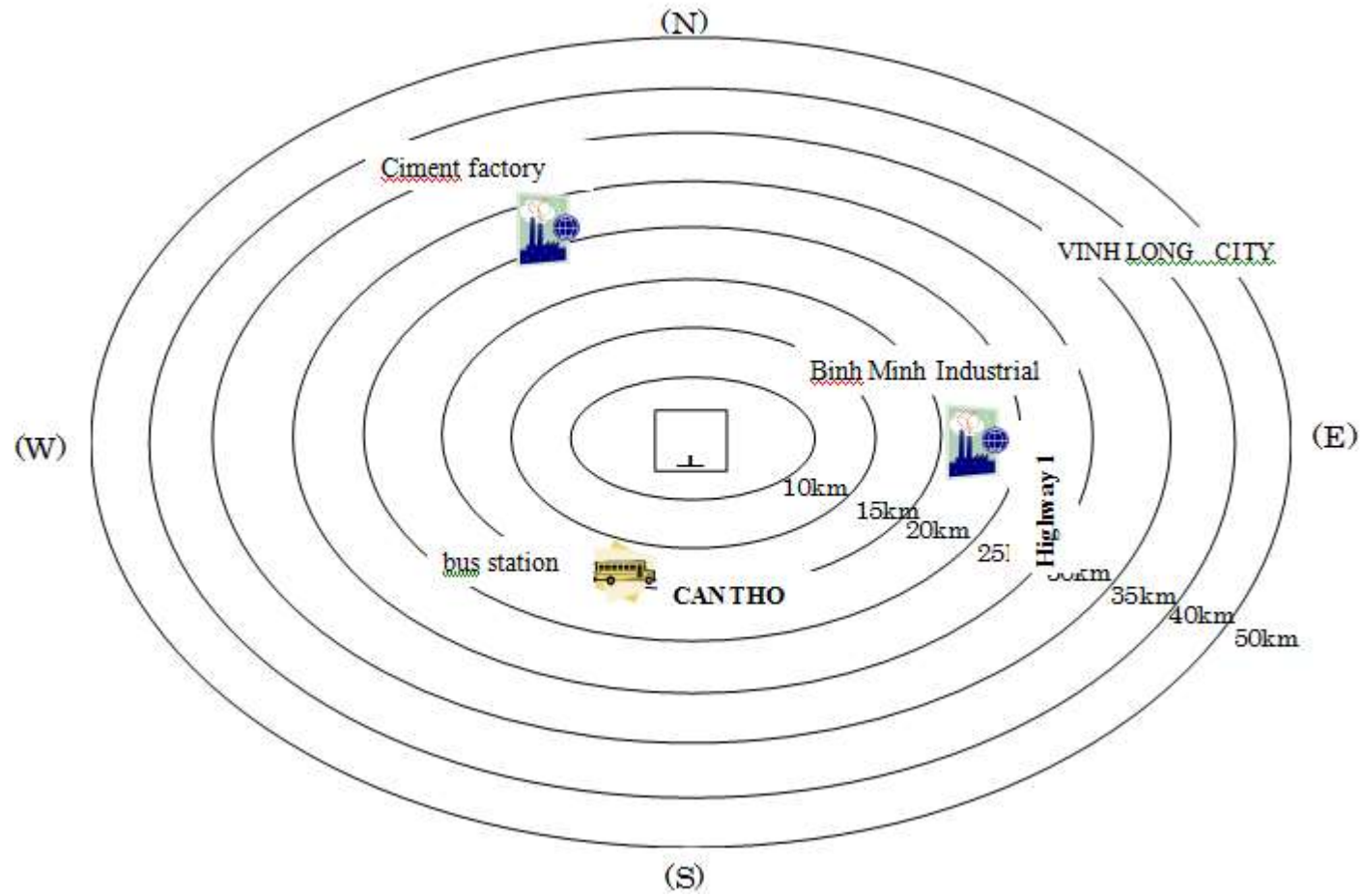
Outline of monitoring site: On-site scale (distance within 150 m)



Outline of monitoring site: Local scale (distance 150 m – 10 km)



Outline of monitoring site: Regional scale (distance 10 km – 50 km)



1.4. Sampling and Measurements

- Wet deposition:
 - Monitoring Interval: 24 hours from 9:00 am to 9:00 am of next day and seven days composite samples can be analyzed in Ha Noi, Hoa Binh, Ho Chi Minh, Can Tho sites. Samples are taken in every precipitation event In Da Nang, Cuc Phuong sites and pH, EC was automatic measured each mm of rainfall; These samples is the combination of 10-day from 2010 to 2012) and 7-day from 2013 to now
 - Monitoring parameters including: pH, EC, F⁻, Cl⁻, NO₃⁻, SO₄²⁻, Ca²⁺, Mg²⁺, K⁺, Na⁺, NH₄⁺; meteorological parameters (temperature, humidity, wind velocity, wind direction, rainfall, ultra-violet).
 - Analytical Method: pH meter, EC meter, IC for anions and NH₄⁺, Na⁺, AAS for cations
- Dry deposition:
 - Monitoring method: Filter Pack,
 - Monitoring Interval: seven days, from 9:00 am, Monday this week to 9:00 am, Monday next week,
 - Monitoring parameters: Gases: SO₂, HCl, HNO₃, NH₃ and ions Cl⁻, NO₃⁻, SO₄²⁻, Ca²⁺, Mg²⁺, K⁺, Na⁺, and NH₄⁺ in the aerosol.
 - Analytical Method: pH meter, EC meter, IC for anions and NH₄⁺, Na⁺, AAS for cations.
- Inland aquatic environment:
 - Monitoring Interval: 4 times/year,
 - Monitoring parameters: pH, EC, Cl⁻, NO₃⁻, SO₄²⁻, Ca²⁺, Mg²⁺, K⁺, Na⁺, NH₄⁺, alkalinity and COD, NO₂⁻, clarity.
 - Analytical Method: pH meter, EC meter, IC for anions and NH₄⁺, Na⁺, AAS for cations, titration method for alkalinity at pH 4.8 endpoint, KMnO₄ method for COD and colorimetry for NO₂⁻
- 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 2009-2014, so this station was conducted measurements. Recommend to the support of EANET Network Center to select new monitoring station in Cuc Phuong province.



Wet only Sampler (OgasawaraUS330)



Wet Sampler with pH, EC automatic measurement each mm of rainfall (Kimoto MCSAM-6-VB)

Some equipment for Acid Deposition Monitoring Analysis in Environmental Laboratory - Center for Environmental Research - IMHEN- MONRE



IC Metrohm Mic 3



pH meter – 793 Metrohm



EC meter – YSI 3200



AAS800 of PerkinElmer



UV-Vis system -HP8453



Untrasonic bath



**Extra-pure Water system 611
DI Sartorius**



Water still Instruction

Chapter 2. State of Acid Deposition in Vietnam

2.1 Outline of the activities on acid deposition and National Monitoring Plan

2.1.1 State of wet deposition

a) pH of rain water

In general, in period of 2005 – 2014, annual average pH values of sites such as Hoa Binh (HB), Cuc Phuong (CP) and Da Nang (DN) are below 5.6, especially, in Danang site the annual average pH values are the lowest, in range of 4.75 – 5.58. Therefore, it means that acid rain has occurred frequently in Hoa Binh, Cuc Phuong and Da Nang. In Hanoi site, the annual average pH values are relatively high, almostly over 5,6 except in 2011 (pH = 5,25). In period of 2010- 2014, pH values of sites Hoa Binh, Cuc Phuong and Da Nang have the increasing trend. Only in Hanoi site, a slightly decreasing trend has been observed. For new sites Can Tho (CT) and Ho Chi Minh (HCM) city (from 2014), pH values fluctuate in range of 5.85 – 6.26, no acid rain has been traced.

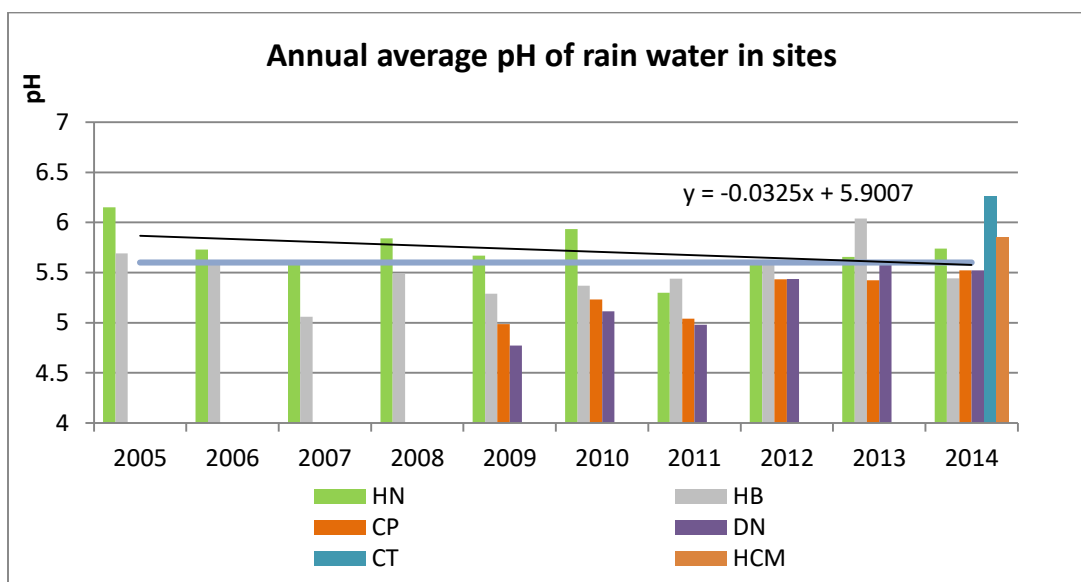


Figure 2.1: Graph of annual average pH of rainwater in sites (2005 – 2014).

In period of 2010 – 2014, annual precipitation amounts in sites like Hanoi, Hoa Binh and Cuc Phuong are similar, in range of 1100mm - 2000mm. Especially, the precipitation at Da Nang site has changed dramatically, which gets peak in 2011 (3639mm), at half as much as other years, however, its pH value got the lowest (pH= 5,0)

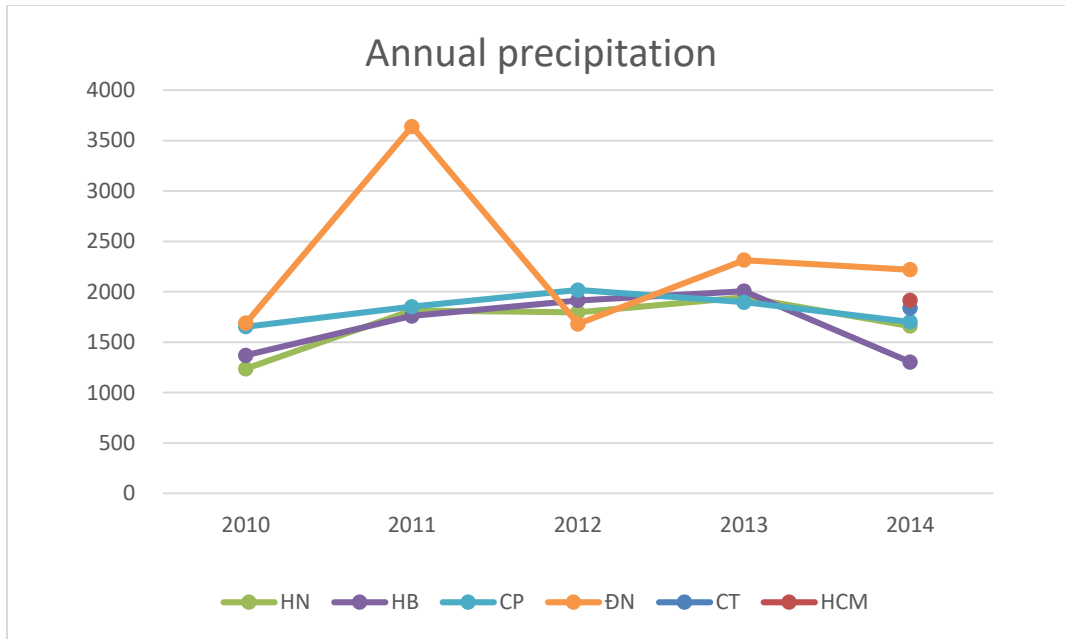
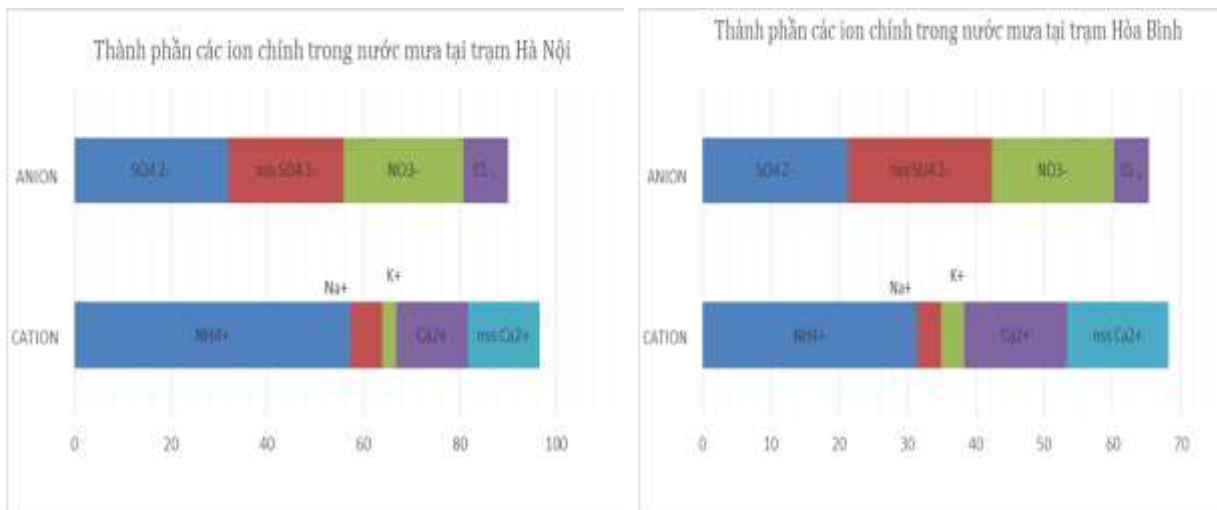


Figure 2.2: Annual precipitation amount in sites (2010 – 2014)

b) Ion composition in rain water:

In sites as Hanoi, Hoa Binh and Cuc Phuong, ions of SO_4^{2-} , NO_3^- , NH_4^+ , Ca^{2+} are predominant in ion composition of rainwater. In particular, concentration of NH_4^+ in rainwater of Hanoi site is very high. Ion composition in rainwater of Da Nang, Can Tho and Ho Chi Minh sites have traced seasalt effect leading to high concentration of Cl^- và Na^+ ions, especially at Da Nang site.



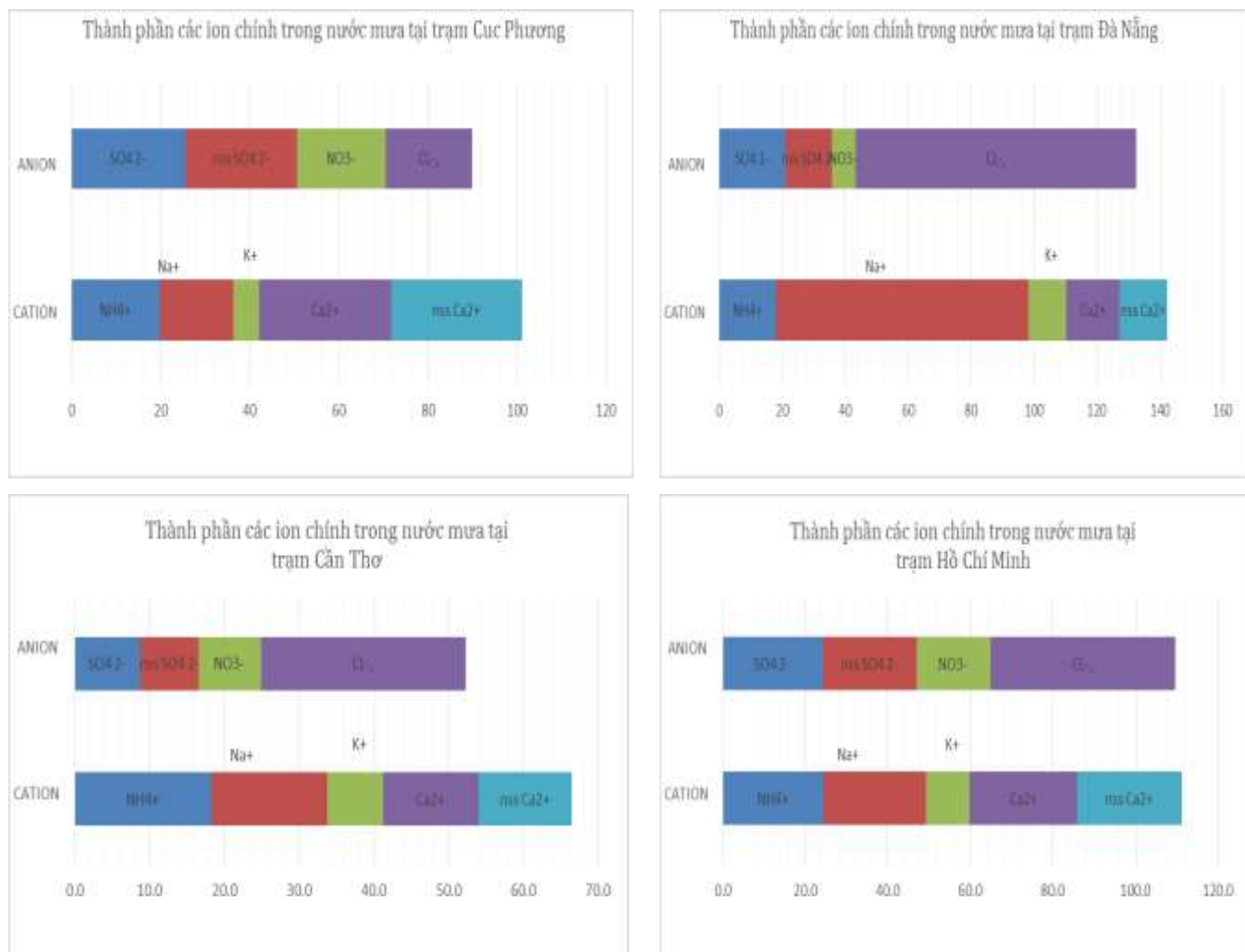


Figure 2.3. Major ions composition in rainwater of sites (2010 – 2015)

c) Trend of annual ion concentration and wet deposition variation

Annual variation of ions nss- SO₄²⁻, NO₃⁻, H⁺ concentration and wet deposition in sites (2010 – 2014) are presented in above figures. There is a significant variation in DN site in 2011 with peak of precipitation amount and low pH value, resulting to high concentration and wet deposition of ions (nss- SO₄²⁻, NO₃⁻, H⁺ are 61mmol/m²/y, 57 mmol/m²/y, 38 mmol/m²/y, respectively). For Hanoi and Hoa Binh sites, ions concentration and wet deposition are lower than those of Cuc Phuong and Da Nang sites.

There is a similar pattern of annual variation between Hanoi and Hoa Binh sites; nss- SO₄²⁻ and NO₃⁻ have the increasing trend while H⁺ has the decreasing trend in the both sites.

Besides, Cuc Phuong and Da Nang sites have the same trend; both of 3 ions have a decreasing trend over time.



Figure 2.4. Variation of annual nss- SO_4^{2-} concentration and wet deposition in sites (2010 – 2014)



Figure 2.5. Variation of annual NO_3^- concentration and wet deposition in sites (2010 – 2014)

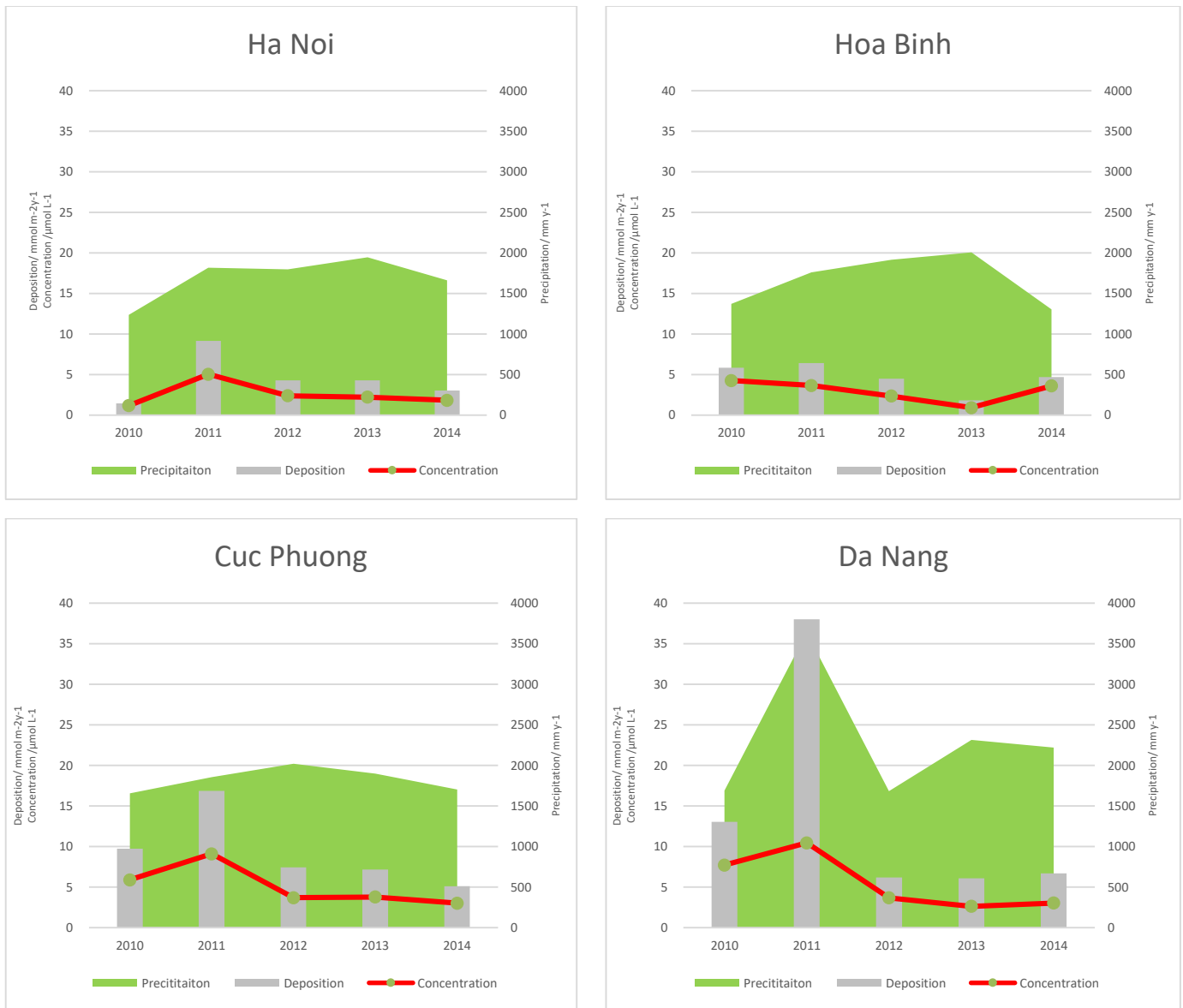


Figure 2.6. Variation of annual H^+ concentration and wet deposition in sites (2010 – 2014)

Seasonal variation of ions wet deposition in sites (2010 – 2014)

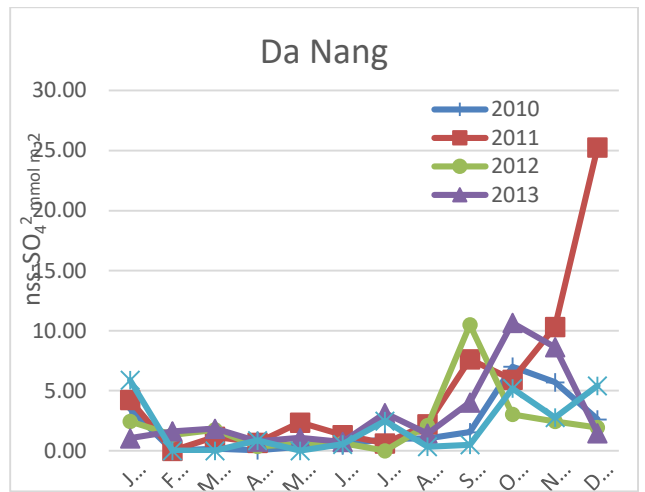
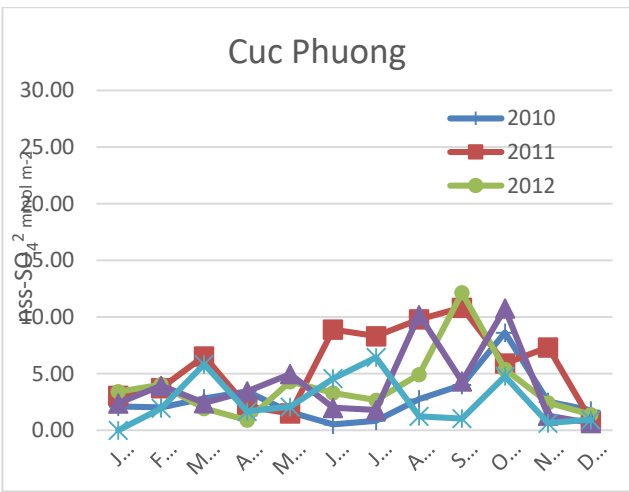
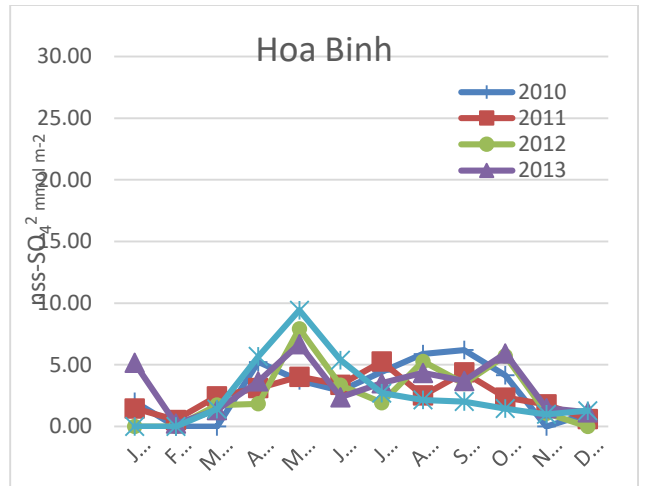
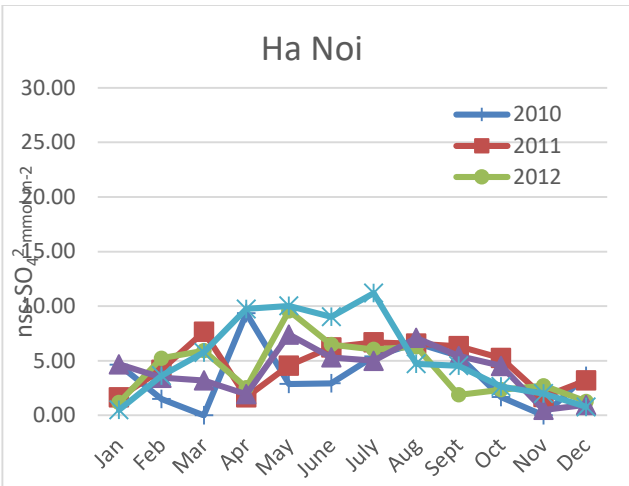


Figure 2.7. Seasonal variation of nss-SO₄²⁻ ion deposition in sites (2010 – 2014)

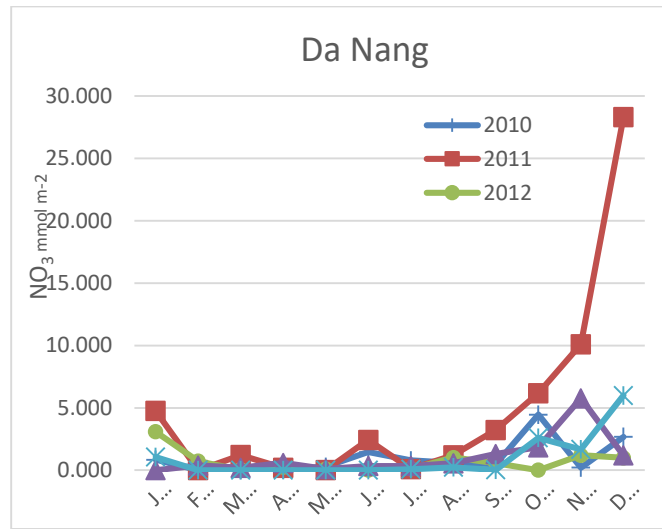
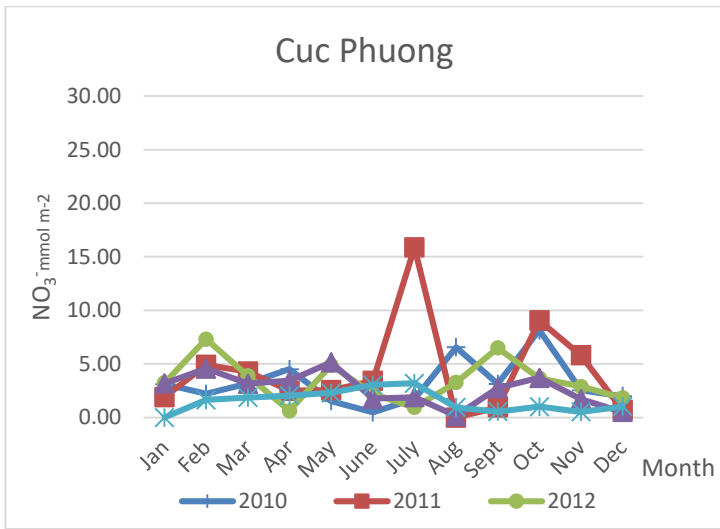
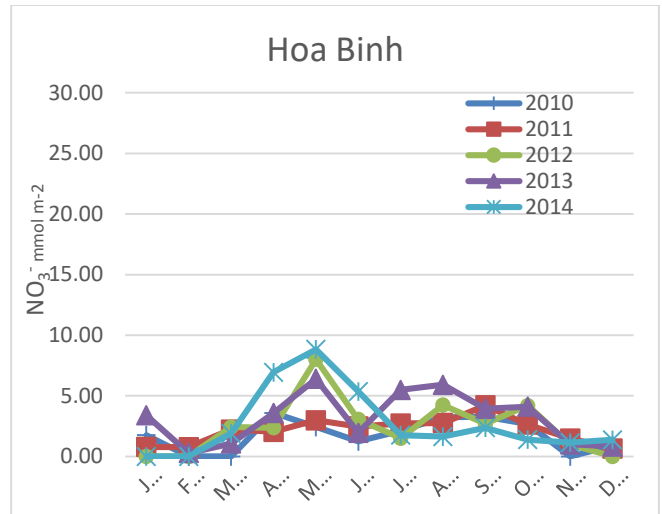
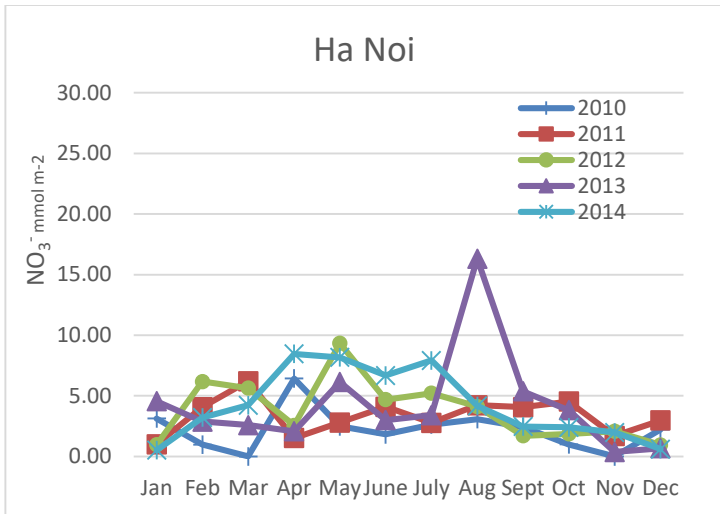


Figure 2.8. Seasonal variation of NO_3^- ion deposition in sites (2010 – 2014)

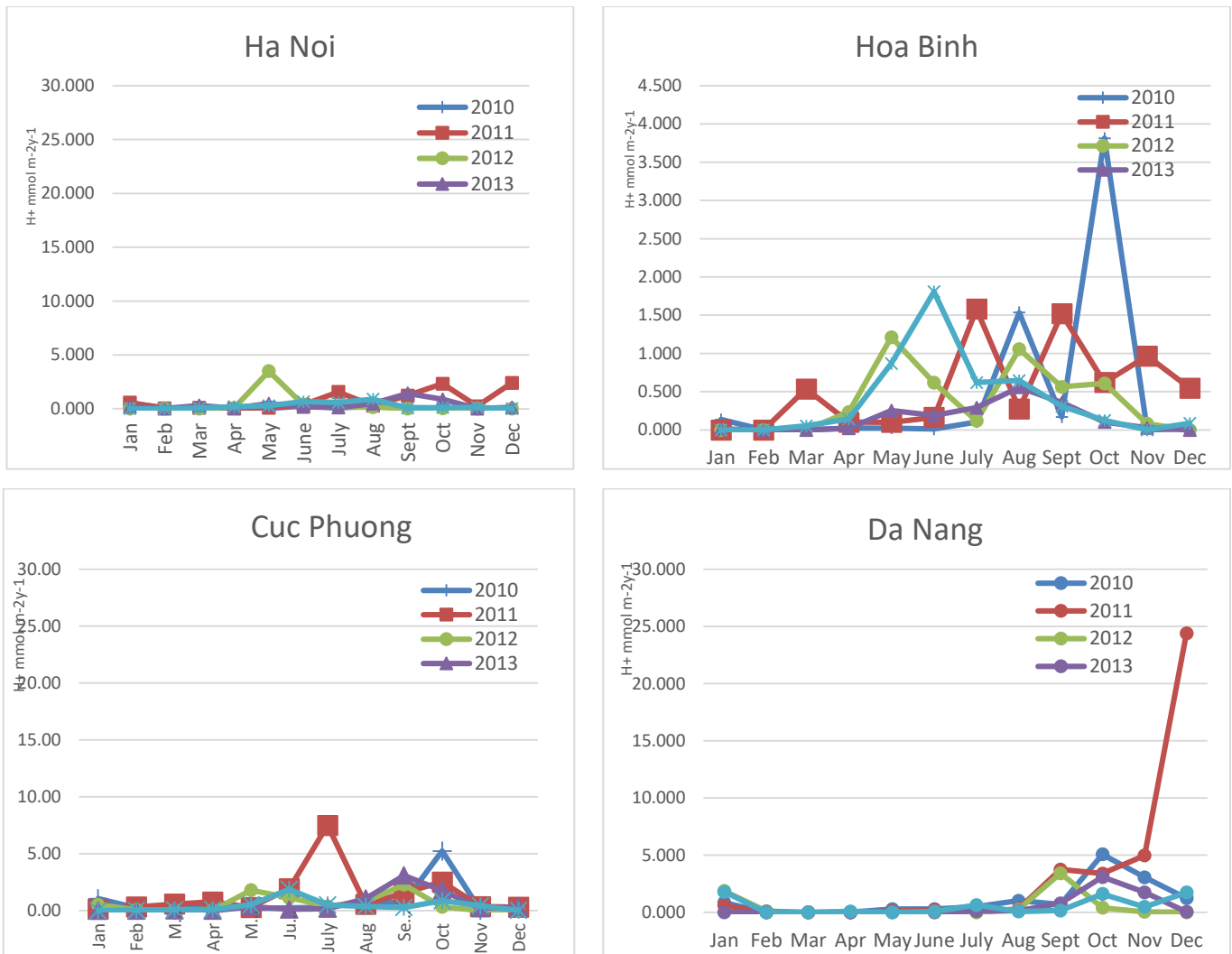


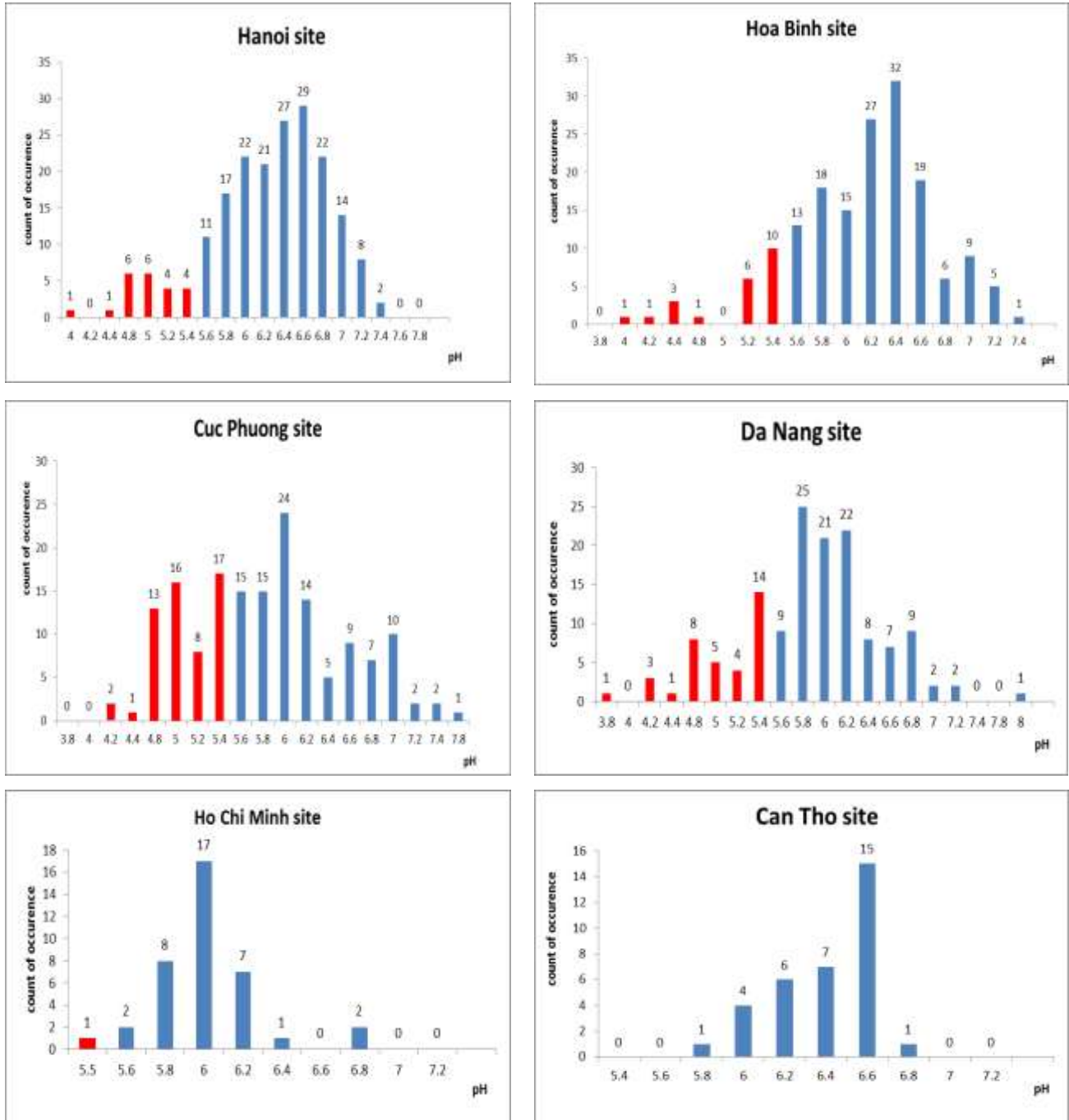
Figure 2.9. Seasonal variation of H^+ ion deposition in sites (2010 – 2014)

Wet deposition amount of ions is largely dependent on local weather/climate condition, especially rainfall (precipitation amount) and air pollution level. Total wet deposition of nss-SO_4^{2-} in Hanoi, Hoa Binh and Cuc Phuong had a decreasing trend in dry season and a increasing trend in rain season. In DN site, total ion wet deposition has increased in rain season , get a peak in December 2011 (deposition of H^+ is 24.4mm/m^2 , NO_3^- is 28.32mm/m^2 , nss-SO_4^{2-} is 25.25mm/m^2).

d) Current state of acid rain

Result on assessing $\text{pH} < 5.6$ frequency in period of 2010- 2014 showed that acid rain frequency is the highest in Cuc Phuong site (35.4%), followed by Da Nang site (25.35%), next to Hanoi

(11.22%), and Hoa Binh (3.59%), Ho Chi Minh (2.63%), only Can Tho site not yet been observed acid rain.



Note: For Ho Chi Minh site and Can Tho site, pH data are collected from 2014.

Figure 2.10. Frequency distribution of rainwater pH values in sites (2010 – 2014)

Correlation between pH- pAi of 4 sites (Hanoi, Hoa Binh, Cuc Phuong, Da Nang) presented a bias toward pH, especially in Hanoi site. The reason can be that Ammonia gas and/ or calcium, magnesium in dust can neutralize acids (HSO_4 , HNO_3) in rain water. Da Nang site has pH- pAi nearly 1, it means that rainwater is not contaminated by ions NH_4^+ và Ca^{2+} .

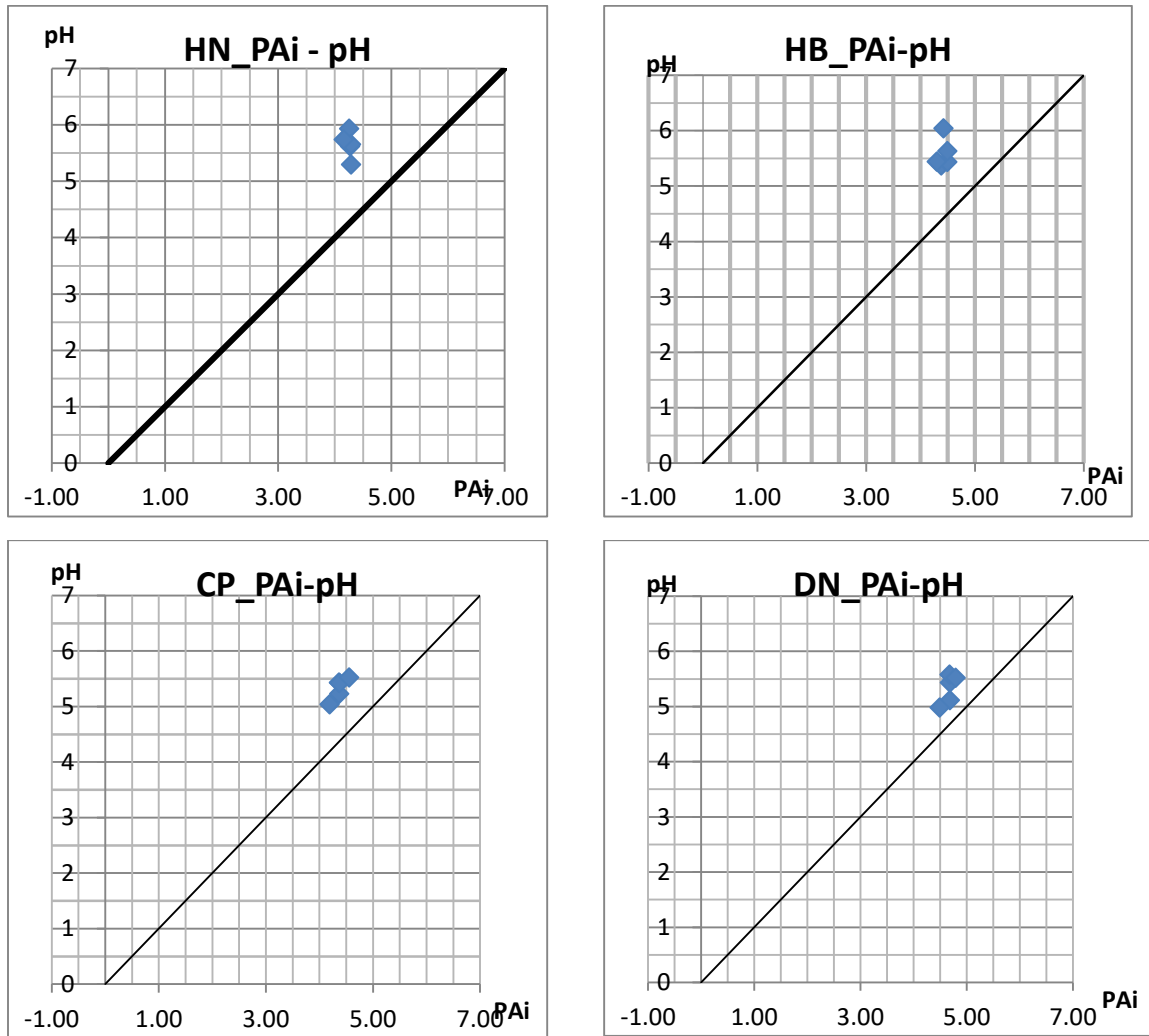


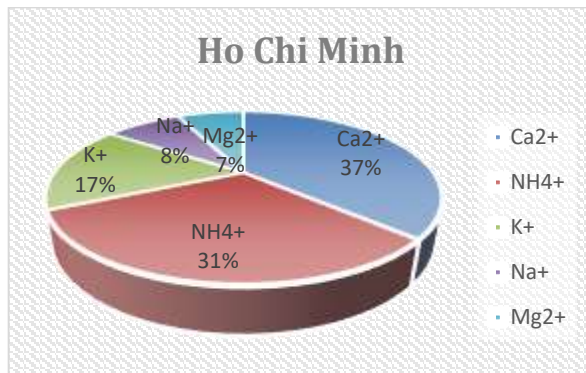
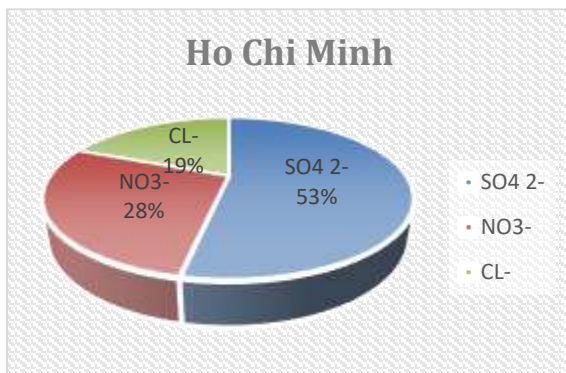
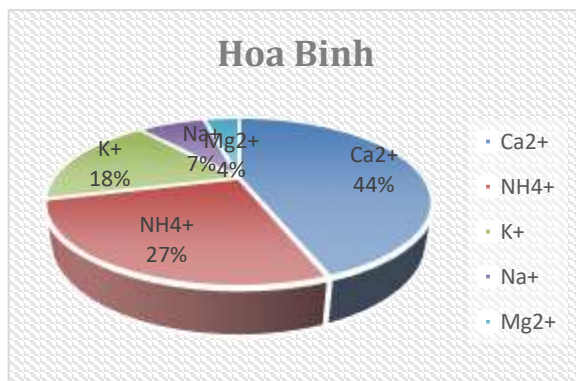
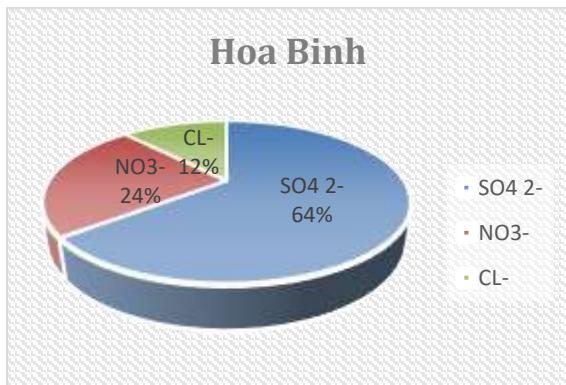
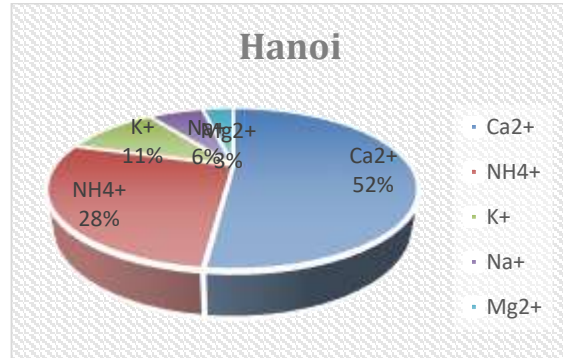
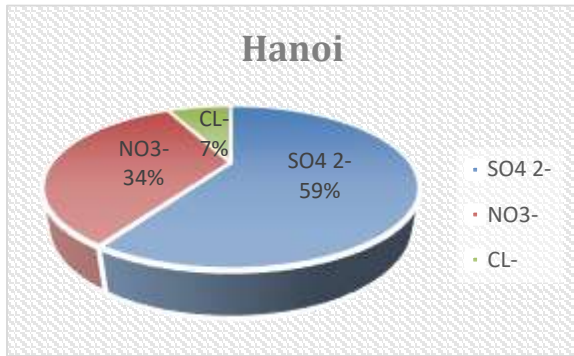
Figure 2.11. Correlation between pH and pAi of sites

2.1.2 State of dry deposition

Assessing air and aerosol concentration and composition

Both 4 EANET sites in Vietnam are operating air quality monitoring by Filter Pack. Ions of Ca^{2+} , NH_4^+ and SO_4^{2-} , NO_3^- are dominant in aerosol composition for almost sites (62-80% and

79-93%, respectively), except for Can Tho site contribution of K^+ and Cl^- is much higher than those of 3 others (26% và 21%, respectively).



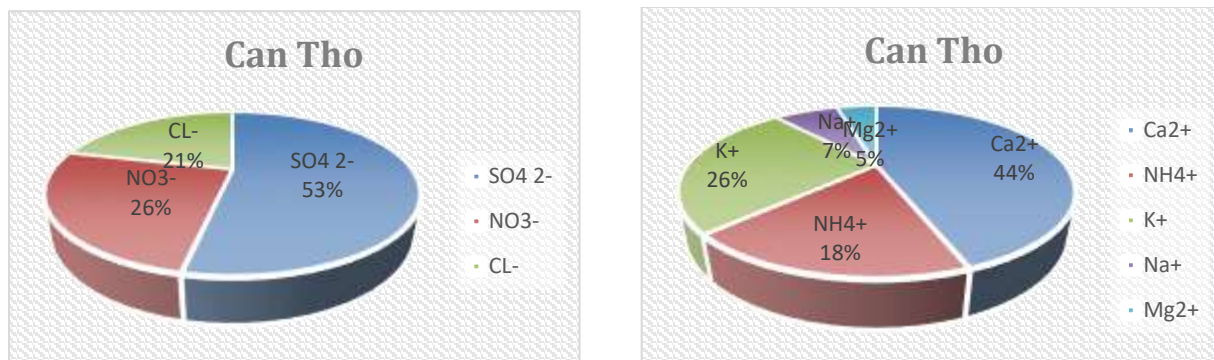
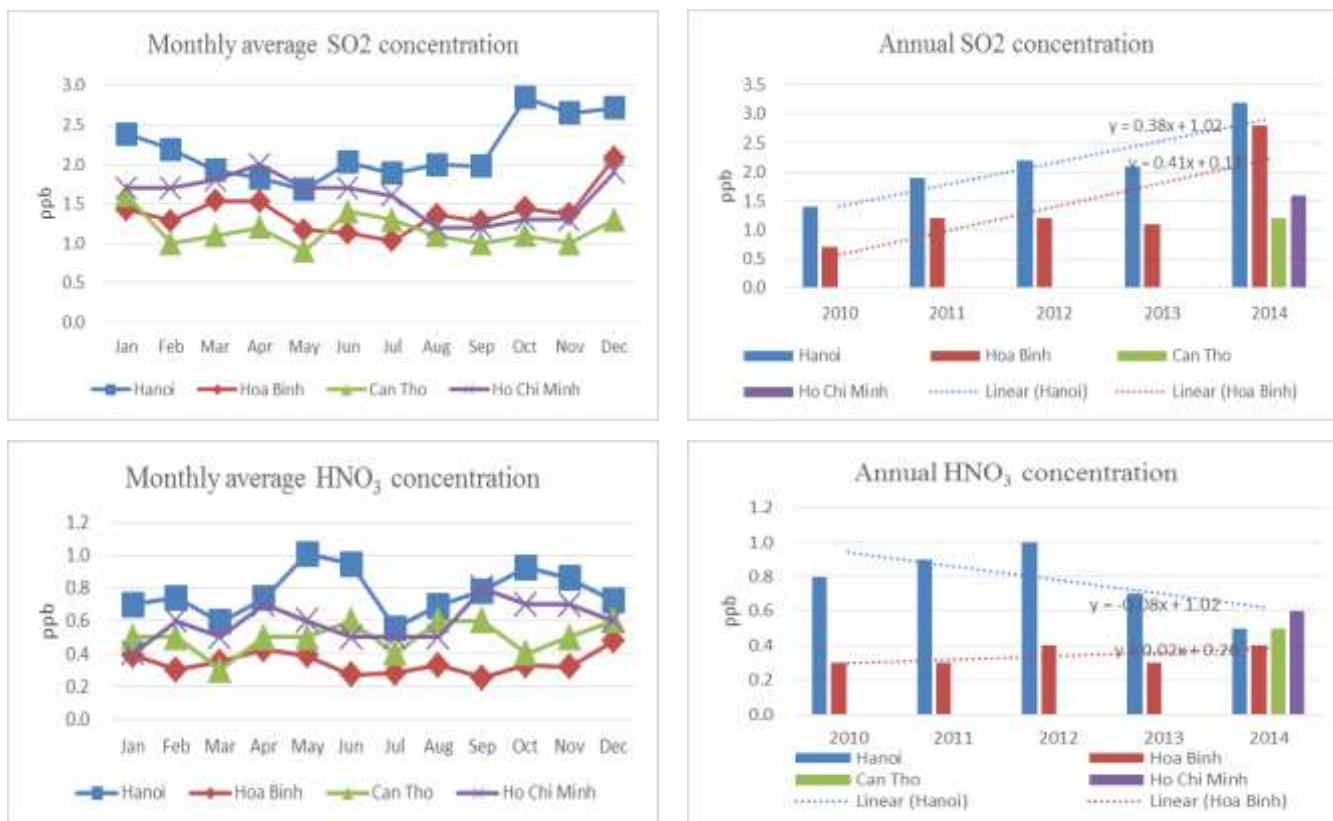


Figure 2.12. Major ion composition of aerosols in sites

Annual SO₂ concentration in Hanoi site is always the highest during 2010- 2014. There is a clear increasing trend of SO₂ concentration in Hanoi and Hoa Binh sites, particularly in 2014. Seasonal trend is detected for Hanoi and Ho chi Minh sites (increasing in dry season and decreasing in rain season), however, the trend is not clear for Hoa Binh and Can Tho sites.

Monthly average HNO₃ and NH₃ concentration of Hanoi and Ho Chi Minh (2 urban sites) are always higher than those of Can Tho and Hoa Binh (2 rural sites).

There is a dramatically decreasing trend of HNO₃ and NH₃ concentration in Hanoi site, recently.



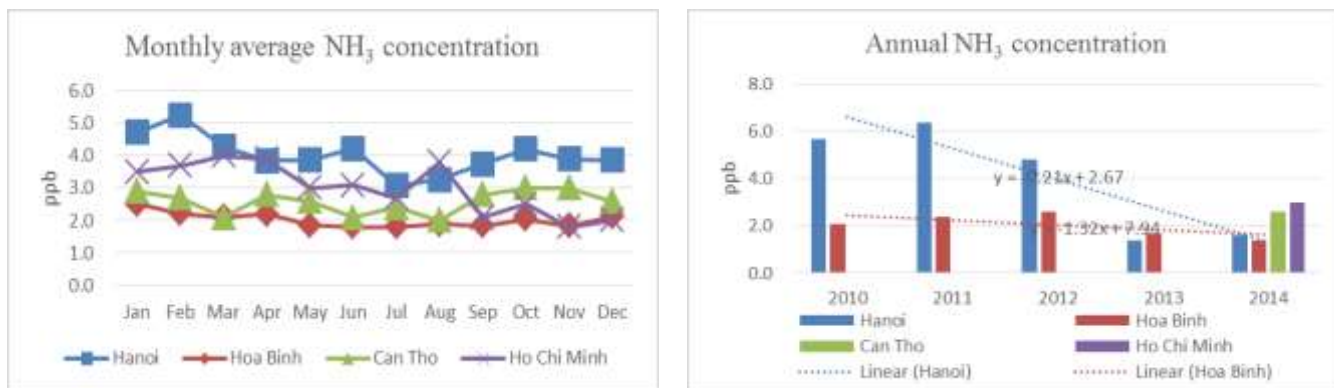


Figure 2.13. Variation of gases concentration in sites (2010-2014)

Estimation of dry deposition flux

Dry deposition flux is estimated according to EANET's guideline for remote (forest) and rural sites.

In case of Vietnam, dry deposition flux is estimated for Hoa Binh (rural sites) which are being monitored by Filter Pack method.

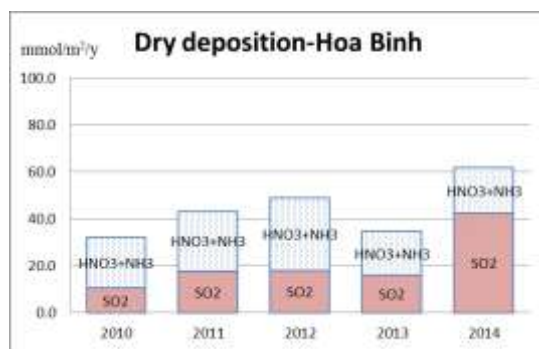


Figure 2.14. Annual dry deposition of Hoa Binh sites

Annual dry deposition amount of sites is in range of 30- 60 mmol/m²/y. In general, total dry deposition in Hoa Binh is not much changed in period of 2010- 2014.

In 2014, dry deposition of 2 sites (Hoa Binh and Can Tho) are not so different in total deposition amount, around 50 mmol/m²/y. However, there is a difference in deposition composition between the northern site (Hoa Binh) and the southern site (Can Tho). For Hoa Binh site, deposition of SO₂ is predominant and contribution ratio of SO₂/ (HNO₃+ NH₃) is equivalent (50%:50%). For Can Tho site, deposition of SO₂ and NH₃ are equal (about 40% of each), and the deposition of HNO₃ only contributes a minority (around 20%).

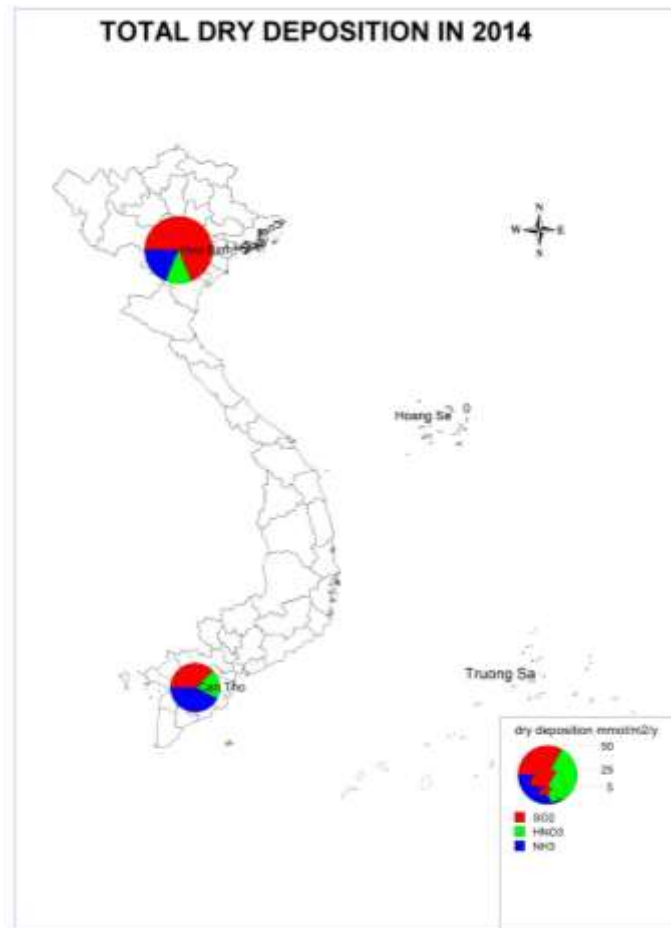


Figure 2.15. Spatial distribution of dry deposition (2014)

2.2 State of inland aquatic environment

Hoa Binh reservoir has been selected to monitor acid deposition for inland aquatic environment in Vietnam since 2001. Inland water samples are taken quarterly/seasonally (in every March/ spring, June/ summer, September/ autumn and December/ winter).

Calculation of ion balance showed that anion HCO_3^- and cation Ca^{2+} are predominant in composition of Hoa Binh reservoir water.

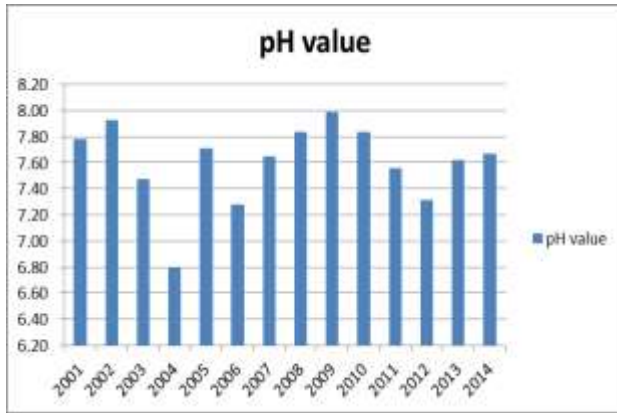


Figure 2.16. Change of annual average pH values

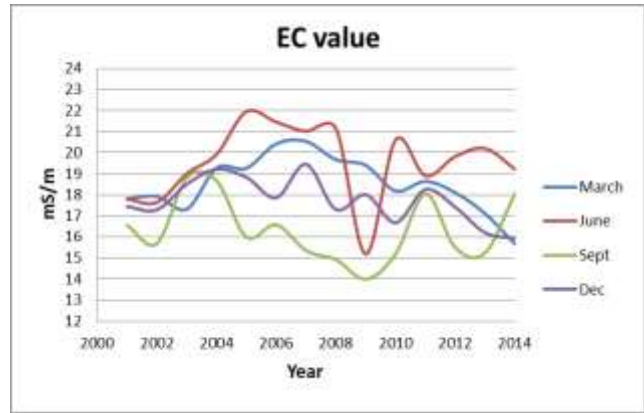


Figure 2.17. Change of seasonal average EC values

EC values fluctuate in range of 14 - 21.95mS/m, and get the highest value in June/summer, next to in March/spring. The summer is rainy season in Vietnam, therefore, the reservoir is disturbed largely due to flood and rainfall.

Annual average pH values are changed from 6.8 to 8.0, almosts are in range of $7 < \text{pH} < 8$ (77%). Seasonal variation of pH values is not detected in duration 2001- 2014.

For major ions concentration (SO_4^{2-} , NO_3^- , Ca^{2+} , Mg^{2+}), the highest values, generally, are observed in June.

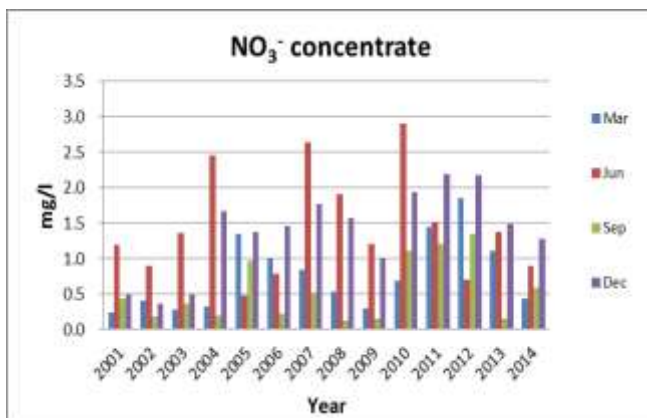


Figure 2.18. Change of SO_4^{2-} concentration in Hoa Binh reservoir water (2001-2014)

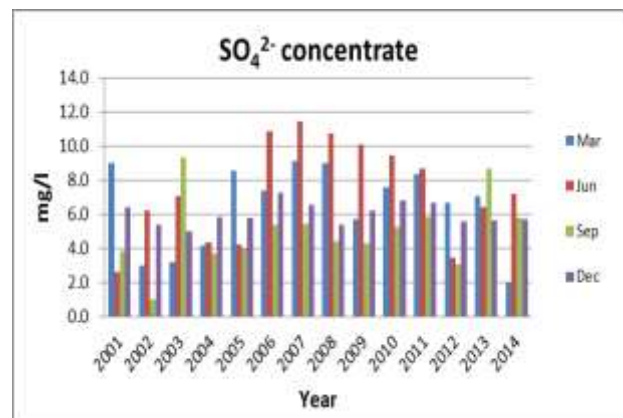


Figure 2.19. Change of NO_3^- concentration in Hoa Binh reservoir water (2001-2014)

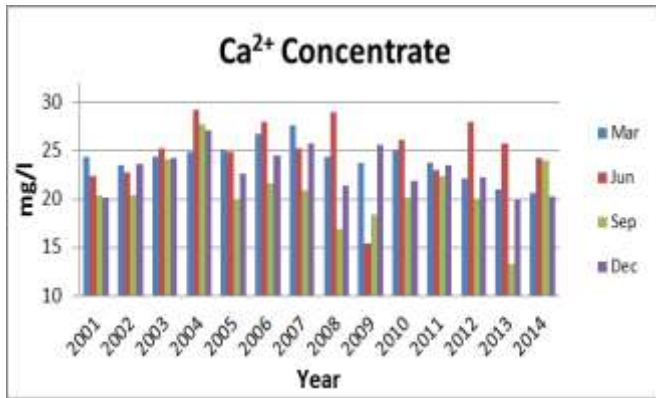


Figure 2.20 Change of Ca²⁺ concentration in Hoa Binh reservoir water (2001-2014)

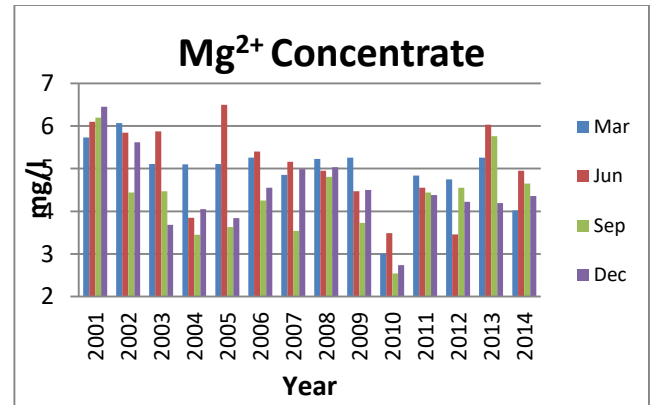


Figure 2.21. Change of Mg²⁺ concentration in Hoa Binh reservoir water (2001-2014)

Water monitoring results indicated that alkalinity of Hoa Binh reservoir is very high (1500µeq/L) which exceeds 7-8 times compared to the level recommended by EANET (<200 µeq/L).

Chapter 3. Review of National Air Quality Management including Acid Deposition

3.1. Legal and institutional structure of air quality management system

Legal documents system of air quality management in Vietnam has been set up along with the legal system of environmental protection, integrating management contents into some Laws and Resolutions of the Ministry of Politic; Strategy, Decision of the Prime Minister and the guiding circulars from the relevant ministries.

In general, the ambient air quality management system in Vietnam can be figured out in the below.

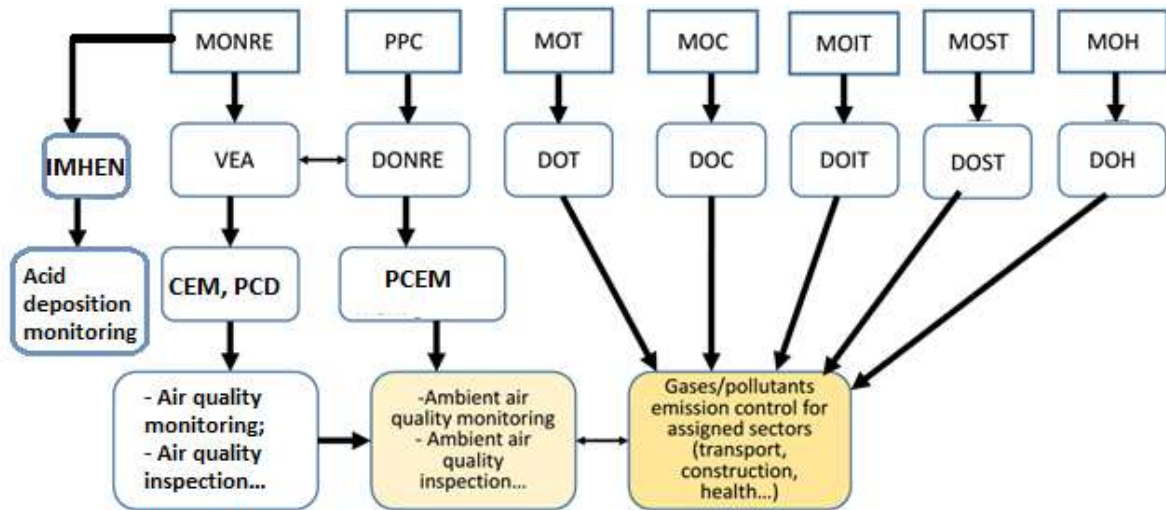


Figure 3.1. Diagram of air quality management and monitoring system in Vietnam

MONRE: Ministry of Natural Resources and Environment

PPC: Provincial People Committee

MOT: Ministry of transportation

MOC: Ministry of construction

MOIT: Ministry of Industry and Trade

MOST: Ministry of Science and technology

MOH: Ministry of Health

IMHEN: Institute of Meteorology, Hydrology and Climate change

VEA: Vietnam Environmental Administration

CEM: Center of Environmental Monitoring

PCD: Pollution control department

DONRE: Department of Natural Resources and Environment

PCEM: Provincial Center of Environmental Monitoring

DOT: Department of transportation

DOC: Department of construction

DOIT: Department of Industry and Trade

DOST: Department of Science and technology

DOH: Department of Health

Functions, Mandates, and Current Actions on AQM of Concerned Ministries:

The functions, mandates, and current actions on AQM of the six concerned ministries are summarized as the follow:

(a) MONRE

- MONRE is the leading central body governing environmental management. Article 140 of Chapter 14 of LEP 2014 (No: 55/2014/QH13) outlines the responsibilities of MONRE with regard to state administration of environmental protection.

- All ministries, ministry-level agencies, and other government bodies cooperate with MONRE in carrying out environmental protection within their sectors.

- The government spends 1% of the state budget expenditure for environmental protection activities but there is limited data on the compliance with this law and how much is used for air quality management.

- VEA, an agency under MONRE, carries out the functions of advising and assisting the Minister of MONRE in environmental management and legal enforcement on a national scale, and manages and implements environmental public services.

- Key departments and agencies within VEA are as follows:

a) The Department of Policy and Legislation (DPL), which assists MONRE in policy making and developing environmental regulations, strategies, and plans.

b) The Department of Appraisal and Environmental Impact Assessment (DAEIA), which manages the EIA and appraisal system.

c) The Center for Environmental Monitoring (CEM), which implements national environmental monitoring including air quality monitoring. CEM has prepared reports on environmental quality within the framework of VEA's functions and mandates, e.g., State of Environment 2013's topic is "Air Environment", published in 2014

d) The Department of Pollution Control (PCD), which focuses on control, prevention, and reduction of environmental pollution in soil, water, and air; hazardous chemical management; prevention, response, and mitigation of environmental pollution/contamination caused by natural disasters or environmental accidents.

- The Center for Hydro-Meteorological and Environmental Station Network, under the National Hydro-Meteorological Service of MONRE, is operating nine automatic air quality monitoring stations in the whole Vietnam. According to the survey implemented by the Project, the tasks for

operating air monitoring stations are demarcated between the center and the Center for Environmental Monitoring (CEM). In particular, the center is in charge of “background monitoring stations”, which exist in places under “no-impact” conditions, and CEM is in charge of “impact monitoring stations”, which exist in places along the road and/or near pollution sources.

- IMHEN, under MONRE, is responsible for researching and training graduate students in the field of meteorology, hydrology, climate change and environment. IMHEN is assigned as national focal point of EANET by the Vietnam Government. IMHEN is in charge of managing the EANET monitoring network in Vietnam.

Current activities related to AQM of MONRE:

As the leading agency for helping the government in environmental management of the environment, MONRE has carried out a lot of activities on pollution control, as follows:

- To strengthen the control of air pollution, noise, chemical emission, and transboundary pollution.
- To complete the system of standards and regulations, and to enhance management of environmental monitoring network of the national local level and ministries.
- To carry out research for control of air and chemical emissions, environmental accidents, industrial zones, villages and rural environment, and environmental protection in food safety management.
- To continue to improve the legal framework, and the system of legal documents in the field of environmental pollution control including those on ambient air protection.
- To work closely with the provincial departments of environmental protection in pollution control.
- To carry out research and to advise the leaders of the departments and ministries of assigned functions and tasks of control of environmental pollution in general and air pollution in particular between ministries and relevant agencies to ensure harmony and unity.

(b) MOT

- To provide technical safety standards, and environmental protection for motor vehicles.

- To evaluate strategic environmental assessment and environmental impact assessment reports for investment construction projects for transport infrastructure and industrial production facilities.
- To coordinate with MONRE and other relevant ministries, ministerial-level agencies, government agencies, and the provincial People's Committee (PC) to direct, guide, and inspect the implementation of the LEP relating to the construction of transport infrastructure and transport operations.
- To provide for the issuance of the certificate of environmental standards for motor vehicles in road, rail transport, inland waterways, maritime and aviation.

The Department of Environment has the following tasks and authority over environmental management sectors:

- a) Act as a leader in building the five-year and annual plan and environmental protection programs of the ministry.
- b) To develop mechanisms and policies for protecting natural resources, the environment, energy efficiency and conservation, climate change, technology transfer and capacity development for environmental protection.
- c) To conduct inspection and certification of environmental standards, technical regulations, and energy labels for motorized transport by road, rail, inland waterway, maritime, and civil aviation.
- d) To regulate the operating conditions of the inspection establishment, and environmental protection laboratory for motor vehicles.
- e) To implement international cooperation activities related to environmental protection of transportation as assigned by the Minister.

Current activities related to AQM of MOT:

There are 105 car inspection stations established all over the country and the National

- Motor Vehicle Test Center (NETC). In the 2008-2012 period, MOT in collaboration with the authorities at the local level organized annual monitoring and inspection of buses and passenger cars by mobile testing devices in order to test and detect vehicles that do not meet the conditions on emissions.

- In 2012, the Prime Minister issued a roadmap for the application of biofuel and environmentally-friendly fuel. According to this roadmap, from 12/2012 gasoline blended with E5 biofuel was produced, blended, and sold for use of road motor vehicles nationwide
- MOT is studying the development of software for alert systems that automatically update cars having their reached expiry date in order to warn the inspection unit to handle them accordingly.

(c) MOIT

- To perform the functions of state management of industry and trade, including the sectors of engineering, metallurgy, electricity, new energy, renewable energy, oil and gas, chemicals, industrial explosives, mining industry and mineral processing, consumer goods, food processing, commercial and domestic markets, export and import, border trade, etc.
- To provide guidance, supervise and carry out inspection of the implementation of the provisions of the law on industrial safety techniques and environmental protection under the state management of MOIT.
- To provide leadership and coordination with MONRE and other ministries that are involved in directing the development of environmental industries as stipulated by law.
- To provide guidance on the implementation of environmental monitoring, resources and waste statistics, building and managing environmental database system for the ministry's management.
- To lead and coordinate with relevant agencies to guide and organize the implementation of programs, tasks, and projects related to climate change under the ministry's management.
- MOIT established the Industrial Safety Techniques and Environment Agency to perform the functions of state management and law enforcement on technical safety and environmental protection in industry and trade.

Current activities related to AQM of MOIT:

- To promote the inspection and control of environmental pollution due to industries.
- To organize monitoring teams for environmental protection works at production facilities.
- The above works were carried out mainly at production facilities and state enterprises which might cause serious air pollution (2008: works were implemented in 35 establishments, 2009: 36 establishments, 2010: 40 establishments, 2011: 26 establishments, 2012: 20 establishments).

- Industrial production establishments have indicated concerns in processing technologies for industrial emission treatment, and efficiency of dust filtration equipment in major plants, especially of foreign direct investment (FDI) funded plants, by instruction of MOIT.
- To implement Vietnam's commitment to the Montreal Convention Protocol implied in January 2010

(d) MOC

- To coordinate with MONRE and MOIT in the appraisal process of issuance of license and reporting of environmental impact assessment (EIA) of development projects under the administration of MOC.
- To direct and guide the integration of planning and environmental protection programs into construction activities.
- To direct and guide the implementation of establishment of strategic environmental assessment (SEA) reports and EIA reports, appraisal of reports on EIA under the authority, monitoring impacts to the environment due to construction activities, management and control of waste, noise, vibration, light, radiation, prevention, response to environmental accidents, environmental pollution, environmental rehabilitation in areas under MOC, such as infrastructure development.
- The Department of Science, Technology and Environment acts as the focal unit with regard to pollution problems in MOC. Their functions/mandates are related to scientific research and technological development, application of advanced techniques, technology transfer, standards, metrology and quality goods, industrial property, technical barriers in trade, environmental protection and information on science and technology.

The main functions/mandates on environmental management are as follows:

- a) To provide guidance on integration of planning and environmental protection programs in the strategy, planning, program for development and to support the preparation of SEA and EIA reports.
- b) To monitor environmental impacts caused by the operation of the construction industry, to provide the situation EIA report of the construction industry, and to carry out management and control of waste, noise, vibration, light, radiation, preventing, response to environmental incidents, remedies for environmental pollution, and environmental restoration in areas.

c) To carry out research and propose for new issuance or adjustment of technical regulations, national standards for the environment, and to submit to MOC for issuance within their authority of the technical regulations on environmental quality and waste management in the areas.

Current activities related to AQM of MOC:

- Control of emission sources from construction activities in Vietnam in recent years has made the following progress:

- To reduce dust caused by transportation trucks carrying earth and sand.
- To reduce dust generation from construction activities and from other activities such as mining and selling of construction materials.
- To develop a greenhouse gas mitigation action plan in the cement manufacturing industry.

(e) MOST:

- MOST performs the state management function with regard to science and technology, including scientific and technological activities, development of the scientific and technological potential, intellectual property, quality measurement standards, atomic energy, radiation and nuclear safety, and management of public services.

- Regarding pollution control works, MOST is responsible for issuance of standards, national technical regulations, procedures, and economic technical norms.

- The agencies under MOST have functions and duties such as development and promulgation of Vietnamese National Technical Regulations (QCVN) for air pollution control, management of system for technical standards and regulations of Vietnam, evaluation and publication of national standards, and guidance on development and evaluation of national technical regulations.

- The Vietnam Standards and Quality Institute under the Directorate for Standards, Metrology and Quality assumes the major responsibilities regarding QCVN.

- The organizational charts of MOST and the Vietnam Standards and Quality Institute are both shown in Attachment 20.

Current activities related to AQM of MOST:

- MOST led the drafting of the clean technology use strategy until 2020, with a vision to 2030, which was approved by the government under Decision No. 2612/QĐ-TTg dated December 30, 2013.

- Specifically, the strategy focuses on the development and application of standards and technical regulations on clean technology in energy-consuming industries which may cause serious pollution to the environment such as textile dyeing, manufacture of fertilizers and pesticides, steel production, mining and mineral processing, thermal power, paper manufacturing, cement production, and sugar production. The specific objectives of the strategy are as follows:

a) By 2020, 100% of new investment projects in the fields above meet the standards and technical regulations on clean technologies, and 60-70% of the production facilities operating in the industries mentioned above complete the development and implementation of technological innovation roadmap towards using clean technology.

b) By 2030, 100% of the production facilities in the industries adopt the standards and technical regulations on clean technology.

(f) MOH:

- To lead and coordinate with MONRE, MOC, and other relevant authorities in issuing regulations, standards, and national technical regulations on environmental protection in health activities.

- To evaluate the SEA report and EIA report for the projects subjected to the approval of the Ministry of Health (MOH).

- To direct and guide the implementation of i) monitoring of environmental impacts from the operation of the health sector, and ii) management and control of pollution and health environmental restoration due to medical waste generation.

- To collect, store, and provide environmental information related to the areas under the jurisdiction of MOH as prescribed by law, such as the National Technical Regulation on Emission of Health Care Solid Waste Incinerators (QCVN02/2013/BTNMT).

- To direct and guide the implementation of measures to protect human health from the impacts of climate change, pollution, and other adverse environmental factors.

- To provide leadership and to guide in the implementation, inspection, and supervision of legal documents, national technical regulations on the management and disposal of medical waste, and environmental protection in health activities.

3.2 Policies and regulations on AQM in Vietnam

(a) Current Standards for Air Pollutants

- QCVN 05 : 2013/BTNMT - National technical regulations on ambient air quality.
- QCVN 06:2009/BTNMT –National technical regulations for hazardous substances in the ambient air.
- QCVN 19:2009/BTNMT – National technical regulations on industrial emissions for dust and inorganic substances.
- QCVN 20:2009/BTNMT – National technical regulations on industrial emissions for some organic matter.
- QCVN 21:2009/BTNMT – National technical regulations on industrial emissions of chemical fertilizer production.
- QCVN 22:2009/BTNMT – National technical regulations on industrial emissions of thermal power.
- QCVN 23:2009/BTNMT – National technical regulations on industrial emissions of cement production.
- QCVN 30:2010/BTNMT – National technical regulations on emission of industrial waste incinerators.
- QCVN 34:2010/BTNMT –National technical regulations on industrial refinery petrochemical emissions for dust and inorganic substances.
- QCVN 51 : 2013/BTNMT - National technical regulations on industrial emissions of steel production

(b) Current Regulations and policies related to air quality management

- Law on Environmental protection dated June 23rd, 2014;
- Resolution No. 35/NQ-CP of the Government dated 18th March 2013 on urgent issues in the field of environmental protection;
- Decree No.38/2015/NĐ-CP of the Government dated on 24th April 2015 on wastes and scraps management;
- Decision No. 432/QĐ-TTg dated 12th April 2012 of Prime Minister on approving Sustainable Development Strategy for Vietnam during the period of 2011-2020;
- Decision No.166/QĐ-TTg dated 21st January 2014 of Prime Minister on promulgating National environmental protection Strategy until 2020 with vision to 2030;

- Decision No. 177/2007 / QD-TTg of 20th July 2007, focusing on the propagandizing, disseminating knowledge about biofuels and promoting the technical infrastructures using biofuels.
- Decision No 49/2009/QD-TTg dated January 1st, 2011 by Prime Minister defining roadmap for application of emission standards for cars, manufactured, assembled and new-imported motorcycles.
- Decision No. 909/QD-TTg dated 17 June 2010 focuses on supplement of legal documents system in order to create a legal framework for controlling emission from the motor vehicles, motorcycles.
- Decision No. 855/QD-TTg dated 6 June 2011 focuses on the application of the further emission standards (Euro 3,4,5) for road motor vehicles.

3.3 National air monitoring system

Ambient air quality monitoring activities in Vietnam has started for implementation since 1995 through monitoring programs at national and local levels. Since 2000 up today, in order to provide continuous monitoring data, 35 automatic atmospheric environmental monitoring stations was built and still has been operated in a number of megacities such as VEA (7 stations), National Meteo and Hydrology center (10 stations), Hanoi (2 stations) Quang Ninh (10 station), Vinh Phuc (2 stations), Da Nang (1 station), Hue (1 station), Khanh Hoa (1 station), Can Tho (1 station), Daklak (1 station), Đồng Nai (2 stations), Quang Nam (1 station). In addition, a number of automatic atmospheric environmental monitoring stations were invested in VEA (1 station), Quang Ninh (1 stations), Daklak (1 station). In addition, in Dong Nai, Quang Ninh, Thai Nguyen provinces, projects on setting automatic atmospheric environmental monitoring stations are implemented at local level. In Ho Chi Minh City, there are used to have 9 atmospheric environmental monitoring stations, but all stations are stopped due to lack of resources.

For semi-automatic monitoring stations, in other locations, due to insufficient expense, still carrying out with interruptive monitoring method with frequency from 4-6 times/year. The air monitoring sites are located primarily at environmental hotspots of mega urban areas or industrial zones.

The environmental monitoring programs in general, and air monitoring programs in particular are just focused on urban areas, areas near the industrial zones ... lack of overall and

periodic monitoring programs for rural areas, trading villages. The monitoring issues in order to control air pollution sources across borders still face many difficulties.

As stipulated in the decision approving the EIA report, the production facilities are required to perform periodic environmental monitoring, but most of the production facilities are not implemented properly and adequately monitoring emissions at the smokestacks. The cause is mainly due to the production facilities had no arrangement or improper technical layout of monitoring position, sampling taking in smokestacks. The installation of the automatically, continuous emissions monitoring systems performed only in large plants in the cement industry, thermal power, chemical, oil refining, chemical production plants. Some other plants have installed but for the purpose of monitoring production technologies, thus there are lacks of environmental parameters, especially toxic parameters.

Monitoring activities not follow a uniform procedure, a lot of units participating in observation with various field sampling and analyses, which make difficult for the evaluation of data quality. Vietnam has issued in the Circular No. 28/2011/TT-BTNMT dated August 1, 2011 on providing for the environmental monitoring technical process for ambient air quality and noise, however, currently there is regulation on industrial exhaust emissions monitoring technical process under Circular number 40/2015/TT-BTNMT dated 17 August 2015 of the Ministry of Natural Resource and Environment. The implementation of QA/QC is still weak, causing difficulties to the data quality assessment. The air monitoring equipment in many places are weak and obsolete, it's not automated in the stages of storage, processing and exchange of data.

Data on emissions still unused, quality on ambient air still not synchronized and has not formed as a database system at national level, causing difficulties to information exploitation, use and share.

4. Conclusion

Through 15 years of development, East Asia acid deposition monitoring network has had significant activities in rising public awareness and solving problem of acid deposition among regional countries. Vietnam is an active member in the EANET's activities. Up to now, there are six stations under EANET in Vietnam. Acid deposition monitoring results show that acid rain has occurred at five of six sites in Vietnam (except Can Tho), but their acid deposition are different from site to site. As a result of transboundary pollution, Cuc Phuong has the maximum

frequency of acid rain, up to 35.4%, in spite of the ecological station. The monitored concentrations of precursors (SO_2 , HNO_3) causing acid deposition also indicated high levels of pollution in urban stations (Hanoi, Ho Chi Minh City). The amount of wet deposition (H^+ , SO_4^{2-} , NO_3^-) and dry deposition (SO_2 , HNO_3) in Vietnam stations is in range from tens to hundreds $\text{mmol/m}^2/\text{year}$.

Facing to the increase of air pollution in recent years, the Vietnamese government has been taking a lot of efforts in institution and policy related to air quality management and air pollution controls. The governmental departments/agencies involving in air quality management have been consolidated and clarified their responsibilities. In addition, many legislation documents have been issued such as Law, Decrees, Circular, plans and national technical standards on air emission control. Moreover, Vietnam needs to develop more monitoring systems of air quality and acid deposition that could contribute to achieve national targets on air quality protection and regional targets, as well.