STEP-BY-STEP APPROACH TO ESTABLISH ACID DEPOSITION
MONITORING NETWORK IN EAST ASIA (EANET):
THAILAND’S EXPERIENCES

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Abstract. Recognizing the adverse effects of acid deposition and its transboundary nature, efforts
have been made for the past six years by countries in the East Asian region to establish acid
deposition monitoring network in the region by taking a step-by-step approach towards the formal
establishment. The First Intergovernmental Meeting held in March 1998 agreed as the first step
to implement preparatory-phase activities for two years with the aim to officially establish the
EANET in the year 2000. With the successful implementation of the preparatory-phase activities,
the Second Intergovernmental Meeting held in October 2000 subsequently agreed to start the
activities of the EANET on a regular basis from January 2001.

Thailand developed and carried out the national monitoring plan for the preparatory-phase
activities through the cooperation of various agencies. Four monitoring sites were included in the
preparatory-phase activities of the EANET. Monitoring capacity in Thailand has been gradually
built during the preparatory-phase and Thailand is now ready to start monitoring activities of the
EANET on a regular basis.

Efforts should be continued to study the complex nature of acid deposition phenomena, to
quantify the adverse environmental impacts of acid deposition, and to eventually reduce emis-
sions of acid precursors. Strong supports from international and regional organizations are
essential for effective implementation of the EANET activities and to address acid deposition
problem in the East Asian region.

Keywords: EANET, East Asia, monitoring network, preparatory-phase, step-by-step approach

1. Introduction

Rapid industrialization and urbanization, high economic and population growth, emissions of acid precursors, i.e. sulfur oxides and nitrogen oxides, into the atmosphere. With all those, the East Asian region has thus emerged as one of the regions in the world potentially subject to excessive atmospheric acidity and is confronting an ecological crisis which involves the excessive deposition of acidic substances from the atmosphere, like Europe and North America. Various investigations has confirmed the seriousness of the acid deposition problem in many parts of the East Asian region and indicate that major contributors to acid deposition in the East Asian region are significant. However, international activities to address acid deposition problem have not yet been sufficiently undertaken in this region.

With no exception, Thailand has also experienced impacts from acid deposition resulting from excessive emission of sulfur dioxide from the Mae Moh lignite-fired
thermal power plant located in the northern part of the country. The 2,625 MW power plant burning high sulfur content lignite did not have sulfur dioxide emission control and emitted sulfur dioxide of almost 150 tons per hour. Impacts to health and vegetation were reported in the area around the power plant.

Since acid deposition is transboundary in nature which can occur at a substantial distance from the original sources of emissions of acidic substances, regional cooperation and collaboration are essential to address the acid deposition problem. The Convention on Long-Range Transboundary Air Pollution (CLRTAP) was adopted in 1979 by countries in Europe to address the transboundary aspect of air pollution the region. Coordinated efforts among parties to the Convention have been made to monitor acid deposition, reduce pollutant emissions, and study the complex nature of acid deposition.

Recognizing the adverse effects of acid deposition and its transboundary nature, countries in the East Asian region have begun to seek common understanding and solutions to address acid deposition problem through regional cooperation taking into account the experience in Europe and North America as called for in Agenda 21 adopted at the United Nations Conference on Environment and Development (UNCED) in June 1992 that “The programme (in Europe and North America) needs to be continued and enhanced, and their experience needs to be shared with other region of the world”.

This paper describes the efforts to establish the acid deposition monitoring network in East Asia (EANET) and Thailand’s experiences in participating in the network activities.

2. Step-by-Step Approach to Establish Acid Deposition Monitoring Network in East Asia (EANET)

2.1. Development of Technical Manuals and Guidelines for Monitoring Acid Deposition

Many countries in the East Asian region, for example, China, Indonesia, Japan, Malaysia, the Republic of Korea, Thailand, and Vietnam, have already carried out acid deposition monitoring and accumulated data on the national level. However, it is difficult to address the present status of acid deposition problem on the regional level based on existing data accumulated on the national level because of the differences from country to country in sampling and analysis methods, monitoring parameters, and gaps in data quality.

In light of the above, efforts have been made for the past six years by countries in the East Asian region led by Japan to establish acid deposition monitoring network in the region to track the deposition from the atmosphere of acidic substances and their adverse impacts on aquatic and terrestrial ecosystems in the region. The ultimate objective is to seek common solutions to address the acid
deposition problem through regional cooperation, such as cooperative measures to control emissions of acid precursors. Participating countries in the East Asian region include China, Indonesia, the Republic of Korea, Malaysia, Mongolia, the Philippines, the Russian Federation, Thailand, and Vietnam.

The first expert group meeting held in October 1993 in Japan to discuss issues relating to an acid deposition monitoring network in East Asia. Three subsequent expert group meeting were held between 1993 and 1997. The meetings were participated by experts from ten East Asian countries mentioned above, experts from international organizations, such as World Meteorological Organization (WMO), Cooperative Programme for the Monitoring and Evaluation of Long-range Transmission of Air Pollutants in Europe (EMEP) of the United Nations Economic Commission for Europe (UN/ECE), United Nations Economic and Social Commission for Asia and the Pacific (UN/ESCAP), and United Nations Environment Programme (UNEP), and experts from other parts of the world, such as Europe, North America, and Australia.

As a result of the four expert group meetings, technical manuals and guidelines for monitoring wet deposition, dry deposition, soil and vegetation, and inland aquatic environments were developed. This is an essential step for the assessment of the status of acid deposition problem in the East Asian region since they will enhance the quality and compatibility of monitoring data obtained from monitoring activities carried out by countries in the region. Monitorings for wet and dry deposition are to observe concentrations and fluxes of acidic substances deposited to the earth surface, while monitorings for soil and vegetation and inland aquatic environments are to assess adverse impacts on terrestrial and aquatic ecosystems.

2.2. TETATIVE DESIGN OF THE ACID DEPOSITION MONITORING NETWORK IN EAST ASIA (EANET)

2.2.1. Objectives and Activities of the EANET

The participating countries agreed to promote the establishment of a regional monitoring network on acid deposition based on a step-by-step approach aiming at monitoring acid deposition in East Asia on a regular basis. The tentative design of the Acid Deposition Monitoring Network in East Asia (EANET) which is essential for the successful operation of the network was developed at the First Intergovernmental Meeting on the Acid Deposition Monitoring Network in East Asia held in Yokohama, Japan in 1998. The objectives of the EANET are as follows,

- to create common understanding of the state of the acid deposition problem in East Asian region;
- to provide useful inputs for decision-making at local, national and regional levels aimed at preventing or reducing adverse impacts on the environment caused by acid deposition;
• to contribute to cooperation on the issues related to acid deposition among the participating countries.

The objectives of the EANET will be achieved through the implementation of acid deposition monitoring by each participating country, central compilation, analysis and evaluation of such monitoring data, and periodic publication of the reports. The quality assurance/quality control (QA/QC) programs will be developed and implemented to ensure obtaining high quality monitoring data.

Such common understanding will become the scientific basis for taking further steps to address the problem, such as cooperative measures to control emissions of acidic substances.

For the effective implementation of the EANET activities, bilateral and multilateral cooperation among the participating countries, collaboration with existing regional, subregional and national initiatives in East Asia and with other international monitoring networks and programs in the world should be promoted.

2.2.2. Institutional Arrangement

The EANET will be governed and operated by the following bodies,

• **Intergovernmental Meeting** composed of representatives of all the participating countries will serve as the decision-making body of the EANET making decisions on matters related to the management of the EANET with respect to scientific, technical, administrative and financial matters; the approval the work program and budget; the implementation of the work program; and the approval of periodic reports on the state of acid deposition in East Asia.

• **Scientific Advisory Committee** established by the Intergovernmental Meeting will advise and assist on such scientific and technical matters as monitoring strategies and methodology; selection of monitoring sites; QA/QC programs; data reporting procedures and formats: collection, evaluation, assessment and analysis of monitoring data; preparation of periodic reports on the state of acid deposition in East Asia; and studies of other scientific issues.

• **Secretariat** designated by the Intergovernmental Meeting will make all necessary administrative and financial arrangements for managing the EANET, arrange meetings of bodies under the EANET; and act as the focal point for all other administrative matters.

• **Network Center** (may have one or more branches) designated by the Intergovernmental Meeting will compile, evaluate, and store monitoring data for the assessment and preparation of periodic reports on the state of acid deposition in East Asian region and implement other tasks such as provision of technical assistance to the participating countries, implementation and coordination of QA/QC programs; development and implementation of education/training programs and research activities
on acid deposition; and provision of scientific and technical support for
the Intergovernmental Meeting, Scientific Advisory Committee, and
other subsidiary bodies.

- National Centers designated by each participating country will collect
and evaluate the monitoring data for the assessment of the national status
of the acid deposition problem and implement such other tasks as prepa-
ration and implementation of a national monitoring plan and a national
segment of the EANET’s QA/QC programs, and submission of
monitoring data to the Network Center.

2.2.3. Financial Arrangements
The administrative and operational costs of national monitoring within each
country will be borne by each participating country. The administrative and
operational costs of the EANET, in particular the Network Center and the Se-
cretariat, will be financed by voluntary contributions by the participating coun-
tries. Efforts should be made to mobilize existing funding sources and seek
new ones.

2.3. The First Step - The Preparatory-Phase of the EANET

Since it was agreed by the participating countries to establish the EANET on a
stepwise manner, the First Intergovernmental Meeting agreed as the first step to
implement activities of the EANET on an interim basis as a preparatory phase
with the objectives,

- to examine the feasibility of the designed EANET activities and relevant
guidelines and technical manuals,
- to provide time for the participating countries to further develop national
monitoring systems for the EANET,
- to formulate policy recommendations for the further development of the
EANET.

It was aimed to start monitoring activities of the EANET on a regular basis in
the year 2000 at the Second Intergovernmental Meeting taking into account
experiences accumulated during the preparatory phase.

The preparatory phase of the EANET were implemented for a period of two
years starting from April 1998 to 2000 during which each participating country
implemented acid deposition monitoring in its country in order to assess the
state of acid deposition as well as ecological impacts in East Asia. There were a
total of 38 network monitoring sites operated by the participating countries in
the preparatory phase of the EANET as shown geographically in Figure 1.

The guidelines and technical manuals for monitoring wet deposition, dry
deposition, soil and vegetation, and inland aquatic environments, and the tenta-
tive design of the EANET were followed to the extent practical with available
resources. In addition, the following activities were carried out, 1) development
and implementation of QA/QC programs including inter-laboratory comparison program of chemical analysis; 2) development and implementation of training programs; 3) Compilation, evaluation, storage of, and access to relevant data and information; etc.

![EANET monitoring sites](image)

*Figure 1. Geographical distribution of 38 EANET monitoring sites during the preparatory phase.*

For the implementation of the preparatory phase of the EANET, three interim bodies were established, namely 1) Interim Scientific Advisory Group; 2) Interim Secretariat; 3) Interim Network Center. The Environment Agency of Japan was designated as the Interim Secretariat and the Acid Deposition and Oxidant Research Center in Niigata, Japan as the Interim Network Center. The Working Group, composed of representatives of the participating countries, acted as the decision making body during the preparatory phase.

The preparatory phase of the EANET was implemented successfully in demonstrating the feasibility of the EANET and the participating countries have developed the basis to start the acid deposition monitoring on a regular basis. However, it is concluded that monitoring data collected during the preparatory phase is from relatively small number of monitoring sites and limited monitoring period and thus is still very limited for the assessment of the state of the acid deposition problems in East Asia. In addition, there still remain many issues in the EANET that require further improvement, such as capacity building, methodology of monitoring site selection, the limited number of monitoring sites,
monitoring methodologies, and the level of QA/QC activities.

2.4. THE NEXT STEP – IMPLEMENTATION OF THE EANET ON A REGULAR BASIS

The Second Intergovernmental Meeting on the EANET was held from 25 to 26 October 2000 in Niigata, Japan. The participating countries issued the Joint Announcement on the Implementation of the EANET in order to cooperatively start the activities of the EANET on a regular basis from January 2001. Monitoring activities will be implemented in line with the Tentative Design of the EANET which will be further elaborated in the future. Efforts will be continued in the future to strengthen the basis upon which the EANET operates. The participating countries will also discuss future EANET activities in order to contribute to development of international cooperative efforts for preventing or reducing adverse environmental impacts of acid deposition.

The Meeting designated the UNEP as the Secretariat for the EANET which will be housed in the office of the Environment Assessment Programme for Asia and the Pacific and supported by the Regional Office for Asia and the Pacific of UNEP. Both of offices are located in Bangkok, Thailand. UNEP is expected to start the Secretariat functions after the Third Intergovernmental Meeting which will be held in Autumn 2001. Before this, the Environment Agency of Japan will continue to serve as the Interim Secretariat.

The Acid Deposition and Oxidant Research Center located in Niigata, Japan was designated as the Network Center for the EANET and will start the Network functions in January 2001. The activities of the Network Center will be implemented in a transparent manner and involving experts from the participating countries as much as possible. The Intergovernmental Meeting, composed of representatives from the participating countries, will continue to serve as the decision making body for the EANET.

Lastly, the Meeting approved the Work Program and Budget for the EANET in 2001 which includes the following activities, among others:

- establishing in each participating country a national monitoring plan toward adequate assessment of the state of acid deposition in East Asia;
- continuing monitoring activities with improved QA/QC;
- developing monitoring methodologies, particularly for dry deposition and impacts on soil and vegetation which are applicable and adequate for East Asia;
- starting consideration of further scientific issues such as emission inventory studies and numerical modeling; and
- continuing consideration of further development of EANET

The participating countries are encouraged to make voluntary financial and in-kind contributions which are indispensable for the implementation of the activities of the EANET, including secondment of staff to the Secretariat and/or the Network Center. Other international organizations including WMO, UN/ECE,
UN/ESCAP, UNEP, CLRTAP, the Northeast Asian Subregional Environmental Cooperation Program, are invited to cooperate and make contributions in promoting the EANET activities.

3. Thailand’s Experiences in Acid Deposition Problem and Participation in the EANET Activities

3.1. Major Acid Deposition Episode in Thailand

The first major episode of impacts of acid deposition in Thailand caused by sulfur dioxide emitted from the Mae Moh lignite-fired thermal power plant occurred in October of 1992 during which the weather was changing from rainy season to winter season. The power plant which is located in the Mae Moh Valley and has a total installed capacity of 2,625 MW burns high sulfur lignite of 3 percent sulfur content on the average and emits uncontrolled sulfur dioxide of almost 150 tons per hour.

During the episode, the maximum ambient hourly ground level concentration of sulfur dioxide of as high as 1,300 ppb was observed between 10:00 a.m. and 14:00 p.m. when sulfur dioxide trapped in air above the valley overnight fumigated to the ground after the inversion was broken up during the late morning to early afternoon. In the winter time, a stable and strong surface inversion layer is developed in the atmosphere above the valley after sunset and is normally associated with high pressure system coming from China.

Large numbers of people, especially with asthma, living in the surrounding area of the power plant, particularly downwind, sought medical attention for respiratory-related symptoms which included stinging nose and throat, cough, chest tightness, asthmatic attack, nausea, vomiting, dizziness, malaise, and occasionally wheezing and shortness of breath. In addition to health impacts, damages to plants were also reported. Leaves of many trees, vegetable, and plants were reported to suddenly wither and fall to the ground over night.

Since then, the Royal Thai Government has implemented both short-term and long-term measures to mitigate the problem. For the long-term measures, it was decided to retrofit the power plant with flue gas desulfurization (FGD) units (wet limestone forced oxidation FGD system with 95% sulfur dioxide removal efficiency) to reduce sulfur dioxide emission to be not more than 11 tons per hour in order to control ambient hourly ground level concentrations of sulfur dioxide to be not more than 300 ppb.

During the installation of FGD units, the power plant was also required to implement several short-term measures to reduce sulfur dioxide emission in order to control ambient hourly concentrations of sulfur dioxide not to exceed 500 ppb. They included using low sulfur lignite of not more than 1 percent sulfur content by weight and reducing electricity generating load during dawn to late morning.
The installation of the last FGD unit was completed in early 2000. The emission of sulfur dioxide is successfully reduced from 150 ton per hour to less than 11 ton per hour. Consequently, ambient hourly ground level concentrations of sulfur dioxide in the valley observed in the valley have been below 100 ppb.

The Mae Moh power plant, if uncontrolled, is considered as the largest point source of sulfur dioxide emissions in Thailand. Its sulfur dioxide emission reduction has resulted in dramatic reduction of the country’s total sulfur dioxide emission especially after the year 1999. Table I and Figure 2 show annual national energy consumption and associated sulfur dioxide and nitrogen oxides emissions.

### Table I

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<tbody>
<tr>
<td>Fuel Consumption (x1000 toe)</td>
<td>43,337</td>
<td>46,398</td>
<td>50,700</td>
<td>56,456</td>
<td>61,452</td>
<td>63,955</td>
<td>58,725</td>
</tr>
<tr>
<td>Sulfur Dioxide Emission (x1000 ton)</td>
<td>1,301</td>
<td>1,237</td>
<td>1,294</td>
<td>1,397</td>
<td>1,382</td>
<td>1,379</td>
<td>884</td>
</tr>
<tr>
<td>Nitrogen Oxide Emission (x1000 ton)</td>
<td>651</td>
<td>712</td>
<td>774</td>
<td>854</td>
<td>946</td>
<td>990</td>
<td>904</td>
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</tbody>
</table>

![Figure 2. Thailand’s annual energy consumption, sulfur dioxide and nitrogen oxides emissions](image-url)
3.2. THAILAND’S PARTICIPATION IN THE EANET ACTIVITIES

Since 1993, Thailand, one of the ten participating countries of the preparatory phase of the EANET, has participated actively in all four expert group meetings, Intergovernmental Meetings, and other relevant meetings, including Working Group meetings and Interim Scientific Advisory Group meetings, to cooperatively establish the Acid Deposition Monitoring Network in East Asia or EANET.

3.2.1. Organization
Since the preparatory phase of the EANET includes a wide range of activities, such as monitorings of both wet and dry depositions and monitoring of ecological impacts on soil, vegetation and inland aquatic environments which involve various agencies in Thailand, an interagency committee was established by the Pollution Control Board to oversee the implementation of acid deposition monitoring activities in Thailand.

The committee chaired by the Deputy-Director-General of the Pollution Control Department of the Ministry of Science, Technology and Environment is composed of representatives from various relevant agencies, such as the Meteorological Department, the Royal Forestry Department, the Royal Irrigation Department, Department of Agriculture, Department of Environmental Quality Promotion, Department of Health, Department of Treaties and Legal Affairs, Electricity Generating Authority of Thailand, and experts from Ramkhamhaeng University and the King Mongkut’s University of Technology Thonburi. The Pollution Control Department serves as the secretariat of the committee.

3.2.2. Monitoring activities during the preparatory phase of the EANET
The Pollution Control Department is designated as the National Focal Point and the Nation Center of Thailand for the preparatory phase of the EANET. The national monitoring plan for the preparatory phase was developed and approved by the committee. The monitoring activities including monitorings of wet and dry depositions, soil and vegetation, and inland aquatic environments, were carried out through the cooperation of various agencies. They include the Meteorological Department, Department of Environmental Quality Promotion, the Royal Forest Department, Department of Agriculture, Electricity Generating Authority of Thailand, King Mongkut’s University of Technology Thonburi, and Ramkhamhaeng University.

Four monitoring sites in Thailand were included in the preparatory phase of the EANET as shown in Table II. They included two urban sites in Bangkok at the Office of Environmental Policy and Planning (OEPP) and the Meteorological Department (MD), one suburban site in Pathumthani at the Environmental Research and Training Center (ERTC), and one remote site in Kanchanaburi at Khao Laem Dam and Reservoir. Monitoring activities were started in March of
Monitoring data collected from March to December of 1999 was submitted to the Interim Network Center.

<table>
<thead>
<tr>
<th>Monitoring Sites (category of site)</th>
<th>Wet Deposition</th>
<th>Dry Deposition</th>
<th>Inland Aquatic Environments</th>
<th>Soil and Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEPP (urban)</td>
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<tr>
<td>MD (urban)</td>
<td>/</td>
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<td>ERTC (suburban)</td>
<td>/</td>
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<tr>
<td>Khao Laem Dam (remote)</td>
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3.2.3. Other activities

Other activities in Thailand during the preparatory phase of the EANET included,

- the development of Standard Operational Procedures (SOPs) for wet and dry deposition monitoring, the development of QA/QC procedures for wet and dry deposition monitoring, Thailand also participated in the Inter-laboratory comparision activities of the EANET.
- hosting the East Asian Workshop on Acid Deposition in October of 1999 with the support from Japan International Cooperation Agency (JICA) and ADORC. All the participating countries of the preparatory phase of the EANET participated in the Workshop. In addition, other five ASEAN countries who have not participated in the EANET activities, namely Brunei, Cambodia, Mynmar, and Singapore, also participated in the Workshop.
- implementing two joint projects with ADORC,
  - the development of acid deposition brochure for disseminating information on acid deposition to the Thai public which was completed in March of this year. Forty thousand copies of brochures containing information in Thai language on acid deposition were produced, of twenty thousand copies are for general public and twenty thousand copies are for primary school children. A public seminar on the brochure project was held in August of this year for distributing the brochures.
  - the joint research on direct measurement of dry deposition flux is still on going. The reference site for the study has been identified for the direct measurement of dry deposition velocity and the measurement will be carried out in 2001.
3.2.4. Capacity building
In term of capacity building, training in Thailand were held 3 times, of which
two times were on dry deposition monitoring and one time on the development
of SOPs and QA/QC procedures for wet and dry deposition monitorings. Two
staffs from the Pollution Control Department were sent to ADORC for a one-
month on-the-job training with particla support from ADORC. At present, one
staff from the Pollution Control Department is in Japan attending the JICA
training course on acid deposition monitoring.

3.3. FUTURE ACID DEPOSITION MONITORING ACTIVITIES IN THAILAND

The national system for acid deposition monitoring in Thailand and data quality
have been much improved as a result of the implementation of the preparatory
phase activities of the EANET. Thailand is prepared to join other nine coun-
tries in East Asia to implement acid deposition monitoring activities of the
EANET on a regular basis starting from January 2001, although there still re-
main many issues that require further improvement.

Acid deposition monitoring network in Thailand will be expanded in 2001 to
include five additional monitoring sites in order to cover other regions of the
country, such as Chiang Mai in the north, Nakorn Rachsima in the northeast,
Chonburi in the east, Nakorn Pathom in the west, and Songkhla in the south.

Thailand has firm commitment towards the sustainable development and re-
regional cooperation. Environmental aspects have been integrated into policies
and planning of national economic and social development. Efforts and mea-
ures have been implemented to reduce emissions to the atmosphere of air pol-
lutants including acid substances. They include cleaner fuel, cleaner automobile,
cleaner technologies, energy conservation, promotion of renewable energy, and
building public consciousness, participation, and partnership.

With the successful implementation of the preparatory phase of the EANET,
regional cooperative and collaborative efforts should be continued and further
enhanced to study the complex nature of acid deposition phenomena, to quan-
tify the adverse environmental impacts of acid deposition, and to reduce emis-
sions of acid substances to the atmosphere. Strong supports from international
and regional organizations are essential to the successful implementation of the
EANET and to address acid deposition problem in the East Asian region.