



EANET

ACID DEPOSITION MONITORING NETWORK
IN EAST ASIA



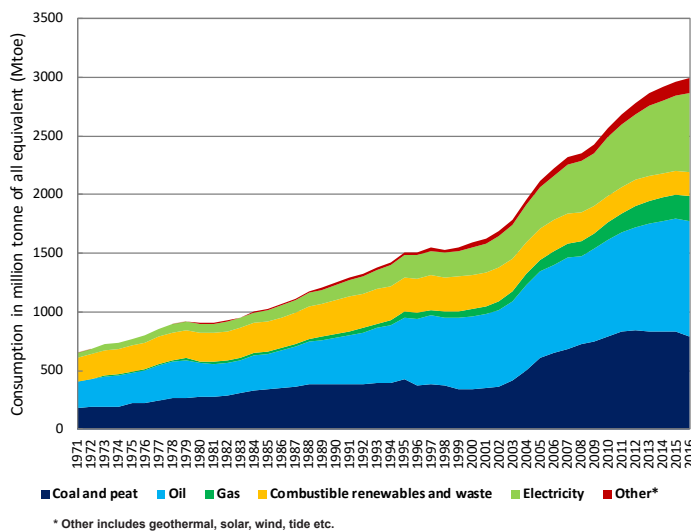
BACKGROUND

Air, water, land and biodiversity in ecosystems are essential for supporting human life on the planet Earth. But ironically though, the ability and capacity of these systems to support human existence have been imperiled by humans themselves through economic activities. There is evidence of unprecedented environmental changes at the global and regional levels, and these changes have major implications on human well-being locally.

Almost one-third of the world's population lives in the East Asian region. Due to rapid economic growth and industrialization, many countries in this region are facing a serious threat from acid deposition including particulate matter (PM) and ozone, particularly if their energy production depends on sulfur-rich coal. Regional cooperation for measures to prevent this issue is urgently needed.



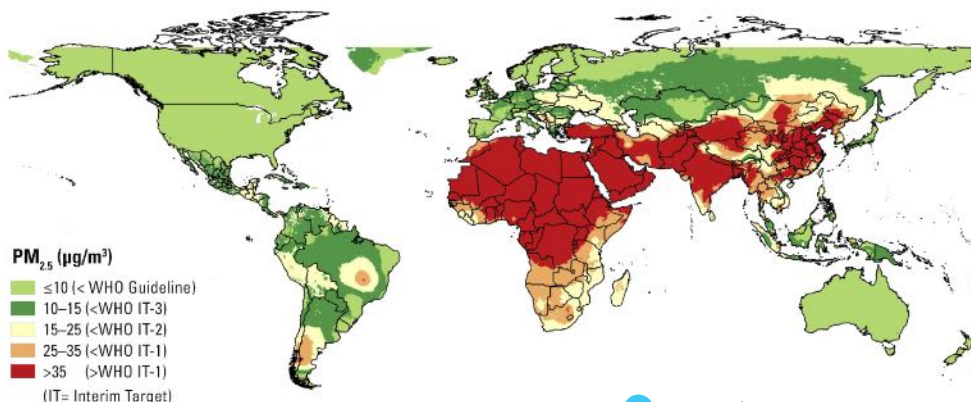
● Air Pollution in East Asia



The Figure of total energy consumption by fuel in East Asia shows increasing trends of energy consumption in East Asia based on the type of fuel. The increasing trend of energy consumption in East Asia is likely to cause more serious issues on acid deposition including particulate matter (PM) and ozone in the future. The situation is serious in that unless the fossil-based fuel consumptions and their environmental aftermath are curtailed, the damage they cause to human health and the environment will continue and become more serious in the decades to come.

● Total energy consumption by fuel in East Asia Source: International Energy Agency (IEA), World Energy Balances, 2018 edition

Comparison of 2017 annual average PM_{2.5} concentrations to the WHO Air Quality Guideline (2005) in the State of Global Air 2019 by Health Effects Institute (HEI) and Institute for Health Metrics and Evaluation's (IHME's) Global Burden of Disease Project is shown in Figure. In 2017, 92% of the world's population lived in areas that exceeded the WHO Guideline for PM_{2.5} (10 µg/m³), 54% lived in areas exceeding Interim Target (IT) 1 (IT-1, 35 µg/m³), 67% lived in areas exceeding IT-2 (25 µg/m³), and 82% lived in areas exceeding IT-3 (15 µg/m³). In this regard, in order to improve such poor air quality, it is required to implement various measures that can positively impact on human health and ecosystems, as well as contribute to achieving the Sustainable Development Goals (SDGs).



● Annual average PM_{2.5} concentration in 2017 relative to the WHO Air Quality Guideline.

Source: HEI/IHME State of Global Air / 2019 <https://www.stateofglobalair.org/report>

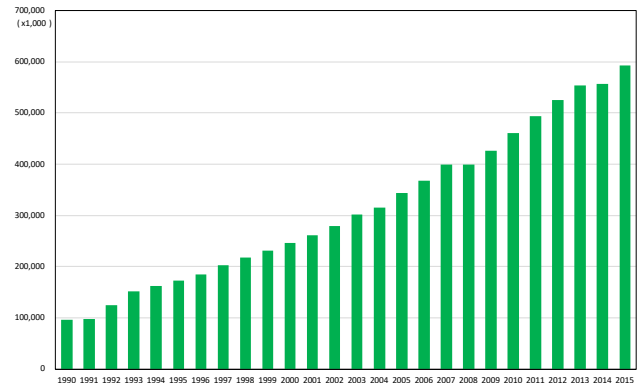
AIR POLLUTION AND ACID DEPOSITION



Decline of forests

the photochemical reaction of NO_x and VOCs under sunlight in the troposphere causes harmful effects on humans and the ecosystem as a strong oxidizing substance. Since the emission of NO_x in East Asia is rapidly increasing due to the rapid rise in the use of automobiles, concentrations of tropospheric ozone are predicted to increase in the future. The figure on the right shows an increasing trend in the number of vehicles in East Asia.

Major air pollutants, those gases or particles emitted from sources directly, which are prevalent in East Asia are sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), volatile organic compounds (VOCs), carbon monoxide (CO), and toxic elements (e.g., lead (Pb), fluorine (F), mercury (Hg)). These pollutants are emitted from automobiles and industries. Secondary pollutants, those gases or particles formed by atmospheric reactions of precursor or primary emissions are ozone (O_3), photochemical oxidants, and secondary aerosols which are also prevalent in East Asia. Ozone produced from

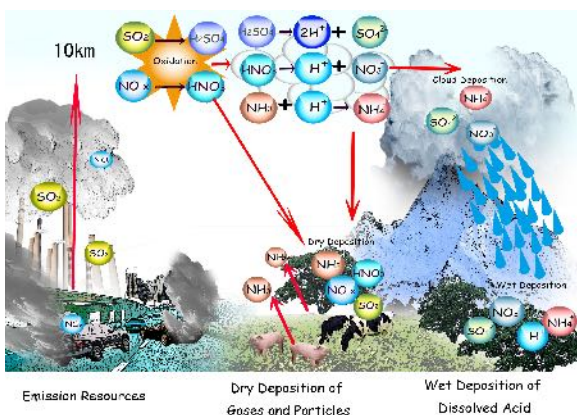


Trend of the number of vehicles in East Asia

Reference: World Development Indicators (WB),
World Road Statistics (IRF), UN Statistical Division

Mechanism of Acid Deposition

SO_2 and NO_x are emitted into atmosphere with other pollutants during the combustion of fossil fuels (oil, coal, etc.) by industries and power plants as well as in engines of motor vehicles. These gases are transformed by chemical reactions with air constituents into sulfuric and nitric acids which are transported and come down to the surface of the earth far from the emission sources. The acid deposition phenomena are realized in two types of processes as shown in the Figure below. One process is "wet deposition" when acids are taken by cloud water and brought down to land and water bodies with rain, snow or fog, which is called rainout, and acids are scavenged by descending raindrops and snowflakes which is called washout. A large amount of dissolved acids cause the strong acidity of precipitation commonly known as "acid rain".



Mechanism of acid deposition

By another process called "dry deposition", airborne acids are removed from the air during fine and cloudy days. They pass through the air to the ground and deposit on water bodies, grasses, trees, buildings, and even inhaled into the human respiratory system causing health problems.

Although ammonia (NH_3), emitted from fertilizers and livestock, does not fall under the criteria as an air pollutant affecting human health, it reacts with nitric and sulfuric acids in the atmosphere to form fine particulate matter through the process of neutralization. After deposition on the ground, ammonium compounds are oxidized into nitrate in soil and produce acid. Moreover, excess nitrogen loads by nitrate and ammonium disturb the nutrient cycles of ecosystems.

ACID DEPOSITION MONITORING NETWORK IN EAST ASIA (EANET)

The Acid Deposition Monitoring Network in East Asia (EANET) is an intergovernmental regional network established for promoting cooperation among countries in East Asia to address acid deposition problems.

Objectives of EANET

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

Thirteen Participating Countries of EANET



Major Activities of EANET

EANET addresses the deposition of major acidifying species and related chemical substances such as SO_4^{2-} , NO_3^- , H^+ , SO_2 , NO_2 , ozone and particulate matter (PM) issues in an integrated approach for implementing the following major activities:

1. Acid deposition monitoring

- Review and revision/establishment where appropriate of the national monitoring plans*
- Implementation of monitoring using common methodologies*
Wet deposition, dry deposition, soil/vegetation, inland aquatic environment and catchment

2. Compilation, evaluation, storage, analysis and provision of data

- Submission of monitoring data to the Network Center*
- Issuing of Data Report
- Periodic report on the state of acid deposition
- Dissemination of the data and relevant information through EANET website

3. Promotion of quality assurance and quality control (QA/QC) activities

- Implementation of QA/QC programs
- Development of Standard Operating Procedures (SOPs)*
- Inter-laboratory comparison projects

4. Implementation of technical support and capacity building activities

- Dispatch of technical missions
- Individual training at the NC
- National training*
- Utilization of existing training programs and others

5. Promotion of research and studies related to acid deposition and air pollution problems

- Joint studies on wet/dry deposition, catchment analysis, etc.
- EANET fellowship research

6. Promotion of public awareness activities

- Development of public awareness materials and implementation of environmental studies
- Workshop on public awareness

7. Other relevant activities

- Cooperation and exchange of information and experiences with other regional and global networks/initiatives

* by participating countries



● EANET Data Report



● Public awareness activities at the Network Center



● EANET Training at the Network Center



● Network Center technical mission

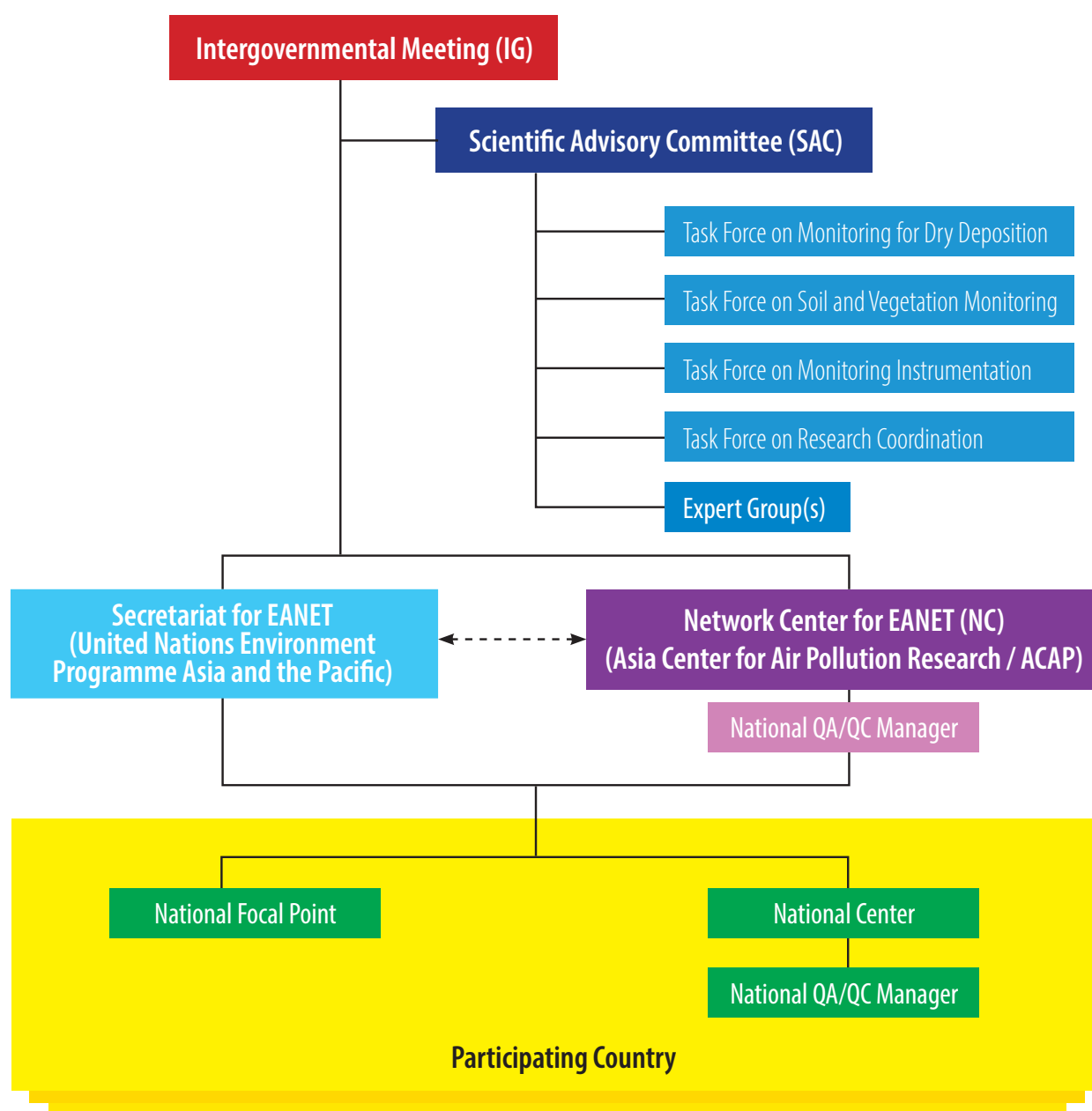
Institutional Framework of EANET

As the institutional framework for EANET, the Intergovernmental Meeting (IG) is the decision-making body of EANET. The Scientific Advisory Committee (SAC) was established under the IG, and the Secretariat and the Network Center were designated to support the network. Several Task Forces and Expert Groups were established under the SAC. These organizations promote the network activities in close communication, coordination and collaboration with the National Focal Points (NFPs), National Centers and National Quality Assurance and Quality Control (QA/QC) Managers in the participating countries.



21st Session of the Intergovernmental Meeting (IG21) in 2019, Beijing, China

Organizational Structure



Roles of Respective Organizations of EANET

Intergovernmental Meeting

- Composed of the representatives of all participating countries and make decisions on the implementation of the network activities.

Scientific Advisory Committee

- Composed of scientific and technical experts nominated by the participating countries and advise and assist the IG on scientific and technical issues of the network; and
- Prepare periodic assessment reports on the state of acid deposition in East Asia.

Secretariat

- Communicate and cooperate with the participating countries;
- Prepare for EANET meetings such as Intergovernmental Meeting (IG), Scientific Advisory Committee (SAC);
- Conduct necessary administrative and financial management for the network; and
- Promote capacity building and public awareness activities in cooperation with the Network Center.

Network Center

- Compile, evaluate, analyze and store EANET monitoring data and related information;
- Disseminate monitoring data and related information;
- Prepare data reports on acid deposition in East Asia;
- Provide technical assistance to the participating countries;
- Implement and coordinate QA/QC activities in the participating countries;
- Promote research activities of EANET; and
- Promote capacity building and public awareness activities in cooperation with the Secretariat.

Participating Countries

National Focal Points

- Communicate and coordinate with the Secretariat and the Network Center for implementation of the network activities.

National Centers

- Collect the national monitoring data and submit to the Network Center;
- Promote national QA/QC activities; and
- Deal with technical matters on the network activities in the countries.

National QA/QC Managers

- Promote national QA/QC activities in cooperation and coordination with the National Centers.



● Scientific Advisory Committee



● Support to participating countries (Senior Technical Managers' Meeting)



● QA/QC activities at a participating country

Monitoring Activities of EANET

EANET monitoring covers five environmental media, wet deposition, dry deposition, soil/vegetation, inland aquatic environment and catchment. The monitoring activities have been conducted following a set of monitoring guidelines and technical manuals. Monitoring for wet and dry deposition is implemented in order to measure concentrations and fluxes of acidic and other substances deposited to the ground, while monitoring soil/vegetation, inland aquatic environment and catchment are being implemented to assess adverse impacts on terrestrial and aquatic ecosystems.



Monitoring interval and parameters

- Wet deposition/rainwater** (every 24 hours or every precipitation event)
 - pH, electric conductivity (EC), concentrations of sulfate (SO_4^{2-}), nitrate (NO_3^-), ammonium (NH_4^+), etc.
- Dry deposition/air concentration** (every day to 2 weeks or every hour when measured by automatic instruments)
 - Sulfur dioxide (SO_2), nitrogen oxides (NO , NO_2), ozone (O_3), nitric acid (HNO_3), hydrogen chloride (HCl), ammonia (NH_3), particulate matter ($\text{PM}_{2.5}$, PM_{10}) and particulate components (SO_4^{2-} , NO_3^- , etc.), etc.
- Soil and vegetation/forest areas** (every 3 to 5 years)
 - pH, concentrations of exchangeable base cations (Na^+ , K^+ , Ca^{2+} , Mg^{2+}), exchangeable acidity (H^+ , Al^{3+}), effective cation exchange capacity (ECEC), etc. for soil, and condition of tree decline and general description for forests (description of trees, understory vegetation survey)
- Inland aquatic environments/lake and river water** (4 times a year for lakes and more than 6 times a year for rivers)
 - pH, electric conductivity (EC), alkalinity, and cations such as ammonium (NH_4^+), and anions such as nitrate (NO_3^-)
- Catchment** (continuously (precipitation and discharge), every week to 2 weeks (chemical components))
 - Precipitation amount, discharge from the stream, major cations (Ca^{2+} , NH_4^+ , etc.) and anions (SO_4^{2-} , NO_3^- , etc.) in the rainwater and stream water, estimation of total deposition (wet + dry), etc.

Monitoring Sites

1. Deposition monitoring sites

1. Wet deposition: 61 sites
2. Dry deposition: 54 sites

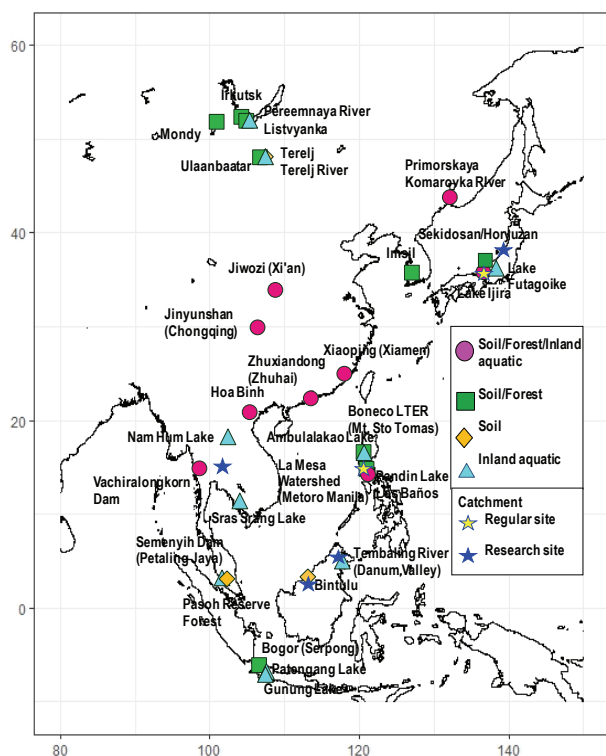


● NC Technical Mission



2. Ecological impacts monitoring sites

1. Soil and vegetation monitoring: 20 areas
2. Inland aquatic environment: 19 lakes/ivers
3. Catchment: 2 sites



● ★ Ijira (Japan)



■ Bogdkhan Mt. (Mongolia)



● Primorskaya (Russia)



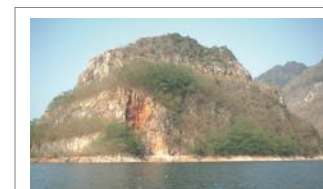
● Xiamen (China)



◆ ▲ Pasoh (Malaysia)



■ Boneco LTER. (Philippines)



● Vachiralongkorn (Thailand)

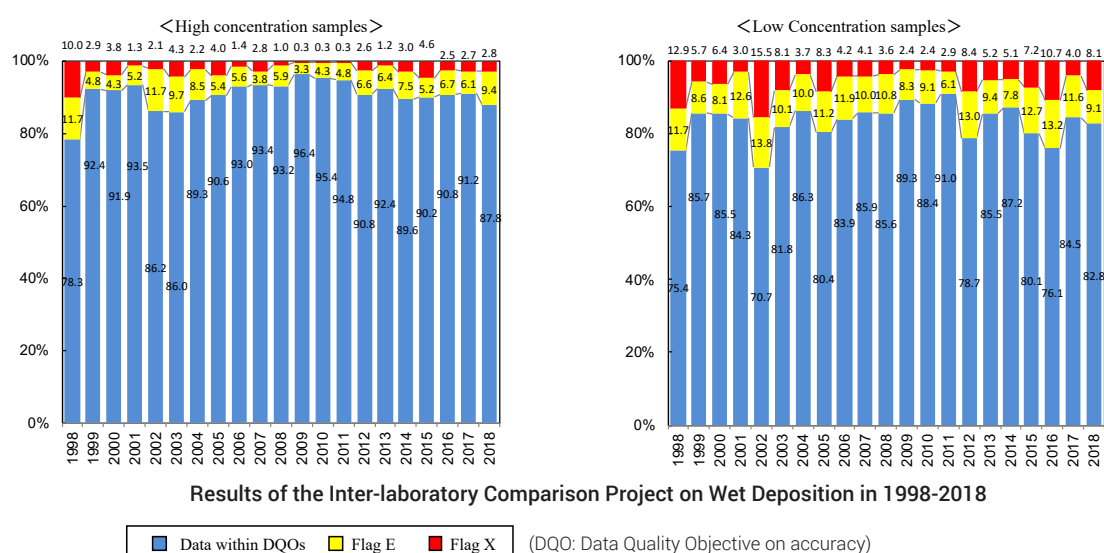
Major Achievement of EANET

Network Development

Monitoring sites of EANET are classified as either acid deposition monitoring sites or ecological survey sites. The number of sites of the network has increased from 42 acid deposition monitoring sites in 2001 (the start of the regular EANET monitoring activities) to 61 sites (22 urban, 18 rural, and 21 remote sites) in 2019. As a result of the coordinated efforts of EANET participating countries, monitoring of soil and vegetation is now being conducted in 20 areas, and monitoring of inland aquatic environments and catchment is being done in 13 lakes/6 rivers and 2 sites respectively. Monitoring sites are shown in the Figures in page 8.

Development of High-Quality Datasets

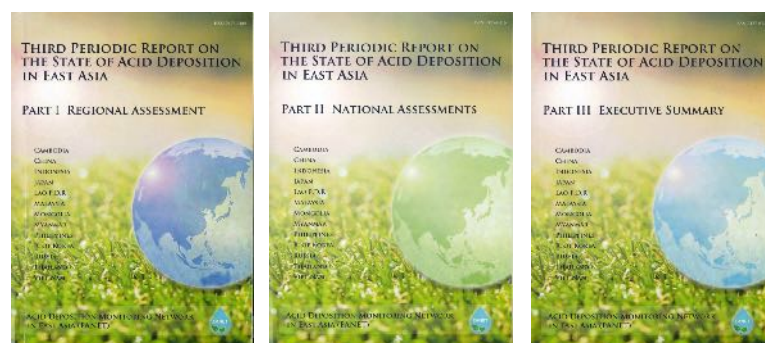
High-quality datasets have been developed through the implementation of quality assurance and quality control measures at the national levels and in the Inter-laboratory Comparison Project schemes. Since 2000, summaries of annual monitoring results have been published regularly in the Data Report on Acid Deposition in the East Asian Region. All monitoring data of the participating countries of EANET from 2000 are available to the public through EANET website (<https://www.eanet.asia>).



Periodic Report on the State of Acid Deposition in East Asia (PRSD)

Periodic Reports on the State of Acid Deposition in East Asia (PRSD) were published by EANET in 2006, 2011 and 2016 respectively as a comprehensive scientific assessment report describing the outcome of EANET's monitoring activities.

The Third Periodic Report on the State of Acid Deposition in East Asia (PRSD3), which is the latest one, consists of three parts: Part I: Regional Assessment, Part II: National Assessment, and Part III: Executive Summary. This report is based on the monitoring data from 2010 to 2014 and includes the future directions and possible impacts of air pollution on the atmospheric environment and ecosystems, particularly soil, vegetation, and the inland aquatic environment.



Periodic Report on the State of Acid Deposition in East Asia (PRSD)

Capacity Building in Participating Countries

The technical capabilities and skills of the participating countries for acid deposition monitoring and assessment were significantly enhanced through a number of EANET activities, including EANET individual training, the technical missions of the Network Center to the participating countries for monitoring, laboratory operations, data management, etc. Other activities to enhance the skills and knowledge of personnel include national workshops, annual expert meetings and other topics related to acid deposition. Numerous EANET publications (technical manuals and guidelines, data publications, reports on QA/QC projects, training materials, etc.) have been produced for use by specialists and researchers involved in monitoring, data quality, and data management. Most are available on EANET website (<https://www.eanet.asia/resources/publications/>).



● EANET training at the Network Center

Raising Public Awareness

Awareness about acid deposition among the general public, particularly among school children and teachers, was raised through a number of activities supported by EANET. Four reports for policy makers were published entitled "Goals, Achievements and Way Forward", "Clean Air for Sustainable Future", "EANET and Clean Air for Sustainable Development", "Towards Clean Air for Sustainable Future in East Asia through Collaborative Activities". EANET has undertaken joint projects with participating countries to develop brochures and videotapes on acid deposition in the national language, and several times has held "Workshop on Public Awareness on Acid Deposition Problems" in the participating countries. An e-learning program on acid deposition problems was developed for environmental education. The capacity building workshops for policy makers of EANET were held to raise awareness of policy makers of participating countries on the adverse impacts on the environment caused by acid deposition. The Factsheets titled "Country efforts and achievements in combating acid deposition" was developed by all participating countries of EANET through collaboration and coordination with the NC and the Secretariat.



● Guideline, Technical Manuals and Training materials



● Reports for Policy Makers

Enhancing Knowledge and Understanding through Research

A number of joint scientific research projects on acid deposition and its effects were conducted by EANET countries. Joint projects with the Network Center include:

- Joint study with Japan, Malaysia and Thailand on catchment analysis
- Joint study with Mongolia on plant sensitivity
- Joint study with Thailand on dry deposition flux
- Joint Study with China, Japan, Thailand and Russia on low cost monitoring methodologies
- Joint study with Russia on evaluation of East Siberian atmospheric environment
- Model Inter-comparison Study in Asia (a multilateral research activity)



Joint catchment analysis in Thailand

Research fellowship program



Fellowship researcher

The annual research fellowship program of the Network Center has been implemented since 2005. Young researchers from the participating countries of EANET are invited every year for approximately two months at the Asia Center for Air Pollution Research (ACAP) in Niigata, Japan to carry out the fellowship research related to the objectives of EANET and develop their research papers.

EANET Science Bulletin

In order to promote EANET research activities and share their findings among the participating countries, EANET Science Bulletin has been published every three years and issued on EANET website since 2008.



EANET Science Bulletin

EANET Newsletter

EANET Newsletter has been published biannually since July 2007 so as to share all of the information on EANET activities and other relevant information.

History of EANET

1. Expert meetings (1993-1997)

The East Asian region, as a result of rapid industrialization, faced increasing risks of problems related to excess deposition of acidic substances. The World Bank estimated in 1995 that by 2020 if present energy and environmental policies remain unchanged, sulfur dioxide emissions in this region would almost triple the 1990 level. Thus the adverse effects of acid deposition in East Asia would become a critical problem in the near future. With this background, expert meetings were held four times since 1993 to discuss the state of acid deposition in the region, effects on ecosystems and future moves toward regional cooperation on this issue. The experts recommended that acid deposition monitoring should be improved and strengthened.

It was difficult to evaluate the state of acid deposition in East Asia utilizing available monitoring data because monitoring methods and analytical techniques differed greatly among countries in the region. Thus, the expert meetings agreed on the necessity of establishing a regional collaborative monitoring network. For this purpose, the expert meetings developed a preliminary outline for the design of such a network as well as proposed guidelines for monitoring methods.

2. Preparatory Phase activities (1998-2000)

The First Session of the Intergovernmental Meeting on the Acid Deposition Monitoring Network in East Asia (IG1) was held in March 1998 in Yokohama, Japan. Based on the agreement at IG1, the preparatory phase activities of EANET started in April 1998 on an interim basis to provide useful inputs to the Second Session of the Intergovernmental Meeting (IG2) held in 2000 for the formal establishment of the Network.

Participating countries during the preparatory phase

China, Indonesia, Japan, Malaysia, Mongolia, Philippines, Republic of Korea, Russia, Thailand and Viet Nam (10 countries)

3. Regular Phase activities (from 2001)

The Second Session of the Intergovernmental Meeting of EANET (IG2) was held on 25 and 26 October 2000 in Niigata, Japan with the participation from ten countries in East Asia that had participated in the preparatory phase activities. The major conclusions of the Session are summarized as follows:



● IG2 in 2000, Niigata, Japan

Major Conclusions of IG2

1. The Meeting concluded that the preparatory phase activities of EANET had been successful.
2. The Meeting decided to start the EANET activities from January 2001 on a regular basis, based on the "Joint Announcement on the Implementation of EANET" and the "Tentative Design of EANET".
3. The Meeting designated the United Nations Environment Programme (UNEP) as the Secretariat for EANET.
4. The Meeting designated the Acid Deposition and Oxidant Research Center (ADORC, present Asia Center for Air Pollution Research (ACAP)) in Japan as the Network Center for EANET.

In accordance with the "Rules of Procedure for the EANET" adopted at the Third Session of the Intergovernmental Meeting (IG3) held in 2001, the Sessions of the Intergovernmental Meeting have been taken place annually since then.

Progress of EANET

1. Adoption of the “Instrument for Strengthening the EANET”

The Seventh Session of the Intergovernmental Meeting (IG7) held in 2005 adopted the Decision 1/IG7 (Niigata Decision) which decides that the participating countries of EANET should begin a process to discuss an appropriate Instrument and its legal status to provide a sound basis for financial contribution to EANET and will report the results of the discussion to the Tenth Session of the Intergovernmental Meeting (IG10) for its consideration.

The Twelfth Session of the Intergovernmental Meeting on EANET (IG12) held in November 2010 in Niigata, Japan adopted the Decision 1/IG12 on “Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)”. The following were stipulated in the Decision:

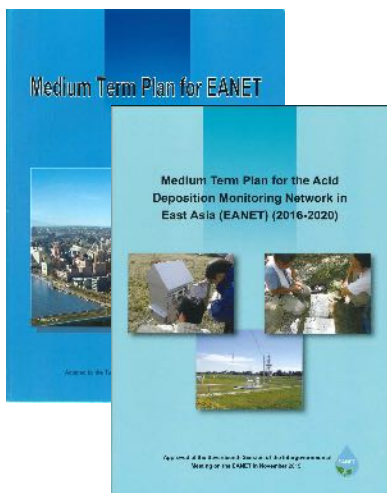
1. Adopts the **“Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)”** for signing in the High Level Segment during IG12 and thereafter;
2. Decides that the Instrument will become operational on the date on which all participating countries have signed it, or on 1st January 2012, whichever is earlier;
3. Encourages participating countries that will not be able to sign the Instrument by the specified date to communicate in writing with EANET Secretariat before IG13 expressing their willingness to continue their EANET activities.



● Representatives of 13 participating countries at IG12 in Niigata, Japan in 2010

1. The objectives and scope of this Instrument stated in the [Item 2] are:
 - a) to create a common understanding of the state of acid deposition problems in East Asia;
 - b) 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; and
 - c) to contribute to cooperation on the issues related to acid deposition among the Participating Countries.
2. The scope of this Instrument may be extended, as decided by the IG.

2. “Strategy on EANET Development” and “Medium Term Plan for EANET”



● Medium Term Plan for the EANET

The Strategy on EANET Development (2006-2010) which was approved by the Eighth Session of the Intergovernmental Meeting (IG8) in November 2006, focused on the whole activities of EANET with clearly stated targets, activities to be undertaken and expected results. The implementation of the Strategy activities since 2006, and the regular activities of the Secretariat and the NC since the start of EANET, has brought EANET closer towards achieving its objectives.

Based on the performance review of the Strategy on EANET Development (2006-2010), the “Medium Term Plan for EANET (MTP) (2011-2015)” was adopted at the IG12 in 2010. Twenty-two activities covering all EANET activities are identified for implementation in the 5-year period, 2011-2015 by the Secretariat, the Network Center, the Scientific Advisory Committee and other relevant bodies of EANET under seven categories. The MTP for the EANET (2016-2020) is the third medium term plan for

the EANET by considering the results of the review of the activities of the Medium Term Plan (2011-2015) and the outcomes of the Feasibility Study on the Expansion of the Scope of the EANET conducted by the Network Center (NC) for EANET. The MTP focuses on the enhancement of the monitoring network, supported by the participating countries, through the implementation of strategic activities to improve geographical coverage, ensure site representativeness, and strengthen monitoring procedures, particularly sampling and analysis, to achieve more comprehensive and precise data. It also includes capacity building activities, activities for the promotion of research on acid deposition and other priority chemical species, including activities relevant to the modeling and emission inventories, public awareness activities and activities for the future development of EANET.

National Focal Points (NFPs) and National Centers of EANET

Participating countries	National Focal Points (Organizations)	National Centers
Cambodia	General Directorate of Environmental Protection, Ministry of Environment (MOE)	Department of Air Quality and Noise Management, General Directorate of Environmental Protection, Ministry of Environment (MOE)
China	Department of International Cooperation, Ministry of Ecology and Environment (MEE)	China National Environmental Monitoring Center (CNEMC)
Indonesia	Air Pollution Control, Ministry of Environment and Forestry (MEF)	Center of Environmental Impact Control Facility (SEICF), Ministry of Environment and Forestry (MEF)
Japan	Air Environment Division, Environmental Management Bureau, Ministry of the Environment (MOE)	Asia Center for Air Pollution Research (ACAP)
Lao PDR	Natural Resources and Environment Research Institute, Ministry of Natural Resources and Environment (MONRE)	Environment Quality Monitoring Center (EQMC), Natural Resources and Environment Institute, Ministry of Natural Resources and Environment (MONRE)
Malaysia	Environmental Management and Climate Change Division, Ministry of Energy, Science, Technology, Environment and Climate Change	Atmospheric Science and Cloud Seeding Division, Malaysian Meteorological Department (MMD)
Mongolia	National Agency for Meteorology and Environmental Monitoring (NAMEM), Ministry of Environment and Tourism (MET)	Central Laboratory of Environment and Metrology (CLEM), National Agency for Meteorology and Environmental Monitoring (NAMEM), Ministry of Environment and Tourism (MET)
Myanmar	Department of Meteorology and Hydrology (DMH), Ministry of Transport and Communications	Hydrology Division, Department of Meteorology and Hydrology (DMH), Ministry of Transport and Communications
Philippines	Environmental Management Bureau (EMB), Department of Environmental and Natural Resources (DENR)	Air Quality Management Section, Environmental Quality Division, Environmental Management Bureau (EMB), Department of Environment and Natural Resources (DENR)
R. of Korea	Air Quality Policy Division, Ministry of Environment (MOE)	Air Quality Research Division, Climate and Air Quality Research Department, National Institute of Environmental Research (NIER)
Russia	Environmental Pollution Monitoring Department, Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)	- Yu. A. Izrael Institute of Global Climate and Ecology (IGCE), Roshydromet - Limnological Institute (LIN), Siberian Branch, Russian Academy of Sciences (SB/RAS)
Thailand	Air Quality and Noise Management Division, Pollution Control Department (PCD), Ministry of Natural Resources and Environment (MNRE)	Transboundary Air Pollution Section, Air Quality and Noise Management Division, Pollution Control Department (PCD), Ministry of Natural Resources and Environment (MNRE)
Viet Nam	Institute of Meteorology, Hydrology and Climate Change, Ministry of Natural Resources and Environment (MONRE)	Center for Environmental Research, Institute of Meteorology, Hydrology and Climate Change, Ministry of Natural Resources and Environment (MONRE)



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