The Ninth Session of the Scientific Advisory Committee
on Acid Deposition Monitoring Network in East Asia
14-16 October 2009, Tsukuba, Japan

Progress report on the activities of the Task Force on Soil and Vegetation Monitoring

Chair of the Task Force

I. Introduction

1. The *Strategy Paper on Soil, Vegetation, and related Ecosystems Monitoring of EANET (2009-2014)*, which was updated by the Task Force on Soil and Vegetation Monitoring, was adopted by the Scientific Advisory Committee (SAC) at its eighth session (SAC8) in 2008. The *Strategy Paper* clarified issues to be implemented for the objectives in the monitoring and proposed work plans for coming years.

2. Detailed implementation plan for the work plans, including procedures and schedules, should be clarified to achieve the targets effectively. Members of the Task Force should lead the activities for making the implementation plans with the support of the Network Center (NC). A role of the respective members was assigned clearly for their strong commitments as shown in Table 1.

3. The second meeting of the Task Force, which was held in Niigata from 15 to 16 July 2009, reviewed progress of the respective activities and discussed further actions. The minutes of the second meeting is attached as an annex **(EANET/SAC 9/8/1 Annex 1).**

II. Continuous efforts for the general works

4. As continuous efforts for establishment of baseline data described in the *Strategy Paper*, implantation plans of the following activities were discussed:
   1) Promotion of continuous monitoring
   2) <u>Improvement of monitoring system</u>
   3) <u>Compilation of the list of experts on ecological impacts in the respective countries</u>
   4) Promotion of capacity building activities

5. It was pointed out **close communication with the national center** and **involvement of experts** in the relevant study fields were important for continuous monitoring on soil and vegetation.

6. Moreover, in particular for the works 2) and 3) above, the following practical suggestions were made:
   2) Improvement of the monitoring system
   The current situation and distribution of the sites for soil, vegetation and related ecosystems were reviewed by the Task Force members. For increasing the number of the monitoring sites, the following suggestions were made:
   - The experts including the Task Force members are urged to discuss with relevant national agencies.
   - In particular, it seemed that blank space could be seen in the northeast of the continent and equatorial Southeast Asia.

   3) Compilation of the list of experts on ecological impacts in the respective countries
   List of the EANET experts on soil, vegetation and related ecosystems was compiled based on the former list of the Network of the Specialist on Soil and Vegetation Monitoring and reviewed by the Task Force members. For updating the list of experts in the countries, it was suggested that the following experts should be considered for listing:
   - The experts who are involved in the EANET-relevant monitoring activities
   - The experts who are willing to contribute to the EANET activities in future

7. It was concluded that practical actions should be made by the respective Task Force members in their countries at the first.

III. Progress of the specific works

8. The *Strategy Paper* proposed the following activities as specific work plans:
   5) Development of the guidelines and methods for the catchment monitoring
   6) Identification of the areas susceptible to acid deposition
   7) Trial campaign for measurement of ozone concentration in forest area and its effects
   8) Promotion of catchment analysis and simulation modeling on soil and inland water

9. Implementation plan of the respective works were reviewed at the second meeting. The current progress of the respective works were as follows:
   5) Development of the guidelines and methods for the catchment monitoring
   The preliminary draft of the guideline for the catchment monitoring was prepared by the activity leader (Dr. Jesada) and cooperative members based on experience on the catchment-scale analysis in the EANET countries. The preliminary draft was reviewed by the Task Force members, especially for elaboration of its style and major contents.

The draft guideline (EANET/SAC 9/8/1 Annex 2) is herein presented for consideration of SAC as the output of this work. It is expected that the final draft will be prepared for adoption by SAC at its 10th Session (SAC10).

6) Identification of the areas susceptible to acid deposition
According to the implementation plan, literature studies will be carried out by the Task Force members utilizing soil maps, geological maps, and vegetation maps in the East Asian region. The sensitivity level of soil, rock, and tree species for acid deposition will be identified. The distribution of sensitive soils, acidic rocks, and sensitive tree species will be visualized on the regional map. **It was suggested that availability of relevant maps and information on soil, vegetation, geology, land-use, etc. should be checked by the Task Force members for their countries as the first step.** Moreover, it was suggested that efforts should be made by the national centers **to analyze total N and C for soil analysis, at least once for each plot**, in order to check the current situation.

7) Trial campaign for measurement of ozone concentration in forest area and its effects
For implementation of this work, additional research grants are essential. The Task Force and NC are making efforts to obtain competitive research grants for the campaign to purchase passive samplers and to hold necessary meetings. **Dr. Sase and Dr. Carandang have applied to the private foundation for the research grant** in cooperation with other cooperative members and Dr. Hajime Akimoto, DG of ADORC. In the applied plan, **the campaign would be implemented from 2010 to 2011**, because of the availability of the budget. Efforts should be made continuously even if the application above is rejected. Moreover, **the Task Force members were requested to check the information on research grants in the respective countries.**

8) Promotion of catchment analysis and simulation modeling on soil and inland water
This work has been promoted as the joint research projects in Japan, Thailand and Malaysia, by using the research grants. **The current research grants will be finished in the end of March 2011.** It was pointed out that efforts should be made to obtain the research grants continuously.

IV. Other works

10. As voluntary contribution of the Task Force to the next periodic report, the following work was also planned in the *Strategy Paper:*

9) Evaluation of ecological monitoring data for the next periodic report

Preliminary data analysis has been started by the activity leader (Dr. Ocampo). It was pointed out that EANET monitoring data were not enough for com prehensive data analysis. For more detailed data analysis, measurement of additional parameters such as heavy metals (e.g. Ex-Mn) may be necessary.

11. Observation of tree declin e is expected to be done every year , according to the Sub-Manual on Forest Vegetation Monitoring (2006). It was suggested that the Task Force members should communicate with their national centers on this matter if necessary.

V. Further development of the Task Force

12. It was suggested that the m embers should be informed of the activities of other T ask Forces. The Chair should communicate with other TFs if necessary.

13. It was suggested that **additional members should be included in the Task Force,** since the Task Force should cover issues on m ostly whole ter restrial ecosystems including rivers/streams in forest catchments. It may be possible that **one or two experts on inland aquatic environment** will be involved.

14. It was suggested that the next m eeting would be held in the sam e season or possibly later (no later than one month before SAC10). Other countries may be considered as the venue.

15. Table 1. Leaders and cooperative members for the specific activities

Activities	Leader	Cooperative members
Promotion of continuous monitoring	-	All
Improvement of monitoring system	-	All
Compilation of the list of experts on ecological impacts in the respective countries	-	All
Promotion of capacity building activities	-	All
Development of t he guidelines and methods for the catchment monitoring	Dr. Jesada	Dr. Takahashi, Dr. Sase, Dr. Carandang
Identification of the areas susceptible to acid deposition	Dr. Takahashi	Dr. Liu, Ms. Noh, Dr. Ocampo, Dr. Mikhailova,
Trial campaign for measurement of ozone concentration in forest area and its effects	Dr. Carandang	Dr. Mikhailova, Prof. Nik, Dr. Jesada, Dr. Sase
Promotion of catchment analysis and simulation modeling on soil and inland water	Dr. Sase	Dr. Takahashi, Dr. Jesada
Evaluation of the ec ological monitoring data for t he next periodic report on the state of acid deposition	Dr. Ocampo	All

ACID DEPOSITION MONITORING NETWORK IN EAST ASIA (EANET)

SECOND MEETING OF THE
TASK FORCE ON SOIL AND VEGETATION MONITORING
SCIENTIFIC ADVISORY COMMITTEE (SAC) OF EANET

(Niigata, 15-16 July 2009)

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PROVISIONAL AGENDA

July 15

09:00-09:15

1. Welcome remarks — Dr. Akimoto

09:15-09:30

2. Introductory remarks by the Chair — Chair

09:30-10:30

3. Report of progress since the first meeting of the Task Force including SAC8 and IG10 decisions relevant to the Task Force — NC and Chair

10:30-11:00 Coffee Break

11:00-11:30

4. Review of Activity 1: Promotion of continuous ecological monitoring in participating countries — NC

11:30-12:00

5. Review of Activity 2: Improvement of monitoring system — NC

12:00-14:00 Lunch

14:00-14:30

6. Review of Activity 3: Compilation of list of experts on ecological impacts in the respective countries — NC

14:30-15:00

7. Review of Activity 4: Promotion of capacity building activities — NC

15:00-15:30

8. Review of Activity 5: Development of the guideline for catchment monitoring — Dr. Jesada

15:30-16:00 Coffee Break

16:00-16:30

9. Review of Activity 6: Step-by-step identification of areas susceptible to acid deposition — Dr. Takahashi

16:30-17:00

10. Review of Activity 7: Trial campaign for measurement of ozone concentration in forest area and its effect — Dr. Carandang

17:00-17:30
11. Review of Activity 8: Promotion of catchment analysis and simulation modeling on soil and inland water — Dr. Sase

17:30-18:00
12. Review of Activity 9: Evaluation of ecological monitoring data for the next periodic report — Dr. Ocampo

18:00 Departure for the hotel

<u>July 16</u>
09:00-10:00
13. Presentation on research activities related to effects on soil and catchment analysis — Members

10:00-10:30
14. Presentation on research activities related to direct effects on vegetation by air pollution — Members

10:30-11:00 Coffee Break

11:00-11:30
15. Presentation on research activities related to direct effects on vegetation by air pollution (continued)

11:30-12:00
16. Presentation of the draft Strategy on Future Development (2011-2015) — NC

12:00-14:00 Lunch

14:00-15:00
17. Discussion on future activities of the Task Force — Chair

15:00-15:30
18. Next steps and schedule — Chair
Closing of the meeting

16:00 Departure for the hotel/Niigata Station

MEETING MINUTES

I. Agenda

The Meeting followed the issues as listed in the Provisional Agenda.

II. Welcome Remarks

The Director General of ADORC welcomed the members of the Task Force on Soil and Vegetation Monitoring of the EANET Scientific Advisory Committee to ADORC, Niigata, Japan (see the attached List of Participants).

III. Report of progress since the first meeting of the Task Force including SAC8 and IG10 decisions relevant to the Task Force

The NC and Chair presented the report of progress since the first meeting of the Task Force including decisions relevant to the Task Force at the Eighth Session of SAC (SAC8) and the Tenth Session of the Intergovernmental Meeting (IG10).

It was reported that IG approved the new member list of the Task Force.

The new Task Force may cover wider field compared with the former one. It was suggested that the rename of the Task Force should be considered

Some members expressed that communication problems occurred sometimes with the relevant organizations/agencies including the National Focal Points within the countries. It was suggested that efforts should be made to have close communications with the relevant organizations/agencies and that the national meeting attended by the relevant organizations/agencies should be utilized for sharing the important information,

The monitoring network should be maintained for a certain period, especially for assessment of ecological impacts, while the policy makers may require some results periodically. It was pointed out that efforts should be made to disclose clear messages with scientific results to the policy makers. The Task Force may have the important role on this issue, since the Task Force was established under the SAC with approval of IG.

IV. Review of Activity 1: Promotion of continuous ecological monitoring in participating countries

The NC presented progress of the activity, “promotion of continuous ecological monitoring in participating countries”.

V. Review of Activity 2: Improvement of monitoring system

The NC presented progress of the activity, “improvement of monitoring system”.

In the two presentations above, it was pointed out that close communication with the national center and involvement of experts in the relevant study fields were important for continuous monitoring on soil and vegetation.

VI. Review of Activity 3: Compilation of list of experts on ecological impacts in the respective countries

The NC presented progress of the activity, “compilation of list of experts on ecological impacts in the respective countries”.

It was agreed that the list of the experts should be confirmed by the Task Force members for their countries at the first and then elaborated step by step adding the new names to be involved.

VII. Review of Activity 4: Promotion of capacity building activities

The NC presented progress of the activity, “promotion of capacity building activities”.

It was informed that Dr. Sase and Dr. Carandang had applied to the private foundation to obtain a research grant for the ozone campaign (activity 7) and the technical workshop could be held by using the grant. The technical workshop will be effective for capacity building of relevant experts.

VIII. Review of Activity 5: Development of the guideline for catchment monitoring

Dr. Jesada presented progress of the activity, "development of the guideline for catchment monitoring" and the catchment analysis principle. Additionally, Dr. Sase introduced the preliminary draft guideline as the cooperative member of this activity.

It was discussed that the draft guideline would be presented at the Ninth Session of SAC (SAC9) and elaborated furthermore taking the comments at SAC9.

IX. Review of Activity 6: Step-by-step identification of areas susceptible to acid deposition

Dr. Takahashi presented progress of the activity, "step-by-step identification of areas susceptible to acid deposition".

It was discussed that availability of relevant maps and information on soil, vegetation, geology, land-use, etc. should be checked by the Task Force members for their countries as the first step.

X. Review of Activity 7: Trial campaign for measurement of ozone concentration in forest area and its effect

Dr. Carandang presented progress of the activity, "trial campaign for measurement of ozone concentration in forest area and its effect".

It was informed that Dr. Sase and Dr. Carandang had applied to the private foundation to obtain a research grant for the ozone campaign. In the applied plan, the campaign would be implemented from 2010 to 2011, because of the availability of the budget.

It was also discussed that efforts would be made to obtain the research grants continuously, even if the ongoing proposal would be rejected.

XI. Review of Activity 8: Promotion of catchment analysis and simulation modeling on soil and inland water

Dr. Sase presented progress of the activity, "promotion of catchment analysis and simulation modeling on soil and inland water".

It was suggested that efforts should be made to obtain the research grants continuously.

XII. Review of Activity 9: Evaluation of ecological monitoring data for the next periodic report

Dr. Ocampo presented progress of the activity, "evaluation of ecological monitoring data for the next periodic report".

It was pointed out that EANET monitoring data were not enough for comprehensive data analysis. For more detailed data analysis, measurement of additional parameters such as heavy metals (e.g. Ex-Mn) may be necessary.

It was suggested that remote sensing images by air plane or satellite could be useful information for assessment of forest decline.

Some data on soil cannot be compared directly between Europe and East Asia because of difference in the analytical methods. It was pointed out that standardization or harmonization of the methodologies should be discussed for future interregional assessment.

<u>XIII. Presentations on research activities related to effects on soil and catchment analysis</u>

The following experts presented their research activities related to effects on soil and catchment analysis

Prof. Nik made a presentation on his project related to acid deposition monitoring at rehabilitated forest in Bintulu, Sarawak. It was informed that various studies on soil and vegetation were conducted there, although they have not published well.

Ms. Noh made a presentation on a study on the effect of soil acidification due to acid deposition in Korea. In her talk, changes in soil chemical properties and their possible causes were discussed in 4 sites of Korea.

Dr. Takahashi made a presentation on high accumulation of sulfur constituents in Japanese Andosols. It was suggested that the accumulated sulfur was derived possibly from volcano or atmospheric deposition.

Mr. Yamashita made a presentation on nitrogen flux in tropical seasonal forest in Thailand. It was informed that the observed data could be applied to the modeling and mapping of soil pH.

<u>XIV. Presentations on other research activities related to direct effects on vegetation by air pollution</u>

The following experts presented their research activities related to direct effects on vegetation by air pollution

Dr. Mikhailova made a presentation on phytomonitoring of atmospheric polluting agents in Baikal region. It was suggested that pine needles could be used as a bio-indicator of air pollutants, such as PAHs.

<u>XV. Presentation of the draft Strategy on Future Development (2011-2015)</u>

NC presented draft Strategy on Future Development (2011-2015). The major modifications are declining the numbers of activities and making the items more general.

<u>XVI. Discussion on future activities of the Task Force</u>

The Chair summarized discussions on the 2nd Meeting. The major works in coming two months and decisions can be summarized as follows:

<u>Works in coming two months</u>

Improvement of the monitoring system:

The current situation and distribution of the sites for soil, vegetation and related ecosystems were reviewed by the Task Force members. For increasing the number of the monitoring sites, the following suggestions were made:

- The experts including the Task Force members are urged to discuss with relevant national agencies.
- In particular, it seemed that blank space could be seen in the northeast of the continent and equatorial Southeast Asia.

Compilation of the list of experts on ecological impacts in the respective countries:
List of the EANET experts on soil, vegetation and related ecosystems was compiled based on the former list of the Network of the Specialist on Soil and Vegetation Monitoring and reviewed by the Task Force members. For updating the list of experts in the countries, it was suggested that the following experts should be considered for listing:

- The experts who are involved in the EANET-relevant monitoring activities
- The experts who are willing to contribute to the EANET activities in future

Identification of the areas susceptible to acid deposition:
It was suggested that availability of the relevant basic information for hot spots should be checked in the respective countries (with its available resolution and digital data) :
-Soil map
-Geological map
-Vegetation map
-Land-use map
-Any information related to ecosystems
Moreover, it was suggested that efforts should be made by the national centers on the following soil analysis at least once for each plot to know the current situation:
-Total N
-Total C

Trial campaign for measurement of ozone concentration in forest area and its effects :
The next application to grants should be prepared for ozone measurements and others
- the Task Force members were requested to check the information on research grants in the respective countries.

Observation of tree decline is expected to be done every year, according to the Sub-Manual on Forest Vegetation Monitoring (2006).
- It was suggested that the Task Force members should communicate with their national centers on this matter if necessary.

Decisions
Members of TF should be informed of the activities of other TFs. The Chair should communicate with other TFs if necessary.

It was suggested that additional members should be included in the Task Force, since the Task Force should cover issues on mostly whole terrestrial ecosystems including rivers/streams in forest catchments.
- It may be possible that one or two experts on inland aquatic environment will be involved.

XVII. Next Steps and Schedule

The Chair introduced next steps and possible schedule.

- It was suggested that the next meeting would be held in the same season or possibly later (no later than one month before SAC10). Other countries may be considered as the venue.

LIST OF PARTICIPANTS

1) Dr. Wilfredo M. Carandang
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2) Dr. Haijiang Liu
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3) Dr. Masamichi Takahashi
Forestry and Forest Product Research Institute
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4) Prof. Nik Muhamad Majid
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5) Dr. Apolonio M. Ocampo
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8) Dr. Jesada Luangjame
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9) Dr. Hiroyuki Sase
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Attachment 1

TASK FORCE ON SOIL AND VEGETATION MONITORING SCIENTIFIC ADVISORY COMMITTEE (SAC) OF EANET

List of Members

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Guideline for Catchment-scale Monitoring in East Asia

(Draft)

Task Force on Soil and Vegetation Monitoring

1. Introduction

Terrestrial ecosystems consist of many components, including atmosphere, plant, soil, and stream. So far, most monitoring activities on acid deposition have been promoted for each component independently, namely monitoring on wet deposition, dry deposition, soil and vegetation, and inland aquatic environment. This approach may be useful to accumulate baseline data for spatial and temporal trend analysis for each component. However, precise discussion on relationship between components may need more integrated approach for both qualitative and quantitative evaluation.

Therefore, integrated monitoring including atmospheric deposition, soil, vegetation, and inland water, is required to evaluate effects of acid deposition on ecosystems qualitatively and quantitatively. Catchment-scale analysis may be one of solutions for this requirement. The integrated approach taking biogeochemical processes into account should be promoted in a catchment scale.

The catchment-scale monitoring may allow more practical discussion on relationship between seasonal or annual changes in stream water chemistry (concentrations or material/elemental fluxes) and those in atmospheric deposition. Material/elemental input-output budget in the catchment can be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance. Moreover, based on the catchment-scale dataset, the simulation model on biogeochemical cycles is expected to be developed.

Strategy Paper on Future Direction of Soil and Vegetation Monitoring of EANET (EANET, 2002) suggested promoting case studies of the catchment-scale analysis to develop monitoring methodologies applicable to the East Asian region. The case studies have been implemented by NC and scientists in the EANET countries in the Sakaerat Silvicultural Research Station (SRS) site in Thailand, the Danum Valley site in Malaysia, and the Kajikawa study site in Japan. Moreover, the regular catchment-scale monitoring has just started in the Lake Ijira catchment, Japan, where acidification of the catchment area was suggested. Acidification mechanisms in the Lake Ijira catchment are being clarified gradually by the catchment-scale analysis.

Preparation of the monitoring guideline was proposed as one of the specific activities in the *Strategy Paper on Future Direction of Soil, Vegetation and related Ecosystems Monitoring of EANET (2009-2014)*, which was adopted by Scientific Advisory Committee (SAC) at its 8th Session in 2008. This *Guideline for the Catchment-scale Monitoring in East Asia* was developed based on experience through the case studies above in the East Asian region *and adopted by SAC at its 10th Session in 2010.* It is expected that additional case studies will start in some other countries or the current case studies will be continued as the catchment-scale monitoring on a regular basis according to the guideline.

2. Basic matters on the catchment-scale monitoring

2.1. Objectives

The catchment-scale monitoring should be implemented for the following final objective:

- To evaluate effects of atmospheric deposition on ecosystems qualitatively and quantitatively on a catchment scale.

  In detail, the following objectives can be proposed:

  - To interpret seasonal or annual changes in the stream water chemistry based on atmospheric deposition and possible biogeochemical processes in a catchment
  - To discuss impacts of atmospheric deposition based on the input-output budget of materials/elements on a catchment scale.
  - To provide necessary dataset to the catchment-scale simulation model for understanding the current status and making future projection of the

material/elemental cycles in the catchment due to the changing environment.

2.2. Selection of monitoring sites

Sites for the catchment-scale monitoring should be selected taking the following recommendations into account:

1) A forest catchment with a stream should be selected, while the size of the catchment may depend on each situation.
2) The catchment, where the water budget has been estimated, is preferable.
3) Sensitivity of soil or bedrock geology to acid deposition and/or atmospheric deposition amounts should be considered for site selection.
4) If possible, the site should be in vicinity of the EANET acid deposition to estimate atmospheric deposition amounts precisely.
5) Other ecological information from nearby sites is valuable.

3. Monitoring items

3.1. Items to be monitored

Items to be monitored and recommended methods are shown in Table 1a) and 1b).

The total deposition as an input and the discharge from the stream as an output should be estimated as minimum requirements (Table 1a). Most of items have been measured or proposed for deposition monitoring or ecological monitoring. The following existing technical documents can be referred for the respective items or methods:

- *Technical Manual for Wet Deposition Monitoring in East Asia* (to be updated in 2010): wet-only sampling
- *Technical Documents for Filter Pack Method in East Asia:* filter pack method
- *Quality Assurance/Quality Control Program for the Air Concentration Monitoring in East Asia:* automatic monitors
- *Sub-Manual on Forest Vegetation Monitoring in EANET:* bulk sampling, passive sampler method, throughfall-stemflow method
- *Technical Manual for Dry Deposition Flux Estimation* (to be established in 2010):

inferential method

- *Technical Manual for Inland Aquatic Environment Monitoring in East Asia* (to be updated in 2010): stream water chemistry, water discharge

Table 1 a) Items to be monitored for estimating input and output

Items to be monitored		Requisite	Recommended methods
Input (total deposition)	Precipitation amount	Mandatory	➢ Rain gauge: at least one gauge in an open space near the catchment If the catchment area is significantly large, spatial variability of the precipitation should be checked in different positions.
	Wet deposition	Mandatory	➢ **Wet-only sampling:** at least 1 sampler in an open space near the catchment (when the EANET site is located in the vicinity or a power supply is available) ➢ **Bulk sampling:** at least 1 or more samplers in an open space near the catchment (when electricity is not available)
	Dry deposition	Optional	➢ **Inferential method:** estimated based on the concentration data by Filter pack method and meteorological data at the EANET site or the nearest meteorological station ➢ **Automatic monitors:** an alternative method for the concentration, or especially for O_3 ➢ **Passive sampling method:** an alternative method for the concentration, or especially for O_3 and NO_2
	Total deposition	Mandatory	➢ Wet + Dry: Calculated as sum of wet and dry depositions above ➢ **Throughfall–Stemflow method:** at least several points under the forest canopy (when electricity is not available)
Output (discharge from the stream)	Water discharge	Mandatory	➢ Weir: runoff of the catchment ➢ **H-Q curve method:** at the outlet of stream in the catchment (when a weir is not available)
	Stream water chemistry	Mandatory	➢ **Periodical collection of stream water to a plastic bottle:** at the outlet of stream of the catchment
	Chemical discharge	Mandatory	➢ Calculation: based on the water flux and the chemical concentration

Note: Bold methods have already referred in the other EANET documents.

In addition to the input and output, items for biogeochemical processes should be monitored to discuss material/elemental cycles in the catchment. Possible items to be monitored for this purpose were shown in Table 1b, while other items may be considered depending on targets. Some of items have been measured or proposed for soil and vegetation monitoring. The following existing technical documents can be referred for the respective items or methods:

- *Technical Manual for Soil and Vegetation Monitoring*: soil chemical properties, soil physical properties, description

Table 1 b) Items to be monitored for biogeochemical processes

Items to be monitored		Requisite	Recommended methods
Soil	Soil chemical properties	Mandatory	➢ **Collection of soil from the permanent plots:** at least two plots (with five sub-plots, respectively)
	Soil solution	Optional	➢ Suction (porous) cup method ➢ Pan Lysimeter method ➢ Resin capsule method
	Soil moisture	Optional	➢ Time Domain Reflectometry (TDR) method ➢ Amplitude Domain Reflectometry (ADR) method
	Soil physical properties	Optional	➢ **Fine earth bulk density: Metal sampling cylinder method** ➢ **Penetration resistance: Pocket penetrometer method**
	Soil gas emission	Optional	➢ Chamber method
Vegetation	Plant growth	Mandatory	➢ **Measurement of tree size (description of trees):** DBH and height of trees at least one plot (with three coaxial circle sub-plots) ➢ Dendrometer ➢ Tree ring analysis
	Species composition	Optional	➢ **Understory vegetation survey**
	Elemental contents	Optional	➢ Litter trap ➢ Leaf element analysis
Water balance	Evapotranspiration	Optional	➢

Note: Bold methods have already referred in the other EANET documents.

Note. Based on the experience in the case study sites in the EANET countries (Luangjame et al., 2009), the following recommendations should be referred for implementation of the monitoring items:

Recommendations for the input items:

1) Spatial variability of the precipitation amount should be considered in mountainous area if the catchment area is relatively large.
2) The throughfall-stemflow (TF-SF) method is useful to estimate total (wet and dry) atmospheric deposition amounts for certain constituents, such as SO_4^{2-}, whose canopy interaction can be negligible.
3) Dry deposition flux should be estimated by appropriate methods other than the TF-SF method to estimate total deposition precisely, especially for nitrogen compounds, taking canopy interactions such as uptake or consumption into account.
4) The deposition and meteorological data collected in the nearest EANET station should be utilized if available. The total deposition can be estimated by using the data of the filter-pack method and the wet-only sampler at the EANET station.
5) In particular in tropical region, wet deposition of nitrogen should be estimated by appropriate methods since microbial consumption of nitrogen is large during the storage in the sampling field. The ion-exchange-resin sampler may be applicable in forest area for long-term collection (for several months).

Recommendations for the output items:

6) The water year should be decided based on hydrological cycle in each catchment taking precipitation and discharge patterns into account.
7) Evapotranspiration should be estimated if possible, for precise water balance, especially in tropical region.
8) Cooperation with hydrologists may be helpful to understand hydrological processes in the catchment in detail.

Recommendations for items of biogeochemical processes:

9) Plant growth should be measured in the catchment area. Tree ring analysis may be useful to estimate the previous growth rate for the long-term analysis. At least, some information on plant growth should be compiled through a literature study.

10) Soil samples should be collected for analysis taking a spatial variation of soil chemical properties in the catchment.

3.2. Chemical parameters to be measured

Major chemical parameters to be measured for the respective items are shown in Table 2.

Table 2 Chemical parameters for the respective items

Items	Requisite	Parameters to be measured
Rainwater samples	Mandatory	➢ Cations: NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, and K^+ ➢ Anions: SO_4^{2-}, NO_3^-, and Cl^- ➢ Electric conductivity (EC) ➢ pH
	Optional	➢ Total organic nitrogen (TON) ➢ Total organic carbon (TOC)
Stream water samples	Mandatory	➢ Cations: NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, and K^+ ➢ Anions: SO_4^{2-}, NO_3^-, and Cl^- ➢ EC ➢ pH ➢ Alkalinity (Gran's plot titration)
	Optional	➢ SiO_2 ➢ TON ➢ TOC ➢ Total dissolved Al
Air concentrations (by filter pack method)	Mandatory	➢ Cations: NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, and K^+ ➢ Anions: SO_4^{2-}, NO_3^-, and Cl^- ➢ Gasses: SO_2, HNO_3, HCl, and NH_3
Soil chemical properties	Mandatory	➢ pH (H_2O) and pH (KCl) ➢ Exchangeable Base Cations (Ca, Mg, K and Na) ➢ Exchangeable Acidity, Al and H ➢ Effective Cation Exchangeable Capacity
	Optional	➢ Total carbon (T-C) ➢ Total nitrogen (T-N)
Soil solution	Optional	➢ Cations: NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, and K^+ ➢ Anions: SO_4^{2-}, NO_3^-, and Cl^- ➢ SiO_2 ➢ pH ➢ EC
Soil gasses	Optional	➢ N_2O ➢ CO_2
Litter and leaf samples	Optional	➢ T-C ➢ T-N ➢ Base cations: Ca^{2+}, Mg^{2+}, Na^+, and K^+ ➢ Total Al

Note: The parameters should be elaborated taking the model simulation into account.

3.3. Measurement frequency

Proposed frequency for measurement of the respective items was shown in Table 3, while actual frequency can be decided depending on the situation of each site.

Table 3 Proposed frequencies for measurement of the respective items

Items to be monitored		Proposed frequency
Input (total deposition)	Precipitation amount	➢ Continuously or daily
	Wet deposition	➢ Daily or weekly: for wet only samplers ➢ Weekly or biweekly: for bulk sampling
	Dry deposition	➢ Weekly: for filter pack method ➢ Continuously: for automatic monitor ➢ Biweekly or monthly: for passive sampling method
	Total deposition	➢ Biweekly, or monthly: for calculation of wet+dry ➢ Biweekly: for throughfall-stemflow method
Output (discharge from the stream)	Water discharge	➢ Continuously or biweekly
	Stream water chemistry	➢ Weekly or biweekly ➢ Intensive sampling (1-2 hour interval) during heavy-rain or snow-melting events
	Chemical discharge	➢ Biweekly, monthly or annual: for calculation
Soil	Soil chemical properties	➢ Once for several years ➢ Twice a year in case of tropical seasonal forest
	Soil solution	➢ Monthly or four times a year
	Soil moisture	➢ Continuously
	Soil physical properties	➢ Once
	Soil gas emission	➢ Monthly or four times a year
Vegetation	Plant growth	➢ Once for several years: for description of trees ➢ Continuously: dendrometer or annual enumeration
	Species composition	➢ Once for several years:
	Elemental contents	➢ Biweekly or monthly: for litter trap ➢ Monthly or bimonthly: for leaf analysis

Note. Recommendations for the measurement frequency:

11) Stream water samples should be collected at the outlet of stream of the catchment

periodically, hopefully at 2-week interval (or twice a month).

12) Intensive sampling of the stream water should be conducted during heavy-rain or snow-melting events if possible.
13) Seasonal variation of soil chemical properties should also be considered for some parameters, such as pH (H_2O), especially in tropical seasonal forest.

4. Monitoring procedures

4.1. Sampling protocols

Field sampling of the mandatory items should be carried out in accordance with sampling protocols described in the existing EANET technical documents (see the section 3.1).

Field sampling of the optional items should also be done so if the existing EANET technical documents can be referred.

Sampling protocols for other optional items may have flexibility depending on the situation of each site but should follow the methods, which have been authorized as the standard method in the EANET countries or at least published in international journals.

4.2. Transportation and storage of samples

Water samples, such as rainwater and stream water, should be refrigerated at 4 °C before shipment to the analytical laboratory. At latest, the samples should be transported to the analytical laboratory weekly or biweekly.

Samples arriving at laboratory should be kept in refrigerator and used for analysis as soon as possible.

4.3. Analytical procedures

Chemical analysis of the mandatory parameters should be carried out in accordance with analytical procedures described in the existing EANET technical documents (see the section 3.1). Analysis of the optional parameters should also be done so if the existing

EANET technical documents can be referred. Possible analytical equipments or methods for the representative mandatory parameters are shown in Table 4.

Chemical analysis for other optional param eters may have flexibility depending on the situation of each laboratory but should follow the methods, which have been authorized as the standard m ethod in the EANET countries or at least published in international journals.

Table 4 Possible analytical equipments or methods for the mandatory parameters

Items	Parameters	Analytical equipments/methods
Water samples: rainwater or stream water	Electric Conductivity (EC)	Conductivity Cell
	pH	Glass electrode (preferably with the Electrode of non-leak inner cell)
	Cations: NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, and K	Ion Chromatography
	Anions: SO_4^{2-}, NO_3^-, and Cl^-	Ion Chromatography
	Alkalinity (only for stream water)	Titration by Burette or Digital Burette with pH Meter
Soil	pH (H_2O) and pH (KCl)	Glass electrode (1:2.5 soil-solution suspension)
	Exchangeable Base Cations (Ca, Mg, K and Na)	AAS, ICP-AES or ICP-MS (CH_3COONH_4-Extraction)
	Exchangeable Acidity, Al and H	Titration (KCl-Extraction)

5. Quality assurance/quality control (QA/QC)

Data quality should be controlled and assured according to the EANET QA/QC program. Basically, protocols on sampling and chemical analysis can be standardized referring the existing EANET technical documents. The following fundamental matters should also be noted in the catchment-scale monitoring.

- Clear assignment of responsibility (personnel in charge of each activity)

- Standard operating procedures (SOPs) for each activity
- Documentation of activities

6. Evaluation

The data should be evaluated on a catchment scale. The input- output budget should be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance to outline the material/elemental cycles in the catchment. The standard units should be used for the input and output. Recommended basic units for evaluation is as follows:

- Water flux (precipitation amount and stream water discharge): mm
- Chemical concentration: $mol_c\ L^{-1}$ (ex. $\mu mol_c\ L^{-1}$ or $mmol_c\ L^{-1}$)
- Ion flux (deposition, discharge or soil/vegetation flux): $mol_c\ ha^{-1}$ or $mol_c\ m^{-2}$
- Elemental flux for N and S: $kg\ ha^{-1}\ y^{-1}$ or $g\ m^{-2}\ y^{-1}$

Based on the compiled data with the standard units on a water-year basis, initial evaluations should be done for the following items:

- Water balance on a catchment-scale: input, output and possible evapotranspiration
- Material/elemental balance on a catchment-scale: input-output budget

7. Data reporting

Dataset should be submitted to Network Center after an initial evaluation is done by the national center. Since the catchment-scale data should be evaluated based on the water year, the dataset should be compiled on a water-year basis of the respective catchment sites.

Existing reporting formats for monitoring on wet deposition, dry deposition, soil and vegetation, and inland aquatic environment can be referred for reporting of the mandatory items.

In addition to the data of the respective items, the following summary tables should be attached.

- Table showing the list of dataset obtained in the catchment site
- Table showing the estimated input-output for a water year

Reference:

Luangjame, J., Garivait, H., Sase, H., Yamashita, N., Ohta, S., Leong, C.P. & Takahashi, M. 2009. Recommendations for preparation of a guidelineon the future catchment monitoring in the EANET participating countries. Second Meeting for the Task Force on Soil and Vegetation Monitoring of EANET.

Recommendations for preparation of a guideline on the future catchment monitoring in the EANET participating countries

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I. Introduction

1. Integrated monitoring including atmospheric deposition, soil, vegetation, and inland water, is required to evaluate effects of acid deposition on ecosystems quantitatively. Catchment-scale analysis may be one of solutions for this requirement. Strategy Paper on Future Direction of Soil and Vegetation Monitoring of EANET, which was adopted at 2nd Session of the Scientific Advisory Committee of EANET in 2002, suggested promoting case studies of the catchment-scale analysis in the East Asian region.
2. Consequently, Network Center has promoted the case studies with experts of the EANET participating counties. The case studies have been promoted in the Sakaerat Silvicultural Research Station (SRS) site in Thailand, the Danum Valley site in Malaysia, and the Kajikawa study site in Japan. Moreover, Ministry of the Environment of Japan has promoted the similar catchment-scale monitoring in the Lake Ijira site in Japan, where acidification of the catchment area was suggested (Yamada et al., 2007; Nakahara et al. submitted; MOEJ, 2009). The intensive survey was carried out at the Lake Ijira site from 2005 to 2007 to estimate the input-output budget precisely.
3. Unique data sets have been accumulated through the surveys, especially in Thailand and in Japan for last 3 and 5 years, respectively. This paper introduces technical recommendations for preparation of guide line or manual on the future catchment monitoring mainly based on experiences in Thailand and Japan. Partly, information of Malaysia was included, too.

II. Site selection

4. A site for the catchment-scale monitoring should be selected in a forest area. A small watershed (valley surrounded by ridges) should be selected as the site to determine

its catchment area. The whole catchment area should be covered by forest. Although the size of the catchment area may depend on the situation; e.g. 3.8 ha in the Kajikawa study site in Japan, 35 ha in the Sakaerat SRS site in Thailand and 35 ha in the Danum Valley in Malaysia, 298 ha in the Lake Ijira catchment in Japan, small size of the catchment covered with similar vegetation and soil is recommended to understand responses and mechanisms in the watershed easily.

5. The catchment should have a stream, which flows out from the bottom of the valley. Information on hydrological processes such as the water budget is a base of the material/elemental budget. The catchment, where the water budget has been monitored for several years, is preferable for the future evaluation of the material/elemental budget, since accumulation of the several years' data is necessary to discuss water budget precisely..
6. Sensitivity of soil and/or bedrock geology to acid deposition should be taken into consideration for site selection. Acrisols, which is high-weathered red soil and relatively sensitive to acid deposition, can be seen in the Sakaerat SRS site and the Danum Valley site.
7. Atmospheric deposition amounts should also be considered. The dissolved inorganic nitrogen (DIN) input at the Kajikawa site and the Lake Ijira site is higher than 10 kg N ha^{-1} y^{-1}, which is the threshold value of the DIN input at which NO_3^- output increases in the stream water (according to observation in European and North American countries).
8. It is recommended that the site should be selected in vicinity of the acid deposition monitoring site to estimate atmospheric deposition amounts precisely. The EANET acid deposition monitoring sites are located in or near the study catchment area in the Sakaerat SRS, the Danum Valley, and the Lake Ijira.
9. Utilization of information from ecological and atmospheric study sites nearby should be considered, since comprehensive analysis of various data is essential for the catchment-scale analysis. For example, the Sakaerat area is famous for ecological studies of tropical seasonal forests and carbon flux studies. In case of the Danum Valley, UK Royal Society have conducted many studies on tropical rain forest ecology, and especially in 2008, the research project, Oxidant and Particle Photochemical Processes above a South-East Asian tropical rain forest (OP3 Project) has been conducted. The various data obtained from the previous studies above may be informative for our data analysis.

Recommendations:

1) *A forest catchment with a stream should be selected, while the size of the catchment may depend on each situation.*
2) *The catchment, where the water budget has been monitored, is preferable.*
3) *Sensitivity of soil or bedrock geology to acid deposition and/or atmospheric deposition amounts should be considered for site selection.*
4) *It is recommended that the site should be in vicinity of the EANET acid deposition to estimate atmospheric deposition amounts precisely.*
5) *Other ecological studies nearby should also be referred.*

III. Measurement of atmospheric deposition

7. The throughfall – stemflow (TF-SF) method is useful to estimate total (wet and dry) atmospheric deposition amounts in forest area, especially for constituents, such as SO_4^{2-}, for which leaching or uptake on the canopy might be very limited. The monitoring procedures for the TF-SF method described in the Sub-Manual on Forest Vegetation Monitoring in EANET can be referred (EANET, 2006a). Chemical analysis of the rainwater samples should be done basically according to the EANET Technical Manual for Wet Deposition Monitoring (EANET, 2000).
8. Deposition amounts of K^+ and NH_4^+ (and maybe NO_3^-) from the TF-SF method may be largely affected by the canopy interactions, such as leaching, uptake, and/or consumption (Sase et al., 2008). The TF-SF method cannot provide the total deposition data for these ions. Therefore, it is important to estimate dry deposition fluxes also by other methods such as the inferential method, especially for nitrogen compounds.
9. Sampling intervals for the TF-SF method should be considered taking meteorological conditions of the study site into account. Biweekly (or twice a month) sampling can be recommended practically in forest area. In the Kajikawa study site, the Sakaerat SRS site, and the Lake Ijira site, biweekly (or twice a month) sampling have been conducted.
10. In tropical region, microbial consumption of nitrogen compounds cannot be neglected during the sample interval under the warm and humid climate. In fact, the data in the Sakaerat SRS site suggested that more than 70% of nitrogen by bulk sampling was consumed during storage in the sampling field (unpublished data). To estimate nitrogen deposition in forest area precisely, alternative methods should be considered.
11. Application of biocide such as thymol can also be considered as one of the solutions for the microbial consumption. However, it was hard to control appropriate

concentration of the biocide in the sampler, since the concentration depends on precipitation amounts for coming weeks. Additionally, use of the biocide in forest area may harmful in the sampling field if rainwater sample overflow around the sampler. Therefore, we do not recommend using the biocide in forest area unless these problems are overcome.

12. As an alternative method to estimate nitrogen deposition in forest area, the sampler packed with an ion exchange resin may be useful for relatively long-term collection (e.g. for several months). The data in Sakaerat SRS site showed that the annual nitrogen deposition collected by the ion-exchange-resin sampler in the open field was comparable to the EANET wet deposition data in the same compound (Toda, unpublished data).
13. Passive samplers may be useful to estimate average air concentrations as well as dry deposition fluxes in forest area without electric supply. However, it may still be necessary to check their reliability, especially in tropical region.
14. Monitoring of Meteorological data in forest area is helpful. Rain gauge with the data logger may be useful to understand precipitation pattern and discharge. Temperature, humidity, and wind speed may also be useful to estimate air concentration measured by passive samplers and dry deposition fluxes.
15. The deposition amounts should be checked by several methods to obtain reliable data in forest area. The deposition data collected in the nearest EANET station should be utilized as reference data.
16. At the Lake Ijira site, dry deposition fluxes were estimated by the inferential method based on the filter-pack method and meteorological data at the EANET station. The data of the wet-only sampler at the EANET station was also referred. Total deposition was precisely estimated as the sum of wet and dry depositions: e.g. the total DIN input was estimated to be 28.7 kg-N ha^{-1} y^{-1} and 18.2 kg-N ha^{-1} y^{-1} in the water-years 2005-2006 and the water-year 2006-2007 respectively, which exceeded significantly the threshold value of NO_3^- discharge (MOEJ, 2009)..
17. Moreover, at the Lake Ijira site, the precipitation amount was measured at three different slope positions to check spatial variability of precipitation in the watershed, which was large (298 ha) and mountainous area. It was clarified that the precipitation amount was the highest at the higher slope position and the lowest at the EANET station, which was located at the small valley on the middle slope position; the difference was more than 30 %. For calculation of wet deposition amounts, the spatial variability of the precipitation was taken into account.

Recommendations:

6) The throughfall-stemflow (TF-SF) method is useful to estimate total (wet and dry) atmospheric deposition amounts for certain constituents, such as SO_4^{2-}.

7) Dry deposition flux should be estimated by appropriate methods other than the TF-SF method to estimate total deposition precisely, especially for nitrogen compounds, taking canopy interactions such as uptake or consumption into account.

8) Especially in tropical region, wet deposition of nitrogen should be estimated carefully since microbial consumption of nitrogen is large during the storage in the sampling field. The ion-exchange-resin sampler may be applicable in tropical countries for long-term collection (for several months).

9) The deposition and meteorological data collected in the nearest EANET station should be utilized (if available). The total deposition can be estimated by using the data of the filter-pack method and the wet-only sampler at the EANET station.

10) Spatial variability of the precipitation amount should be considered in mountainous area if the catchment area is relatively large.

IV. Measurement of stream water

18. <u>Water discharge should be measured at the bottom of the catchment to discuss the input-output balance of water.</u> The water budget will be a base of material/elemental budget. A V-notch weir and/or a partial flume with the data logger may be useful to measure water flux precisely. In case of the Kajikawa study site, a V-notch weir and a partial flume are installed, while a V-notch weir is installed in the Danum Valley site.
19. If it is difficult to install the weir, the water level logger can be installed instead. In this case, the water depth and flow velocity should be measured periodically, and then the discharge will be estimated based on the H-Q curve derived from relationship between the water level and water flux. In case of the Sakaerat SRS site and the Lake Ijira site, the water level logger is installed.
20. <u>The water year should be decided based on hydrological cycle in each catchment.</u> A period with the lowest precipitation and discharge may be a timing of starting a water year. The water year was defined as starting at the end of May and the beginning of January, in the Kajikawa study site and the Sakaerat SRS site, respectively. The input (precipitation) and output (discharge) balance of water should be estimated based on the water year.
21. To discuss the water balance precisely, evapotranspiration should be estimated by

several approaches. Especially in tropical region, the evapotranspiration may significantly contribute to the water balance in the catchment. At least, literature studies should be referred to discuss possible evapotranspiration in the area, even if enough meteorological data cannot be obtained for the estimation.

22. Collaboration with hydrologists may be helpful to discuss the hydrological cycle and water balance precisely. In case of the Danum Valley site, practical collaboration is promoted with the Malaysian and UK hydrologists, and the study site was selected at the existing small catchment site that was established for hydrological studies. Utilization of such ongoing hydrological study sites may be one of the options.
23. Stream water samples should be collected at the bottom of the catchment periodically, hopefully at 2-week interval (or twice a month). Frequent sampling is preferable. In all the sites above, stream water samples are collected at roughly 2-week interval. Chemical analysis of the stream water samples should be done basically according to the EANET Technical Manual for Monitoring of Inland Aquatic Environment (EANET, 2000).
24. Intensive sampling of the stream water is recommended to be conducted during heavy rain events to discuss effects of increase in groundwater level and direct runoff. In study sites in Japan, intensive sampling has been conducted at one- to three-hour intervals using an automatic water sampler, and temporary acidification of the stream water has been detected during heavy rain events (Kamisako et al, 2008; MOEJ, 2009).

Recommendations:

11) Water discharge should be measured by appropriate methods at the bottom of the catchment.

12) The water year should be decided based on hydrological cycle in each catchment taking precipitation and discharge patterns into account.

13) Evapotranspiration should be measured, if possible, for precise water balance, especially in tropical region.

14) Cooperation with hydrologists may be helpful.

15) Stream water samples should be collected at the bottom of the catchment periodically, ideally at 2-week interval (or twice a month).

16) Intensive sampling of the stream water should be conducted during heavy rain events if possible.

V. Biogeochemical processes

24. Biogeochemical processes in plant-soil systems should be studied to interpret the stream water chemistry and discuss effects of atmospheric deposition in the catchment. Soil chemical properties, litter fall amount/chemistry, tree growth, elemental fluxes in soil horizons, etc. can be proposed as candidate items for monitoring. Items to be measured should be decided depending on targets of processes dominate in each site.
25. Plant uptake may be one of the biggest sink of nitrogen in forest ecosystems. It was reported that NO_3^- concentration was decreased during the plant-growing period in summer in the Kajikawa study site (Kamisako et al., 2008) and the Lake Ijira site (Nakahara et al., submitted). In particular at the Lake Ijira, close relationship between reduction of tree growth and changes of river water chemistry can be seen by the tree ring analysis in the last 20 years (Nakahara et al., submitted). Plant growth and its effects on material cycles should be considered.
26. Soil samples should be collected for analysis taking a spatial variation of soil chemical properties in the catchment into account. In case of the Sakaerat SRS site, pronounced spatial variation in soil pH was observed at different scales in a surface soil, and it was suggested that the variations at a large scale or a small scale were related to topographic factors (e.g. positions on a slope) or vegetation conditions (e.g. accumulation of A0 horizons), respectively (Yamashita, unpublished data).
27. Seasonal variation of soil chemical properties should be taken into consideration in case of tropical seasonal forests. The soil pH (H_2O) was significantly higher in wet season than in dry season in the Sakaerat SRS site, while seasonal difference was not found for exchangeable cations (Yamashita, unpublished data). The similar phenomenon was reported also in the first periodic report of EANET (EANET, 2006b).

Recommendations:

17) Plant growth should be measured in the catchment area. Tree ring analysis may be useful to estimate the previous growth rate for the long-term analysis. At least, information on plant growth should be compiled through a literature study.

18) Soil samples should be collected for analysis taking a spatial variation of soil chemical properties in the catchment.

19) Seasonal variation of soil chemical properties should also be considered for some parameters, such as pH (H_2O), especially in tropical seasonal forest.

VI. Catchment-scale analysis

28. Seasonal or annual changes in stream water chemistry (concentrations or material/elemental flows) can be compared with changes of atmospheric deposition. Meteorological data and the data on biogeochemical processes may be helpful for a comprehensive analysis to understand relationship between stream water chemistry and atmospheric deposition. Material/elemental budget may be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance.
29. The input-output budget can outline the current situation of material/elemental cycles in the catchment. The annual DIN input was higher than the threshold value for NO_3^- discharge in the two Japanese catchments; Kajikawa study site and the Lake Ijira study site. However, the situation is slightly different between them. At the Kajikawa study site, the pattern of nitrogen leaching may be still regulated by plant growth seasonality, while the NO_3^- concentration in the stream water is relatively high even in summer. The stream water is well neutralized by leaching of base cations, such as Ca and Mg, from the soil (Kamisako et al., 2008). The catchment may proceed gradually to the nitrogen saturation with reduction of acid neutralizing capacity (ANC) of soil.
30. On the other hand, at the Lake Ijira site, the NO_3^- concentration is increasing year by year and not regulated by plant growth pattern anymore. The catchment seems to have been mostly nitrogen-saturated. Moreover, the output of sulfur was approximately two times larger than the input, suggesting sulfur accumulated in the past was discharged. The stream water is being acidified during the last decade, probably due to effects of NO_3^- and SO_4^{2-} discharge. The base cations are significantly discharged, more than 900% compared with the input, suggesting reduction of ANC in the catchment. In fact, soil pH decreased more than 0.5 units during the last decade (MOEJ, 2009).
31. <u>Development of biogeochemical model applicable to the East Asian catchments may be essential to understand the current status and future projection of the material/elemental cycles in the catchment.</u> Collaboration with the model simulation is being promoted in Japan, Thailand, and Malaysia. Results of the model simulation should be fed back to the field monitoring for improvement of the monitoring methodologies and parameters.

Recommendations:

20) *The input-output budget should be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance to outline the*

material/elemental cycles in the catchment.

21) *Development of biogeochemical model applicable to the East Asian catchments should be promoted to understand the current status and make future projection of the material/elemental cycles in the catchment under changing environment.*
22) *The monitoring methodologies and parameters should be elaborated taking the model simulation into account.*

Acknowledgements:

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Recommendations for preparation of a guideline on the future catchment monitoring in the EANET participating countries

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2. Consequently, Network Center has promoted the case studies with experts of the EANET participating counties. The case studies have been promoted in the Sakaerat Silvicultural Research Station (SRS) site in Thailand, the Danum Valley site in Malaysia, and the Kajikawa study site in Japan. Moreover, Ministry of the Environment of Japan has promoted the similar catchment-scale monitoring in the Lake Ijira site in Japan, where acidification of the catchment area was suggested (Yamada et al., 2007; Nakahara et al. submitted; MOEJ, 2009). The intensive survey was carried out at the Lake Ijira site from 2005 to 2007 to estimate the input-output budget precisely.
3. Unique data sets have been accumulated through the surveys, especially in Thailand and in Japan for last 3 and 5 years, respectively. This paper introduces technical recommendations for preparation of guide line or manual on the future catchment monitoring mainly based on experiences in Thailand and Japan. Partly, information of Malaysia was included, too.

II. Site selection

4. A site for the catchment-scale monitoring should be selected in a forest area. A small watershed (valley surrounded by ridges) should be selected as the site to determine

its catchment area. The whole catchment area should be covered by forest. Although the size of the catchment area may depend on the situation; e.g. 3.8 ha in the Kajikawa study site in Japan, 35 ha in the Sakaerat SRS site in Thailand and 35 ha in the Danum Valley in Malaysia, 298 ha in the Lake Ijira catchment in Japan, small size of the catchment covered with similar vegetation and soil is recommended to understand responses and mechanisms in the watershed easily.

5. The catchment should have a stream, which flows out from the bottom of the valley. Information on hydrological processes such as the water budget is a base of the material/elemental budget. The catchment, where the water budget has been monitored for several years, is preferable for the future evaluation of the material/elemental budget, since accumulation of the several years' data is necessary to discuss water budget precisely..
6. Sensitivity of soil and/or bedrock geology to acid deposition should be taken into consideration for site selection. Acrisols, which is high-weathered red soil and relatively sensitive to acid deposition, can be seen in the Sakaerat SRS site and the Danum Valley site.
7. Atmospheric deposition amounts should also be considered. The dissolved inorganic nitrogen (DIN) input at the Kajikawa site and the Lake Ijira site is higher than 10 kg N ha^{-1} y^{-1}, which is the threshold value of the DIN input at which NO_3^- output increases in the stream water (according to observation in European and North American countries).
8. It is recommended that the site should be selected in vicinity of the acid deposition monitoring site to estimate atmospheric deposition amounts precisely. The EANET acid deposition monitoring sites are located in or near the study catchment area in the Sakaerat SRS, the Danum Valley, and the Lake Ijira.
9. Utilization of information from ecological and atmospheric study sites nearby should be considered, since comprehensive analysis of various data is essential for the catchment-scale analysis. For example, the Sakaerat area is famous for ecological studies of tropical seasonal forests and carbon flux studies. In case of the Danum Valley, UK Royal Society have conducted many studies on tropical rain forest ecology, and especially in 2008, the research project, Oxidant and Particle Photochemical Processes above a South-East Asian tropical rain forest (OP3 Project) has been conducted. The various data obtained from the previous studies above may be informative for our data analysis.

Recommendations:

1) *A forest catchment with a stream should be selected, while the size of the catchment may depend on each situation.*
2) *The catchment, where the water budget has been monitored, is preferable.*
3) *Sensitivity of soil or bedrock geology to acid deposition and/or atmospheric deposition amounts should be considered for site selection.*
4) *It is recommended that the site should be in vicinity of the EANET acid deposition to estimate atmospheric deposition amounts precisely.*
5) *Other ecological studies nearby should also be referred.*

III. Measurement of atmospheric deposition

7. The throughfall – stemflow (TF-SF) method is useful to estimate total (wet and dry) atmospheric deposition amounts in forest area, especially for constituents, such as SO_4^{2-}, for which leaching or uptake on the canopy might be very limited. The monitoring procedures for the TF-SF method described in the Sub-Manual on Forest Vegetation Monitoring in EANET can be referred (EANET, 2006a). Chemical analysis of the rainwater samples should be done basically according to the EANET Technical Manual for Wet Deposition Monitoring (EANET, 2000).
8. Deposition amounts of K^+ and NH_4^+ (and maybe NO_3^-) from the TF-SF method may be largely affected by the canopy interactions, such as leaching, uptake, and/or consumption (Sase et al., 2008). The TF-SF method cannot provide the total deposition data for these ions. Therefore, it is important to estimate dry deposition fluxes also by other methods such as the inferential method, especially for nitrogen compounds.
9. Sampling intervals for the TF-SF method should be considered taking meteorological conditions of the study site into account. Biweekly (or twice a month) sampling can be recommended practically in forest area. In the Kajikawa study site, the Sakaerat SRS site, and the Lake Ijira site, biweekly (or twice a month) sampling have been conducted.
10. In tropical region, microbial consumption of nitrogen compounds cannot be neglected during the sample interval under the warm and humid climate. In fact, the data in the Sakaerat SRS site suggested that more than 70% of nitrogen by bulk sampling was consumed during storage in the sampling field (unpublished data). To estimate nitrogen deposition in forest area precisely, alternative methods should be considered.
11. Application of biocide such as thymol can also be considered as one of the solutions for the microbial consumption. However, it was hard to control appropriate

concentration of the biocide in the sampler, since the concentration depends on precipitation amounts for coming weeks. Additionally, use of the biocide in forest area may harmful in the sampling field if rainwater sample overflow around the sampler. Therefore, we do not recommend using the biocide in forest area unless these problems are overcome.

12. As an alternative method to estimate nitrogen deposition in forest area, the sampler packed with an ion exchange resin may be useful for relatively long-term collection (e.g. for several months). The data in Sakaerat SRS site showed that the annual nitrogen deposition collected by the ion-exchange-resin sampler in the open field was comparable to the EANET wet deposition data in the same compound (Toda, unpublished data).
13. Passive samplers may be useful to estimate average air concentrations as well as dry deposition fluxes in forest area without electric supply. However, it may still be necessary to check their reliability, especially in tropical region.
14. Monitoring of Meteorological data in forest area is helpful. Rain gauge with the data logger may be useful to understand precipitation pattern and discharge. Temperature, humidity, and wind speed may also be useful to estimate air concentration measured by passive samplers and dry deposition fluxes.
15. The deposition amounts should be checked by several methods to obtain reliable data in forest area. The deposition data collected in the nearest EANET station should be utilized as reference data.
16. At the Lake Ijira site, dry deposition fluxes were estimated by the inferential method based on the filter-pack method and meteorological data at the EANET station. The data of the wet-only sampler at the EANET station was also referred. Total deposition was precisely estimated as the sum of wet and dry depositions: e.g. the total DIN input was estimated to be 28.7 kg-N ha^{-1} y^{-1} and 18.2 kg-N ha^{-1} y^{-1} in the water-years 2005-2006 and the water-year 2006-2007 respectively, which exceeded significantly the threshold value of NO_3^- discharge (MOEJ, 2009)..
17. Moreover, at the Lake Ijira site, the precipitation amount was measured at three different slope positions to check spatial variability of precipitation in the watershed, which was large (298 ha) and mountainous area. It was clarified that the precipitation amount was the highest at the higher slope position and the lowest at the EANET station, which was located at the small valley on the middle slope position; the difference was more than 30 %. For calculation of wet deposition amounts, the spatial variability of the precipitation was taken into account.

Recommendations:

6) *The throughfall-stemflow (TF-SF) method is useful to estimate total (wet and dry) atmospheric deposition amounts for certain constituents, such as* SO_4^{2-}.
7) *Dry deposition flux should be estimated by appropriate methods other than the TF-SF method to estimate total deposition precisely, especially for nitrogen compounds, taking canopy interactions such as uptake or consumption into account.*
8) *Especially in tropical region, wet deposition of nitrogen should be estimated carefully since microbial consumption of nitrogen is large during the storage in the sampling field. The ion-exchange-resin sampler may be applicable in tropical countries for long-term collection (for several months).*
9) *The deposition and meteorological data collected in the nearest EANET station should be utilized (if available). The total deposition can be estimated by using the data of the filter-pack method and the wet-only sampler at the EANET station.*
10) *Spatial variability of the precipitation amount should be considered in mountainous area if the catchment area is relatively large.*

IV. Measurement of stream water

18. <u>Water discharge should be measured at the bottom of the catchment to discuss the input-output balance of water.</u> The water budget will be a base of material/elemental budget. A V-notch weir and/or a partial flume with the data logger may be useful to measure water flux precisely. In case of the Kajikawa study site, a V-notch weir and a partial flume are installed, while a V-notch weir is installed in the Danum Valley site.
19. If it is difficult to install the weir, the water level logger can be installed instead. In this case, the water depth and flow velocity should be measured periodically, and then the discharge will be estimated based on the H-Q curve derived from relationship between the water level and water flux. In case of the Sakaerat SRS site and the Lake Ijira site, the water level logger is installed.
20. <u>The water year should be decided based on hydrological cycle in each catchment.</u> A period with the lowest precipitation and discharge may be a timing of starting a water year. The water year was defined as starting at the end of May and the beginning of January, in the Kajikawa study site and the Sakaerat SRS site, respectively. The input (precipitation) and output (discharge) balance of water should be estimated based on the water year.
21. To discuss the water balance precisely, evapotranspiration should be estimated by

several approaches. Especially in tropical region, the evapotranspiration may significantly contribute to the water balance in the catchment. At least, literature studies should be referred to discuss possible evapotranspiration in the area, even if enough meteorological data cannot be obtained for the estimation.

22. Collaboration with hydrologists may be helpful to discuss the hydrological cycle and water balance precisely. In case of the Danum Valley site, practical collaboration is promoted with the Malaysian and UK hydrologists, and the study site was selected at the existing small catchment site that was established for hydrological studies. Utilization of such ongoing hydrological study sites may be one of the options.
23. Stream water samples should be collected at the bottom of the catchment periodically, hopefully at 2-week interval (or twice a month). Frequent sampling is preferable. In all the sites above, stream water samples are collected at roughly 2-week interval. Chemical analysis of the stream water samples should be done basically according to the EANET Technical Manual for Monitoring of Inland Aquatic Environment (EANET, 2000).
24. Intensive sampling of the stream water is recommended to be conducted during heavy rain events to discuss effects of increase in groundwater level and direct runoff. In study sites in Japan, intensive sampling has been conducted at one- to three-hour intervals using an automatic water sampler, and temporary acidification of the stream water has been detected during heavy rain events (Kamisako et al, 2008; MOEJ, 2009).

Recommendations:

11) Water discharge should be measured by appropriate methods at the bottom of the catchment.

12) The water year should be decided based on hydrological cycle in each catchment taking precipitation and discharge patterns into account.

13) Evapotranspiration should be measured, if possible, for precise water balance, especially in tropical region.

14) Cooperation with hydrologists may be helpful.

15) Stream water samples should be collected at the bottom of the catchment periodically, ideally at 2-week interval (or twice a month).

16) Intensive sampling of the stream water should be conducted during heavy rain events if possible.

V. Biogeochemical processes

24. Biogeochemical processes in plant-soil systems should be studied to interpret the stream water chemistry and discuss effects of atmospheric deposition in the catchment. Soil chemical properties, litter fall amount/chemistry, tree growth, elemental fluxes in soil horizons, etc. can be proposed as candidate items for monitoring. Items to be measured should be decided depending on targets of processes dominate in each site.
25. Plant uptake may be one of the biggest sink of nitrogen in forest ecosystems. It was reported that NO_3^- concentration was decreased during the plant-growing period in summer in the Kajikawa study site (Kamisako et al., 2008) and the Lake Ijira site (Nakahara et al., submitted). In particular at the Lake Ijira, close relationship between reduction of tree growth and changes of river water chemistry can be seen by the tree ring analysis in the last 20 years (Nakahara et al., submitted). Plant growth and its effects on material cycles should be considered.
26. Soil samples should be collected for analysis taking a spatial variation of soil chemical properties in the catchment into account. In case of the Sakaerat SRS site, pronounced spatial variation in soil pH was observed at different scales in a surface soil, and it was suggested that the variations at a large scale or a small scale were related to topographic factors (e.g. positions on a slope) or vegetation conditions (e.g. accumulation of A0 horizons), respectively (Yamashita, unpublished data).
27. Seasonal variation of soil chemical properties should be taken into consideration in case of tropical seasonal forests. The soil pH (H_2O) was significantly higher in wet season than in dry season in the Sakaerat SRS site, while seasonal difference was not found for exchangeable cations (Yamashita, unpublished data). The similar phenomenon was reported also in the first periodic report of EANET (EANET, 2006b).

Recommendations:

17) Plant growth should be measured in the catchment area. Tree ring analysis may be useful to estimate the previous growth rate for the long-term analysis. At least, information on plant growth should be compiled through a literature study.

18) Soil samples should be collected for analysis taking a spatial variation of soil chemical properties in the catchment.

19) Seasonal variation of soil chemical properties should also be considered for some parameters, such as pH (H_2O), especially in tropical seasonal forest.

VI. Catchment-scale analysis

28. Seasonal or annual changes in stream water chemistry (concentrations or material/elemental flows) can be compared with changes of atmospheric deposition. Meteorological data and the data on biogeochemical processes may be helpful for a comprehensive analysis to understand relationship between stream water chemistry and atmospheric deposition. Material/elemental budget may be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance.

29. The input-output budget can outline the current situation of material/elemental cycles in the catchment. The annual DIN input was higher than the threshold value for NO_3^- discharge in the two Japanese catchments; Kajikawa study site and the Lake Ijira study site. However, the situation is slightly different between them. At the Kajikawa study site, the pattern of nitrogen leaching may be still regulated by plant growth seasonality, while the NO_3^- concentration in the stream water is relatively high even in summer. The stream water is well neutralized by leaching of base cations, such as Ca and Mg, from the soil (Kamisako et al., 2008). The catchment may proceed gradually to the nitrogen saturation with reduction of acid neutralizing capacity (ANC) of soil.

30. On the other hand, at the Lake Ijira site, the NO_3^- concentration is increasing year by year and not regulated by plant growth pattern anymore. The catchment seems to have been mostly nitrogen-saturated. Moreover, the output of sulfur was approximately two times larger than the input, suggesting sulfur accumulated in the past was discharged. The stream water is being acidified during the last decade, probably due to effects of NO_3^- and SO_4^{2-} discharge. The base cations are significantly discharged, more than 900% compared with the input, suggesting reduction of ANC in the catchment. In fact, soil pH decreased more than 0.5 units during the last decade (MOEJ, 2009).

31. <u>Development of biogeochemical model applicable to the East Asian catchments may be essential to understand the current status and future projection of the material/elemental cycles in the catchment.</u> Collaboration with the model simulation is being promoted in Japan, Thailand, and Malaysia. Results of the model simulation should be fed back to the field monitoring for improvement of the monitoring methodologies and parameters.

Recommendations:

20) *The input-output budget should be calculated based on the atmospheric deposition chemistry, stream water chemistry, and water balance to outline the*

material/elemental cycles in the catchment.

21) *Development of biogeo chemical model applicable to the East Asian catchments should be promoted to understand the curr ent status and make futur e projection of the material/elemental cycles in the catchment under changing environment.*
22) *The monitoring methodologies and param eters should be elaborated taking the model simulation into account.*

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