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Discussion on estimation of dry deposition flux and consideration of less expensive monitoring methods

Network Center for EANET

1. Introduction

According to the framework described in the second edition of "Strategy Paper for Future Direction of Dry Deposition Monitoring of EANET" which was endorsed in SAC5 (2005, Niigata), the following activities are included in "Strategy on EANET Development (2006-2010)" which was endorsed in IG8 (2006, Viet Nam) as expected outcomes for dry deposition monitoring. This report is a discussion paper for the following expected outcomes.

Regarding Dry Deposition Fluxes

- ➢ Development and application of monitoring methods for dry deposition considering current country-specific monitoring methodology
  - Technical Manual for dry deposition fluxes estimation prepared by Task Force on Dry Deposition Monitoring (2008-2010)
  - Estimation of dry deposition fluxes at the selected monitoring sites (2009-2010)

Regarding Air Concentrations Monitoring

- ➢ Consideration and efforts on appropriate distribution of monitoring sites
  - Establishment of new EANET sites (2007-2010)
- ➢ Consideration on possible application of less expensive methods of monitoring including passive sampler
  - Recommendation on use of less expensive methods to reduce monitoring cost and increase numbers of monitoring (2007-2008)
- ➢ Establishment of the framework for reviewing substances to be monitored including other air pollution and monitoring parameters
  - Recommendation on monitoring parameters, measurements and equipment (2006-2007)

2. Discussion on estimation of dry deposition fluxes

Further verification is still required for the measurement methods of dry deposition flux because the dry deposition process is affected by a character of the depositing matters, surface properties and the meteorological conditions. Measurement technique for dry deposition flux can be divided mainly into direct measurement and inferential method. The direct measurement represented by the Gradient Method is not appropriate for a routine monitoring in the network because it requires prohibitive cost and skilled works. On the other hand, the inferential method does not require the special equipments but can calculate the flux from the multiplication between air concentration and dry deposition velocity (V_d) which is calculated by some parameters like meteorological factors, land use types and seasonal categories.

Inferential method can output dry deposition flux without high cost and skilled measurements and the second edition of Strategy Paper for Future Direction of Dry Deposition Monitoring of EANET recommends its application in EANET. However, every necessary meteorological factor has not been monitored at many sites in the current states of EANET. Thus, as a case study, NC presented example estimation of dry deposition flux of SO_2 at SAC6 by means of a meteorological simulation model outputs. Figure 2 shows the estimated annual amount of SO_2 dry deposition, annual amount of nss-SO_4^{2-} wet deposition and annual precipitation in 2004 at EANET sites.

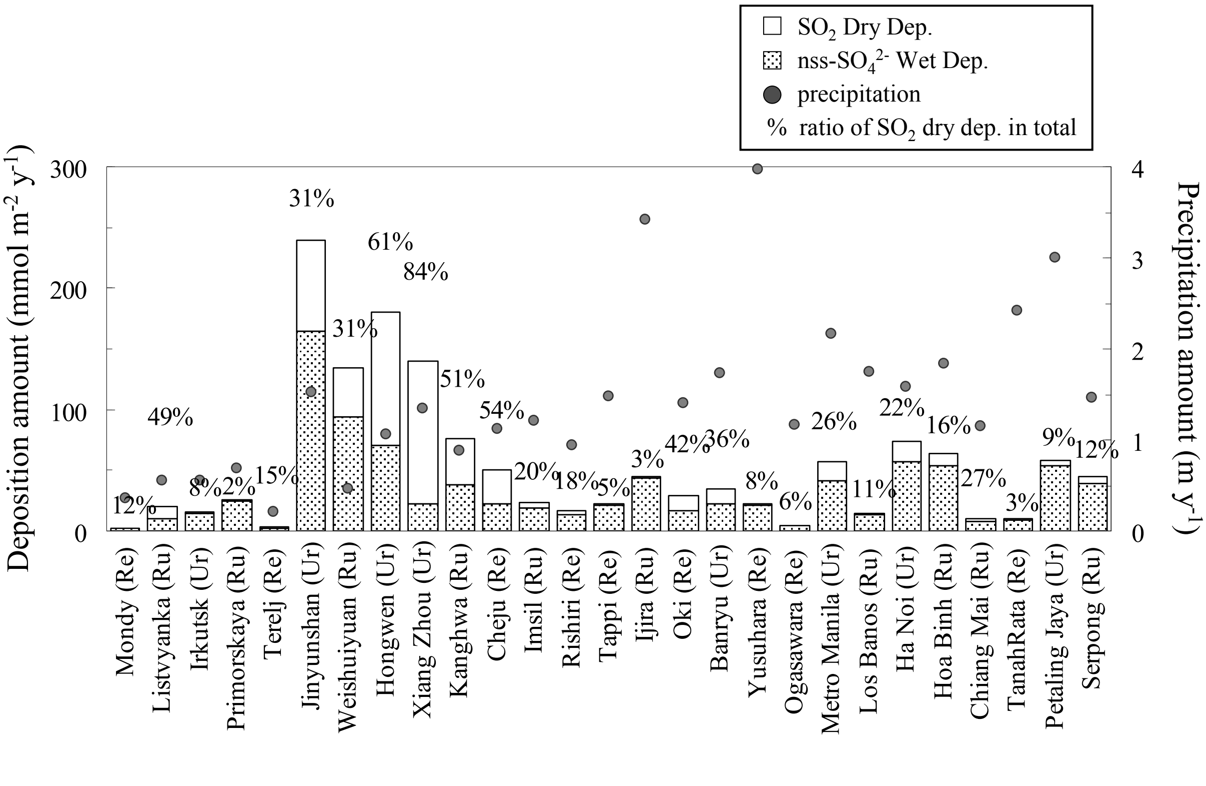

Figure 2 Estimated annual amount of SO_2 dry deposition, annual amount of nss-SO_4^{2-} wet deposition and annual precipitation in 2004 at EANET sites.

In order to evaluate the ecological impact caused by the acid deposition, it is essential to estimate both of the wet and dry depositions. Though each country recognizes that dry deposition flux must be evaluated in EANET, there are various opinion among countries. For example, (1) dry deposition flux should be estimated by each country freely, (2) we want to use dry deposition velocity (V_d) that was obtained by our direct measurement survey, and (3) simple direct measurements like throughfall measurement and surrogate surface measurement method can also be applied. At this moment, it seems to be important to grasp the approximate amount of dry deposition and its estimation should be implemented in a hurry by using any kinds of estimation method. If we get different results of estimated dry deposition amount, comparison study can be suggested and ecological impact should be evaluated according to minimum/ensemble/maximum deposition amount.

Enhancement of meteorological measurement (temperature, wind speed and direction, relative humidity and solar radiation) should be required for every site. Also followings are tasks to be required for Task Force on Dry Deposition Monitoring for the present;

- Review of existing researches of direct measurement and inferential method
- Validation of inferential method by using direct measurement results
- Consideration of the contents of Technical Manual for dry deposition fluxes estimation
- Establishment of Ad hoc group to conduct above tasks if necessary

3. Discussion on Air Concentrations Monitoring

Three kinds of outcomes mentioned in first chapter are expected for air concentration monitoring. The purposes of the consideration of less expensive methods are reducing costs and the expansion of monitoring network. In addition, one of the purposes of the recommendation on monitoring parameter, measurements and equipment is also the expansion of monitoring network. Since the establishment of new EANET sites is included in the expansion of monitoring network, these three expected outcomes are closely related to each other. As a first step, this paper focuses on the possivirity of less expensive methods to deal with the expected outcomes.

In 2006, the number of sites for air concentration monitoring was 38 and it was less than that for wet deposition monitoring sites (49 sites). Also the priority chemical species for EANET dry deposition monitoring, which are recommended in the second edition of Strategy Paper for Future Direction of

Dry Deposition Monitoring of EANET, are not covered at several sites. The priority chemical species are as follows;

First priority: SO_2, O_3, NO, NO_2 (urban), HNO_3, HCl, NH_3,
Particulate components (SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, Mg^{2+}, K^+, and Ca^{2+}), PM10

Second priority: NO_2 (rural and remote), PM2.5

Automatic monitor can measure SO_2, O_3, NOx, PM10 and PM2.5 in high time resolution, but its installation needs high cost. Filter pack measurement can cover SO_2, HNO_3, HCl, NH_3 and particle components. In order to estimate dry deposition amount, both of gaseous and particulate components must be monitored. Thus, filter pack can be recommended as one of the most appropriate methods for less expensive method. However, since filter pack cannot monitor NOx and O_3, those monitoring data are limited in EANET. In this context, passive sampler can be recommended as another less expensive monitoring method.

Passive sampler can be applied for the monitoring of SO_2, O_3, NOx and NH_3 and does not require high cost as well as electricity and hard works. Table 1 summarizes merits and demerits of passive sampler. Though it seems that passive sampler can be installed at many sites easily, time resolution of the monitoring data is long (2-4 weeks) and appropriate concentration conversion coefficient should be examined for NOx monitoring at each site. In addition, it can be recommended to use filter pack for the monitoring of SO_2 and NH_3 because other priority species can be monitored at the same time. Table 2 summarizes experiences and studies for passive sampler in EANET.

Automatic monitor should be installed if hourly data is necessary in order to conduct a detailed research like AOT40 and a validation of simulation model. However preparation of high cost and maintenance system are required for its installation. Thus, as an example, the following procedure can be considered for the expansion of the monitoring network;

Step 1. Review of existing researches of passive sampler and its performance tests in different regions

Step 2. Enhancement of air concentration monitoring network based on the introduction of passive sampler at existing or new sites (O_3 and NOx, but also SO_2 and NH_3 if not monitored).

Step 3. Evaluation of the relationship between spatial distribution of air concentrations and ecological impacts

Step 4. Select of important sites based on the results of Step 3 and installation of automatic monitors to selected sites.

Table 1 Merit and demerit of passive sampler

Merit	***Demerit***
- low cost	- long time resolution data
- easy establishment (no electricity, no special equipments)	- uncertainty for low concentration species (SO_2, NH_3)
- good agreement with Automatic monitor (O_3, NOx)	- need more consideration for concentration conversion coefficient (NOx)
- wide use in the world	- need information of temperature, humidity and pressure

Table 2 Past, ongoing and future activities for passive sampler in EANET

Project	***Targets***
➢ Monitoring data from Malaysia in 2001-2003	- SO_2, NO_2, HNO_3 and NH_3 as monitoring data
➢ Joint research project with Mongolia on plant sensitivity (2001-)	- O_3 and SO_2 for plants sensitivity in forest
➢ Joint research project with Thailand on catchment analysis (2005-)	- SO_2, O_3, NOx and NH_3 for plants sensitivity in forest and deposition analysis
➢ Joint research project with Thailand on dry deposition (gas concentration) monitoring methodology (2006-)	- SO_2, O_3, NOx and NH_3 for the comparison among automatic monitor, filter pack and passive sampler
➢ Sub-Manual on forest vegetation monitoring (endorsed in 2006)	- SO_2, O_3, NOx and NH_3 for plants sensitivity in forest

As an example of existing research of passive sampler, Figure 1 shows the comparison of NO_2, NOx and O_3 concentrations measured by passive sampler and automatic monitor. These results are provided by *Japan Environmental Laboratories Association* (JELA). Two kinds of concentration conversion coefficients were applied to calculate air concentration of NO_2 and NOx. Original coefficient (white dots) was derived by using temperature, relative humidity and pressure and improved coefficient (gray dots) was derived by using only temperature. The improved coefficient shows better agreement with automatic monitor at both of high and low concentration sites. Since concentration conversion coefficients for O_3 is not affected by humidity and pressure, just one coefficient was applied. It is found that passive sampler shows a good agreement with automatic monitor in O_3 monitoring.

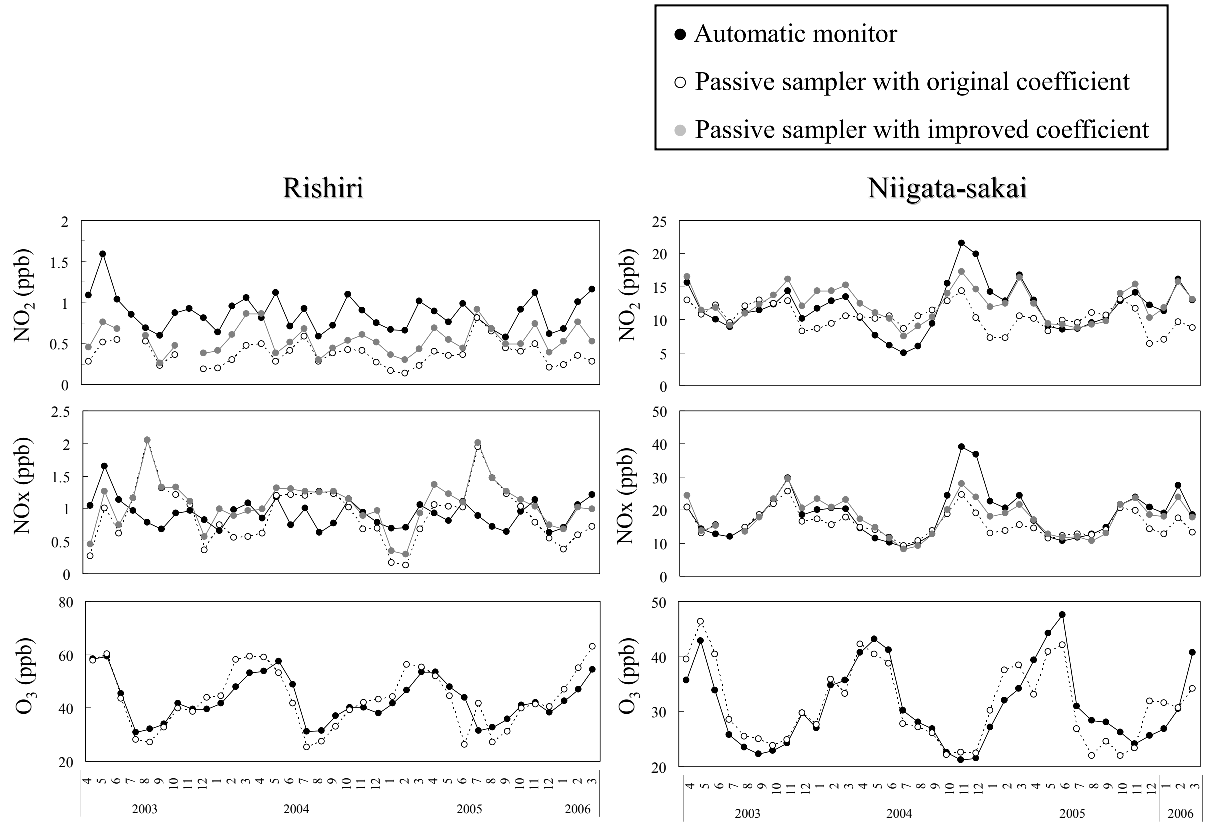

Figure 1 Comparison of NO_2, NOx and O_3 concentrations measured by passive sampler and automatic monitor. These results are provided by *Japan Environmental Laboratories Association* (JELA).

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