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Consideration on use 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 air concentration monitoring. This report is a discussion paper for the following expected outcomes.

- *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. Typical less expensive methods and their effectiveness for EANET 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 possibility 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+}), PM_{10}

Second priority: NO_2 (rural and remote), $PM_{2.5}$

Automatic monitor (AT), diffusion denuder sampling method (DD), filter pack sampling method (FP), and passive sampler (PS) can be suggested as the major methodology for air concentration monitoring. AT can measure SO_2, O_3, NOx, PM10 and PM2.5 in high time resolution, but its installation needs high cost and skilled maintenance system.

DD and FP can measure gases (e.g. SO_2, HNO_3, HCl, and NH_3) and particulate components at the same time. DD can measure gases and particulate components separately without sampling artifact, which is the over estimation of NH_3 and under estimation of ammonium salts caused by the volatilization of ammonium salts on the sampling filter. However, since expensive equipments and skilled works are required for DD, it has not come into wide use recently. Though the artifact is worried for ammonia measurement for FP, it can be recommended as one of the most appropriate methods in EANET because it is less expensive method. However, since FP cannot monitor NOx and O_3, those monitoring data are limited in EANET.

In this context, PS can be recommended as another less expensive monitoring method. Since PS can be applied for the monitoring of SO_2, O_3, NOx and NH_3, the parallel use of FP and PS can cover every priority species except for PM_{10} and $PM_{2.5}$. In addition, the quantity of artifact in FP can be evaluated and determined by the difference of NH_3 concentration between FP and PS.

3. Discussion on the procedure for application of passive sampler to EANET

The implementation of PS monitoring does not require high cost as well as electricity and special maintenance works. Table 1 summarizes merits and demerits of PS. Though it seems that PS 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, the parallel use with can be recommended because other priority species can be monitored at the same time. Table 2 summarizes experiences and studies for PS in EANET.

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 and ongoing activities using 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

AT 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. On the other hand, PS is useful to complement the monitoring network, increase of monitoring sites, and selection of hot spots to be monitored by AT. "Strategy Paper for Future Direction of Dry Deposition Monitoring of EANET" recommends PS for the monitoring of O_3 and NOx from the technical view point. However, regarding the introduction of new monitoring system into EANET, feasibility study for its implementation should be considered in **Task Force on Monitoring Instrumentation**. The followings are issues on the introduction of PS to be discussed in SAC and Task Force on Monitoring Instrumentation for the present;

1. Discussion on the action plan and data reporting for passive sampler monitoring in EANET

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

3. Performance tests of passive sampler in different regions

4. Enhancement of air concentration monitoring network based on the introduction of passive sampler at existing or new sites

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

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

4. Example of performance test for passive sampler conducted in Japan

As an example of existing research of PS, Figure 1 shows the comparison of NO_2, NOx and O_3 concentrations measured by PS and AT. 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 AT 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 PS shows a good agreement with AT in O_3 monitoring.

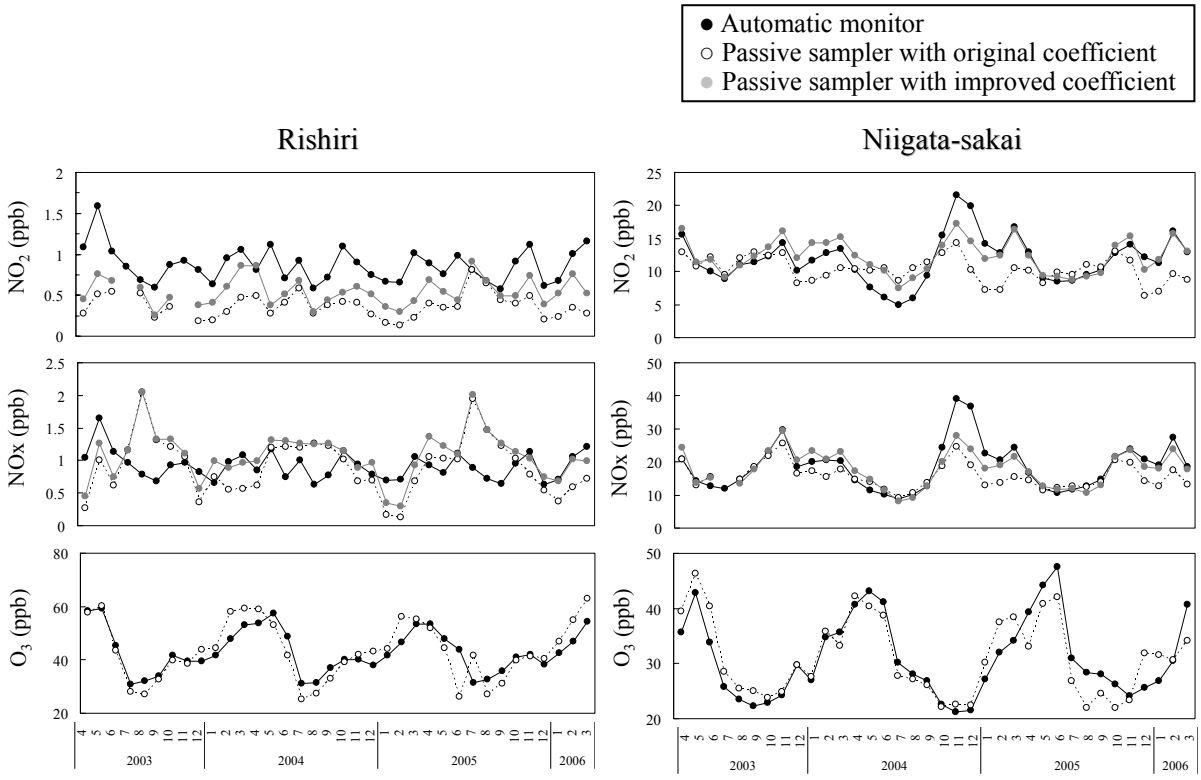

Figure 1 Comparison of NO_2, NOx and O_3 concentrations measured by passive sampler and automatic monitor. (provided by *Japan Environmental Laboratories Association*)