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on the Acid Deposition Monitoring Network in East Asia
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PROGRESS OF CATCHMENT STUDIES IN THE EANET COUNTRIES IN 2020/2021

Network Center for the EANET

I. Introduction

1. Water-soluble substances derived from atmospheric (wet and dry) deposition, including acidic substances and related ion constituents, are flowed/cycled with hydrological and biogeochemical processes in terrestrial ecosystems. Some of these substances end up flowing into rivers and streams. As a result, the river water chemistry may reflect the atmospheric input and reactions in the ecosystems. Therefore, the observational method utilizing a catchment/watershed as the unit area for the budget analysis has been widely used in the United States and Europe[1], for integrated assessment of effects of atmospheric deposition on ecosystems.

2. In the EANET, the idea on catchment analysis had already been described in the technical documents, such as *"Guidelines for Acid Deposition Monitoring in East Asia"* and *"Technical Manual for Soil and Vegetation Monitoring in East Asia"*, when the regular-phase activities of the EANET started in 2001, although detailed methodologies had not been yet established at that time. Therefore, the Scientific Advisory Committee (SAC) and its Task Force on Soil and Vegetation Monitoring (TFSV) recommended to promote catchment analysis and develop the monitoring methods for the EANET in the strategy papers[2], which were drafted by TFSV and adopted by SAC.

3. The Asia Center for Air Pollution Research (ACAP) as the Network Center for EANET (NC), has promoted catchment analysis in cooperation with SAC and TFSV, according to recommendations in the technical documents and strategy papers. In this report, the recent progress of catchment analysis in the EANET is overviewed with major outputs, such as scientific papers.

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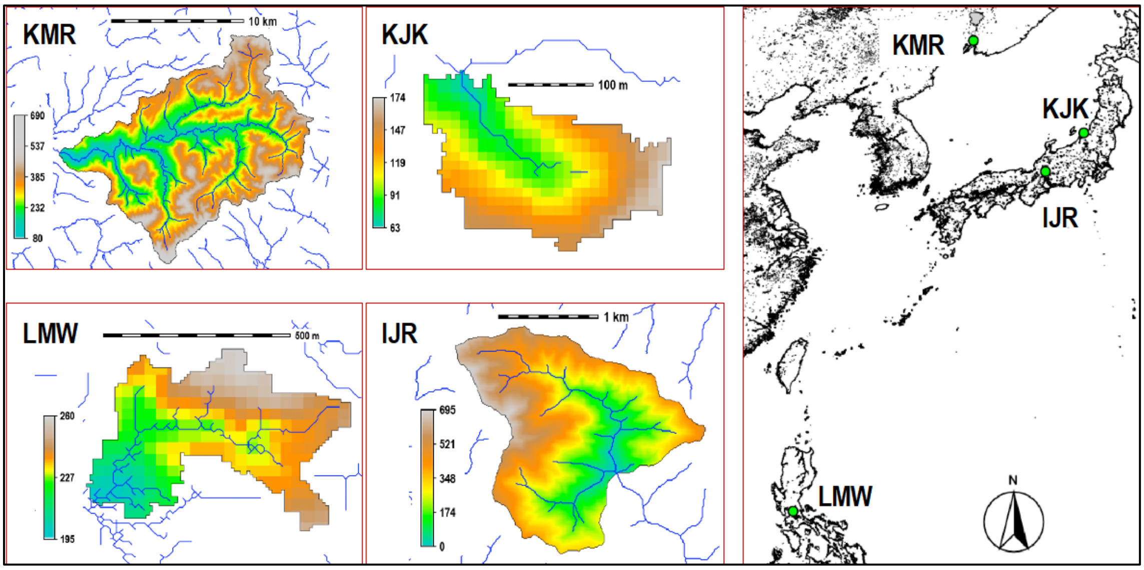
[1] Such as, the Hubbard Brook Experimental Forest (USDA Forest Service) and the network for ICP Integrated Monitoring under CLRTAP since 1960s and 1990s, respectively. In particular, the former is famous for the first observational evidence of acid deposition effects on forest ecosystems in the United States.

[2] The current version is ***"Strategy Paper for Future Direction of EANET on Monitoring of Effects on Agricultural Crops, Forest and Inland Water by Acidifying Species and Related Chemical Substances"***, which was adopted at the 20th Session of SAC.

II. Progress and outputs of the projects

4. The current active catchment sites relevant to the EANET are shown in Fig. 1. The field surveys at the Kajikawa catchment (KJK) have been continued since 2002 as one of the NC's research activities to assess the response of forest ecosystems to changing atmospheric deposition. Simultaneously, the regular EANET monitoring data assessment have been promoted for the Lake Ijira catchment (IJR) and Komarovka River catchment (KMR) since 2005 and 2016, respectively, because acidification phenomena in these sites were suggested in previous reports. The data at the La Mesa Watershed (LMW), the new site launched in 2019, are expected to be accumulated gradually.



5. It should be pointed out that the EANET Non-Core budget and external research budgets/grants have been supporting the research activities above. Currently, the Grant-in-Aid for Scientific Research (KAKENHI), Japan, and the Ph.D. Thesis Study in Niigata University support intensive surveys at KJK and data assessment at KMR, respectively. The intensive surveys on isotopic analysis at KJK and IJR are collaborating with the national monitoring in Japan, too.

A) Findings at KJK, IJR and KMR

6. Major findings highlighted in the latest publications from KJK and IJR include:
   - The atmospheric sulfur (S) inputs at IJR and KJK have been decreasing, reflecting the regional emission trend.

- Accordingly, the S output from stream water has been decreasing gradually at KJK, but its response was slightly delayed, resulting in budget discrepancies in recent years (Fig. 2, after Sase et al. 2021a; EANET 2021).
- At IJR, the S isotopic analysis clarified that geological S largely affected stream water chemistry, and therefore, the S outputs exceeded the inputs. It is pointed out that the net export percent has been increasing due to the enhanced contribution of geological S with the recent increase in precipitation.

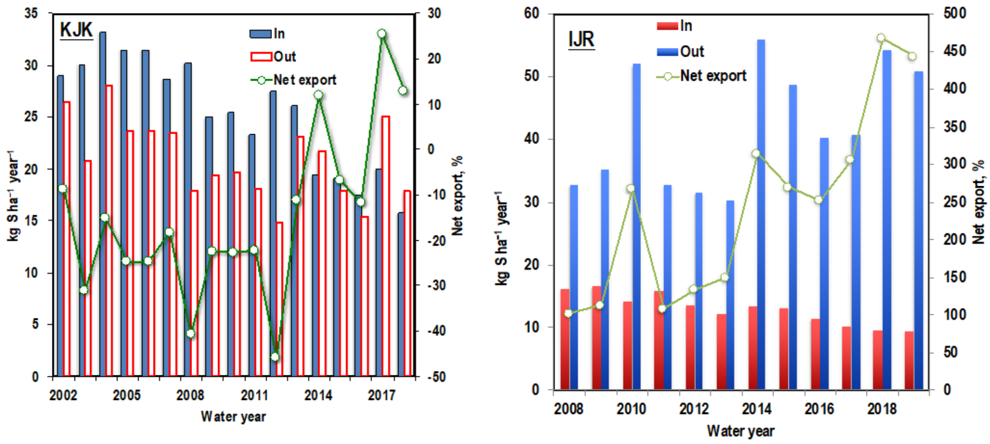


Fig. 2. Atmospheric S input (In), S output from stream water (Out), and the net export percent at the Kajikawa catchment (KJK) and the Lake Ijira catchment (IJR) (after Sase et al. 2019; 2021a; EANET 2021)

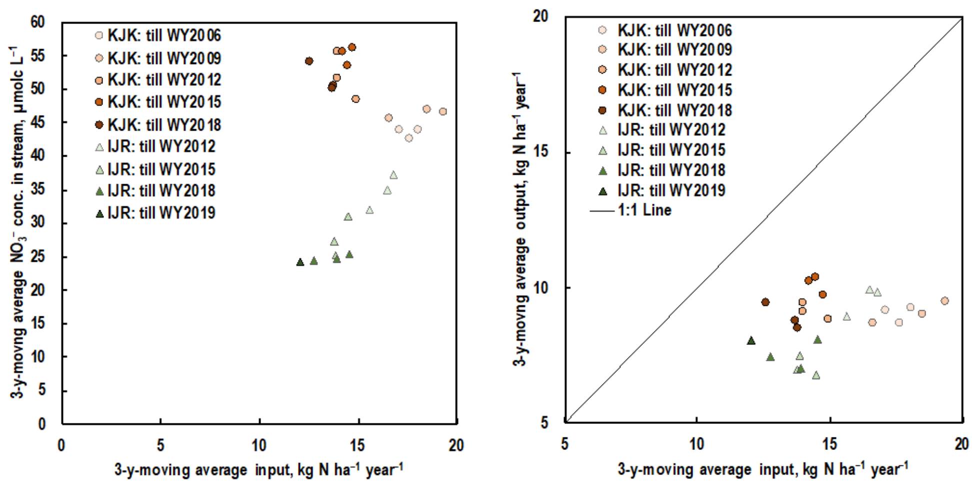


Fig. 3. Relationships between the atmospheric N inputs and NO_3^- concentrations in stream water (left) and between the atmospheric N inputs and N outputs from ecosystems (right) in Lake Ijira catchment (IJR) and Kajikawa catchment (KJK) (EANET 2021). Three-year-moving averages are plotted for several periods to show

chronological changes. Water year (WY) in IJR, from November to October in the next year (after Sase et al. 2019); WY in KJK, from June to May in the next year (after Sase et al. 2021a).

- The NO_3^- concentration in stream water has been decreasing smoothly with the atmospheric nitrogen (N) input at IJR, while it has been increasing with a decrease of the N input at KJK (Fig. 3 left, EANET 2021). The N outputs from ecosystems are approaching the 1:1 line not only at KJK but also at IJR due to the effects of an increase in precipitation amounts at IJR (Fig. 3 right, EANET 2021).
- To assess whether or not forest catchments could recover smoothly from N saturation, forest conditions and changing climatic conditions should be continuously monitored, together with atmospheric N deposition (Sase et al. 2021b).

- Scientific journals containing the above findings:

  Sase H et al. 2021a. Transboundary air pollution reduction rapidly reflected in stream water chemistry in forested catchment on the Sea of Japan coast in central Japan. Atmospheric Environment 248: 118223.

  Sase H et al. 2021b. Nitrogen saturation of forested catchments in central Japan - Progress or recovery? Soil Science and Plan Nutrition (accepted).

7. An additional analysis of trace elements in rainwater at KJK suggested that anthropogenic effects have been decreasing recently, which corresponded well to the trend of non-sea salt S. Isotopic ratios of Pb in rainwater suggested changes in sources of the elements. It was also suggested that a portion of trace metals in rainwater was not trapped in soil and directly leached into stream water. A journal paper on this subject is now under preparation, while the brief introduction has already been included in PRSAD4.

8. An NC scientist supervises the Ph.D.-course study of a colleague from the Institute of Global Climate and Ecology (IGCE), Russia, as the Visiting Professor of Niigata University. The catchment analysis of KMR dataset suggested that not only atmospheric deposition but also changes in meteorological conditions contributed to the acidification of the stream water. A journal paper on this subject is under preparation.

9. The response of forest ecosystems to decreasing atmospheric deposition is not simple, and meteorological conditions affect its process largely. It is suggested that "recovery of ecosystems from acidification and nitrogen saturation" is not necessarily observed under changing climate,

even if the atmospheric deposition has decreased relatively smoothly.

B) The necessity of further studies

10. The NC has been studying discharge processes of pollutants accumulated/cycled in soil-plant systems of forest catchments in cooperation with the KAKENHI project. It was suggested that extreme weather events, such as heavy rain, would disturb the discharge processes and alter elemental cycles in forest ecosystems. A journal paper on this subject is under preparation, too.

11. Moreover, it was clarified that S derived from atmospheric deposition in the past has been accumulated in forest soil at IJR (Sase et al. 2019; Tanikawa et al. under review). This can be called the "Legacy Pool" of atmospheric deposition (Fig. 4). Climate change, including extreme weather events, may disturb the legacy pool and cause the sudden discharge of pollutants to stream water, reducing the resilience of forest ecosystems. The NC is trying to obtain a new grant to study this subject intensively.

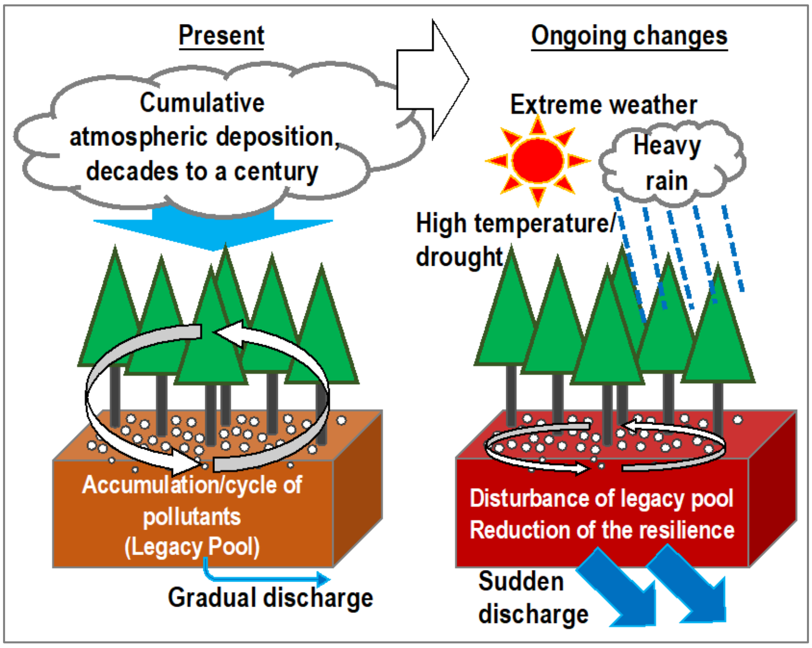


Fig. 4 Schematic views on the possible sudden discharge of air-pollutant "Legacy Pool" to be triggered by extreme weather events

III. Actions Required at SAC21

12. SAC21 is invited to review the progress of catchment analysis whether it is worth continuing related research activities.