C-3.1.1 Study on the effect of dry and wet acidic depositions on plants

Contact person Nouchi Isamu

Head, Air Quality Conservation Lab.
National Institute of Agro-Environmental Sciences
Ministry of Agriculture, Forestry and Fishery
Kannondai 3-1-1, Tsukuba, Ibaraki, 305 Japan
Tel: +81-298-38-8161 Fax: +81-298-38-8199
E-mail: nouchi@ss.niaes.affrc.go.jp

Total Budget for FY1993-FY1995 14,449,000 Yen (FY1995; 4,819,000 Yen)

Abstract Daily analyzed data of rain, throughfall and stemflow at a Japanese cedar stand site in mixed woods were applied to the model that determines the dry deposition by material balance at a tree canopy. The dry deposited amount of acidic matters onto the site was estimated approximately 4 times larger than wet deposited amount. In addition, the result suggested that the daily rain amount smaller than 10mm caused insufficient washing the dry deposited matter out of tree canopy.

Another method for monitoring dry deposition using model branch made of Teflon chips was tested. The result showed linear relationship between dry deposition on model branch and that on real tree branch. However, the gradient of the linear function varied with dry deposited components.

Relatively high concentration of H2O2 in fog and cloud water was observed up to about 4 ppm in central Japanese mountainous region. Some agricultural crops were exposed to simulated rain containing various concentration of H2O2. The results suggested that high concentration of H2O2, up to 100 ppm, in water would not affect the growth of plants.

Japanese cedar seedlings were exposed to simulated acid rain. The result showed that simulated acid rain of which pH is as low as pH2.5 had little effect on the growth of Japanese cedar seedlings and cation leaching from the seedlings was increased by simulated acid rain of which pH is 3.0 or lower, compared with that in the case of pH 5.6.

Key Words Dry Deposition, Woods, Hydrogen Peroxide, Leaching

1. Introduction

To examine the effect of acid deposition on ecosystem, dry deposited amount should be monitored as well as wet deposited amount, or rain chemistry. However, the method for monitoring dry deposition onto ecosystem such as forest has not been established. It is needed to establish the technique for monitoring dry deposition through long period over wide area.

Hydrogen peroxide in rain water is considered to be an important oxidizer which makes "acid rain". Monitoring H2O2 concentration in background is needed. On the other hand, hydrogen peroxide inside plant is toxic for the plant. However, on the effect of wet deposited hydrogen peroxide on plant, there is little information[1].

Under such background as above, this study was addressed to following objectives.

2. Research Objectives

1) To consider the techniques for monitoring dry deposition onto woods site.
2) Measuring H2O2 concentration in fog or cloud water at a mountainous region.
3) To examine the effect of H2O2 in rain water on the growth of plants.
4) To evaluate the critical acidity which cause any acute effect on plants.

3. Methods

3-1 Methods for monitoring dry deposition onto woods site

Daily analyzed data of rain, throughfall and stemflow at a Japanese cedar stand site in mixed woods[2] were applied to the model[3] to determine the dry deposition of different components onto the site by material balance at a tree canopy. The mixed woods is surrounded by farm land.

Another method considered here for monitoring dry deposition was using model branch[4]. In the mixed woods surrounded by farm land, the model branches which are made of Teflon chips in polyethylene sink net, and the each weight of which is about 500 g, were put near the tree branches that had just washed by distilled water with or without covers to prevent dry deposition. At 3 to 10 days after that, the dry deposited amount of different matters onto model branches and tree branches were measured and calculated, respectively.

3-2 Measurement of H2O2 concentration in mountainous region in central Japan

At the site with 2700 m elevation in Mt. Norikura, H2O2 concentration in fog and cloud water was measured during summer season in 1993, with differential method using an enzyme.

3-3 Exposure of plants to simulated rain containing hydrogen peroxide

To examine the effect of hydrogen peroxide in rain or fog water on the growth of plants, three species of plants, radish, bushbean and cucumber, were exposed to simulated rain containing high concentration of H2O2 up to 100 ppm. The experiment which exposed radish and cucumber plants to simulated acid rain containing 100ppm of H2O2, of which pH is up to pH 2.5, was also performed.

3-4 Exposure of Japanese cedar seedlings to simulated acid rain

To estimate the critical level of acidity to cause acute effect on tree, Japanese cedar seedlings were exposed to simulated acid rain of which pHs were 5.6, 3.0, 2.7 and 2.5. Exposure was performed continuously 3 times a week through over 1 year.

4. Results and Discussion

4-1 Calculation of dry deposited amount onto woods site

Fig.1 shows the accumulated amount of SO42- dry deposition onto Japanese cedar stand site in mixed woods calculated by the model using the daily analyzed chemistry data of rain, throughfall and stem flow. Accumulated dry deposition of SO42- continuously increased with time. Assuming that SO42- would not leach from tree, the dry deposited amount of SO42- was estimated approximately 4 times larger than the wet deposited amount. This magnification value seems to be close to the value at forest edge rather than deeper inside forest[5]. The other finding about this method is derived from the relationship between daily rain amount and calculated dry deposition rate per day, namely the daily rain amount smaller than 10mm caused insufficient washing the dry deposited matter off the tree canopy (Fig.2).

Concerning the method using model canopy, the result showed linear relationship between dry deposition on model branch and that on real tree branch. However, the gradient of the linear function varied with dry deposited components (Fig.3).

4-2 Measurements of H2O2 concentration in cloud water in mountainous region and the effect of high concentration of aqueous H2O2 on plant growth

Relatively high concentration of H2O2 in fog and cloud water was observed up to about 4 ppm at Mt. Norikura, located in central Japanese mountainous region, in the summer season in 1993 (Fig.4). This value is comparable to that observed in the US mountainous site[6].

As the results of the experiments which exposed some agricultural crops to simulated rain containing H2O2, high concentration of H2O2, up to 100 ppm, in water did not affect the growth of tested plants. In addition, 100 ppm of H2O2 in simulated acid rain of which pHs were 3.0 to 2.5 did not promote the negative effect of the simulated acid rain on the growth of the plants tested here.

4-3 Effect of simulated acid rain on the growth of Japanese cedar seedlings

Fig.5 shows the effect of simulated acid rain on the growth of Japanese cedar seedlings. The result showed that simulated acid rain of which pH is as low as pH2.5 had little effect on the growth of Japanese cedar seedlings. However, the ratio of top/root dry weight tended to decrease in the case of pH 2.5 compared with pH 5.6.

Other findings is that the leaching of certain kinds of cation from the seedlings was increased by simulated acid rain of which pH is 3.0 or lower, compared with that in the case of pH 5.6 throughout the entire exposure period (Fig.6).

References

1) Okamoto,R., Oshima,H., Yamaguchi,T., Ozaki,Y., Kawakami,K. and Fujii,K., 1992: Chemical monitoring of precipitation in Tsukuba area (1985-1990). Noukanken-shiryo, **13**.

2) Kobayashi,T., Nakagawa,Y., Tamaki,M., Hiraki,T. and Shoga,M., 1995: Evaluation of acidic deposition onto the forest canopies -Studies on the method of estimating dry deposition and leaching rate dividedly-. Kankyoukagakukai-shi, **8**, 25-34.

3) Takenaka,C. and Win,K.K., 1994: Dry deposition sampling method in forest. Taikiosen-gakkai-kouenyoushishu, 318.

4) Hanson,P.J. and McLaughlin,S.B., 1989: Growth, photosynthesis, and chlorophyll concentrations of red spruce seedlings treated with mist containing hydrogen peroxide. *J. Environ. Qual.*, **18**, 499-503.

5) Beier,C., Gundersen,P. and Rasmussen,L., 1992: A new method for estimation of dry deposition of particles based on throughfall measurements in a forest edge. *Atmos. Environ.*, **26A**, 1553-1559.

6) Olszyna,K.J., Meagher,J.F. and Bailey,E.M., 1988: Gas-phase, cloud and rain water measurements of hydrogen peroxide at a high-elevation site. *Atmos. Environ.*, **22**, 1699-1706.

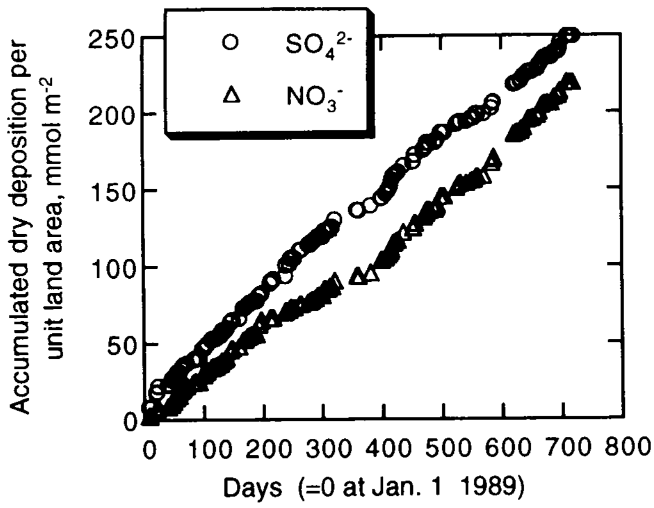

Fig.1 Accumulated dry deposition of SO_4^{2-} and NO_3^- on a Japanese cedar stand site calculated by material balance model at tree canopy.

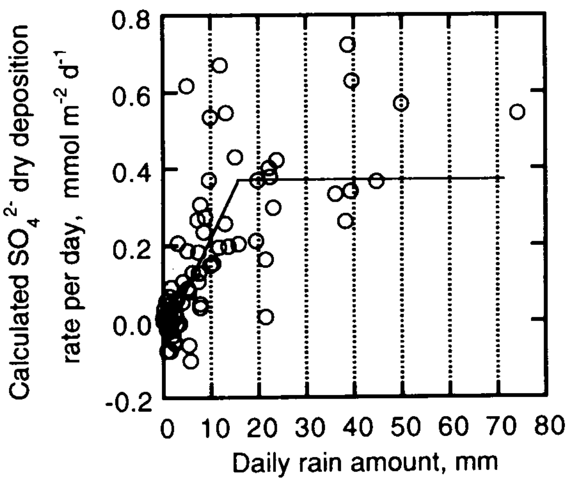

Fig.2 Effect of daily rain amount on the calculated value of SO_4^{2-} dry deposition rate per day.

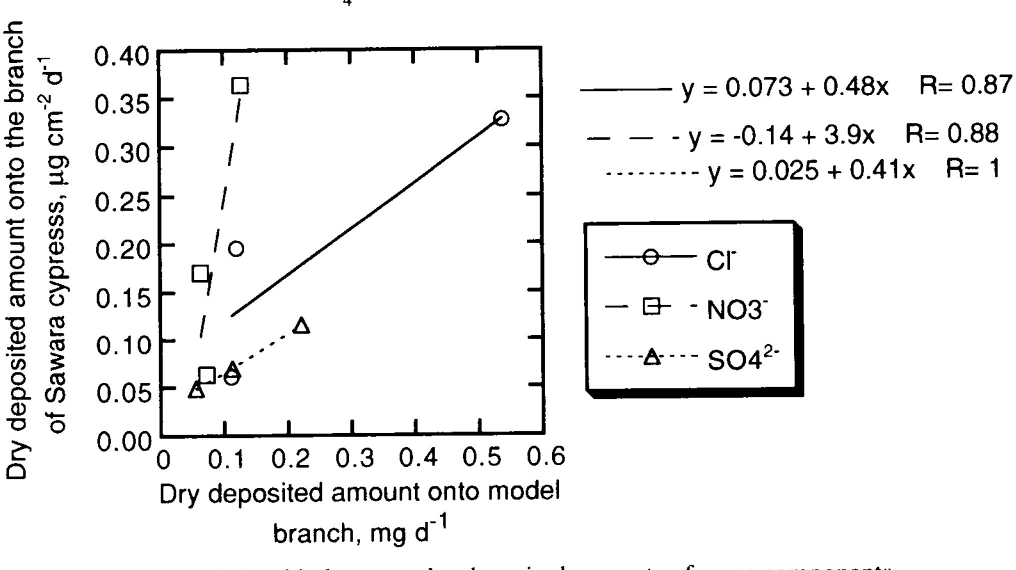

Fig.3 Relationship between dry deposited amounts of some components onto model branch and those onto tree branch.

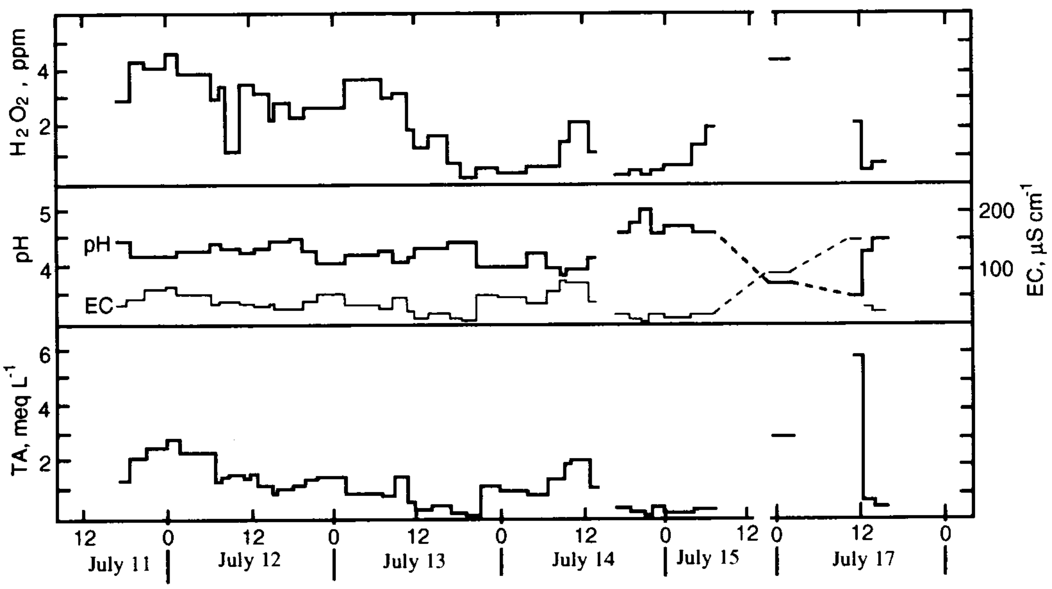

Fig.4 H_2O_2 concentraion, pH, EC and total ion concentrtion in cloud water in Mt. Norikura(July 11-17, 1993)

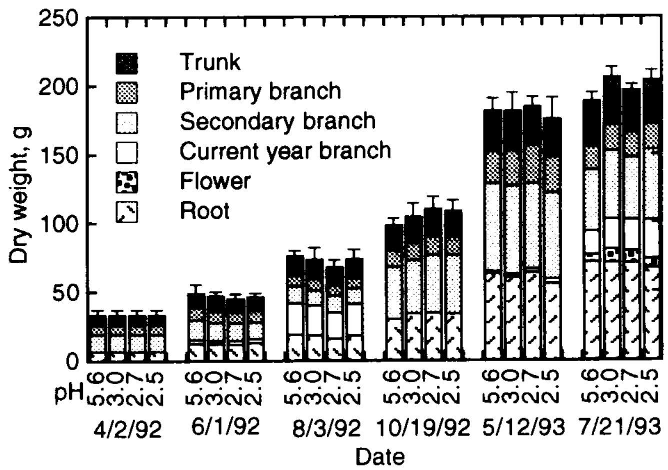

Fig.7 Effect of simulated acid rain on the dry weight of Japanese cedar seedlings

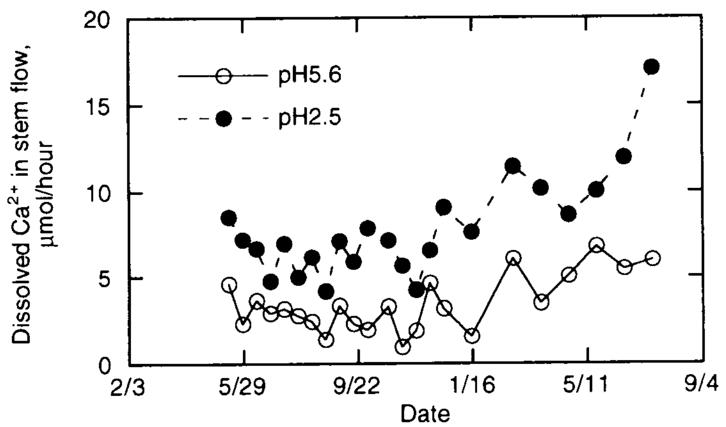

Fig.6 Seasonal change in the amount of dissolved Ca^{2+} in stem flow