An Observation of Acid-snow

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1. Introduction

The second investigation of acid-rain in Japan started in 1988. The interim report of this investigation showed that observed pH-values of precipitation ranged from 4.3 to 5.3. This means acid-rain is a very common phenomenon in Japan region. Haneda and Matsumoto (1983) studied water quality of precipitation in Akita city situated Northwestern part of Japan. They reported that the average pH-value in 1981 was 4.34 that may belong to the highest acidified rain in Japan. From conversation of persons concerned to forestry, a growth of trees is getting worse. We have no means to prove this phenomenon occurring in forestry. However, acid-rain may cause great damage to plants, forests, soils, lakes and rivers. In the snowy regions of Japan, such as western part of Tohoku and Hokkaido, there is much snowfall than rain between December and March. The quantity of snowfall is equivalent to almost a quarter of annual precipitation. For these reason, it is important to monitor continuously the acidity of the falling snow and deposited snow in this area.

2. Measuring the acidity of snow

Measuring the pH-value and electrical conductivity of falling snow in Akita city was started on February 1992. To obtain a snow sample newly deposited each day, a 0.5-meter-size wood plate was set up 1 meter high from the ground. Sampling was carried out at 9 : 00 a.m. to correspond to the report time of the daily snowfall data by J.M.A. The volume of a snow sample must be over 100 cubic centimeter to acquire liquidized snow over 1 cubic centimeter. To avoid volatilization of matters in this liquid, an operation to melt the snow sample was executed very slowly. A sampling point is indicated by an open circle in figure 1.

Observational results of the pH-value on falling snow are as follows.

1) The pH-values ranged between 3.9 to 7.1 in the 1992 winter. The ratio of highly acidified snow, which valued lower than 5.6 P.H., was 69% in this season.

2) The pH-values ranged between 3.9 to 9.5 in the 1993 winter. The ratio of highly acidified snow was 89% in this season.

3) The pH-values ranged between 3.6 to 5.9 in the 1994 winter. The ratio of highly acidified

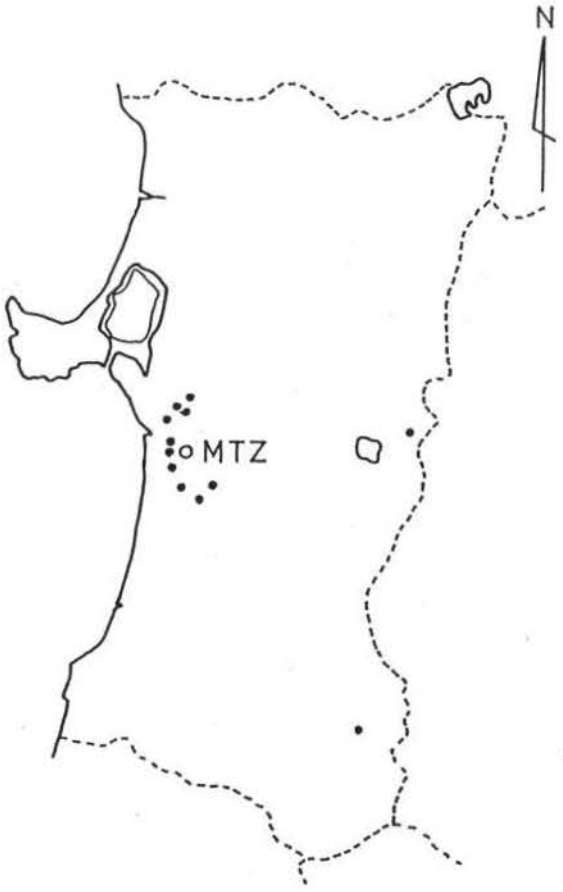

Fig. 1 Sampling points

snow was 94% in this season.

It seems that acidity of falling snow may increase gradually. But sampling number in each season was small as 35, 53 and 34, respectively. Then we must understand that the highly acidified snow ranged in ratio from 69% to 94%.

We have started to monitor the acidity of rain since 1992. The pH-values scattered between 3.8 to 7.4. The ratio of acid-rain was totally 72% which is slightly lower than falling snow. Study group of Toyama's Snow (1993) showed that the pH-value on falling snow observed in Toyama Prefecture ranged between 4.2 to 5.0. Their results are almost same as ours. Frequency distributions of the pH-values for falling snow and rain are shown in figure 2 and figure 3, respectively.

In order to find the seasonal variation of pH-values and electrical conductivities on the snow, monthly averages are calculated and shown in Table-1. It is a subject of interest that the pH-values were small in the middle of winter, January and February. The variance suggests that an increase in the use of fuel for heating caused an increase of carbon dioxide, sulfur dioxide. Then acidity of snow or rain had increased in that season. Electrical conductivity indicates ionized matters as calcium, sodium, potassium and chlorate. Haneda and Matsumoto (1983) pointed that these chemical materials in the precipitation had increased with wind velocity. From our Table-1, weak relation can be seen between electrical conductivity and wind velocity.

The probe for acidity of deposited snow was perfomed temporary near Akita city and Higashinaruse village on February 1992, March 1992, January 1993, May 1993 and December 1993. Sampling points on this study are indicated by closed circles in Figure 1. As shown in the Table-2, the pH-values of deposited snow are not neutrality. If chemical materials in deposited snow could be washed out in the process of snow melting, it is expected that the acidity and the electrical conductivity of deposited snow are lower than falling snow. Our results are not

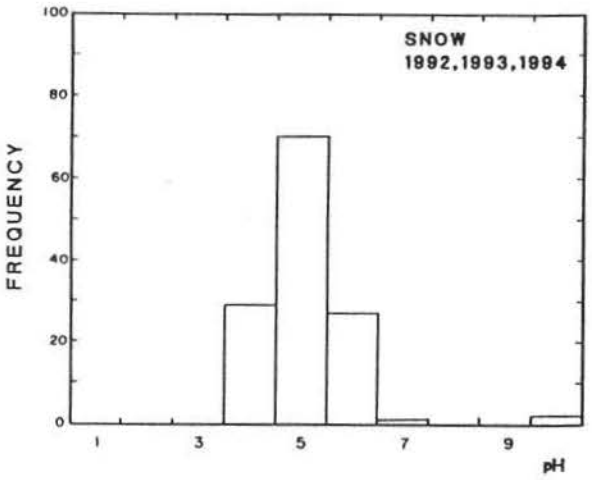

Fig. 2 Frequency distribution of the pH-values for falling snow

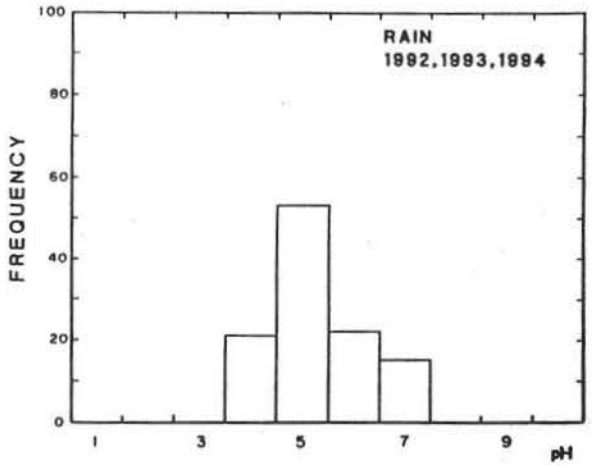

Fig. 3 Frequency distribution of the pH-values for rain

Table 1 Monthly average of pH-value (pH) and electrical conductivity (E.C.) of falling snow, temperature (Temp.) and wind velocity (W.V.) in Akita city

Year	Month	pH	E.C.(mS/cm)	Temp.(°C)	W.V.(m/s)
1992	Feb.	4.61	0.251	0.2	5.8
	Mar.	5.28	0.058	1.1	4.0
	Nov.	5.60	0.156	1.3	5.9
	Dec.	4.48	0.121	1.5	5.9
1993	Jan.	4.36	0.261	0.7	6.4
	Feb.	4.54	0.058	0.6	5.5
	Mar.	5.15	0.043	2.1	4.4
	Dec.	5.04	0.153	3.0	5.8
1994	Jan.	5.06	0.215	-0.6	4.4
	Feb.	4.57	0.226	1.3	6.1
	Mar.	4.64	0.396	2.5	5.2

Table 2 The pH-value (pH) and electrical conductivity (E.C.) of deposited snow

Date	Observation point	pH	E.C.(mS/cm)
'92 Feb. 10	Ooyanaginuma	4.9	0.024
'92 Feb. 22	Akita Fujikura	4.7	0.074
'92 Feb. 25	Akita Kamishinjo	4.5	0.061
ditto	Akita Sasaoka	5.7	0.041
ditto	Akita Heiwa-park	4.7	0.053
ditto	Akita Sensyu-park	5.6	0.074
'92 Feb. 26	Akita Yotsugoya	4.7	0.099
'92 Mar. 27	Tazawako-plateau	4.9	0.019
'93 Jan. 7	Kawabe-machi	4.9	0.053
ditto	Yuwa-machi	4.1	0.127
ditto	Akita Ushijima	4.4	0.070
ditto	Akita Matsubara	4.4	0.062
ditto	Akita Heiwa-park	4.9	0.017
ditto	Akita Fujikura	4.1	0.075
'93 Dec. 27	Ooyanaginuma	4.9	0.038

consistent with above assumption. These data suggest that the deposited snow keeps acidic materials when it melts completely.

3. Discussion

The 1992 Environment Statement told that the total discharge of carbon dioxide from person's activities in Japan has been increasing at the rate of around 4% per year. This fact shows that there seems to be no improvement in our project of carbon dioxide suppression and acidity decreasing. Snow flakes in Akita area are supposed to be originated at about 5000 meters because the top of cumulonimbus is limited to this height in winter. Many materials are taken into snow flakes on the route to the ground. According to this process, acidity of falling snow may be caused by the consumption of fuel in winter.

From the analysis of predominant wind velocity and wind direction in winter season observed by J.M.A., it is found that Akita city area is enclosed by nodal line of 0 m/s as shown in figure 4. This phenomenon means that strong upward or downward force may act on the air along the nodal line. Because the air convection depends on the temperature distribution, upward

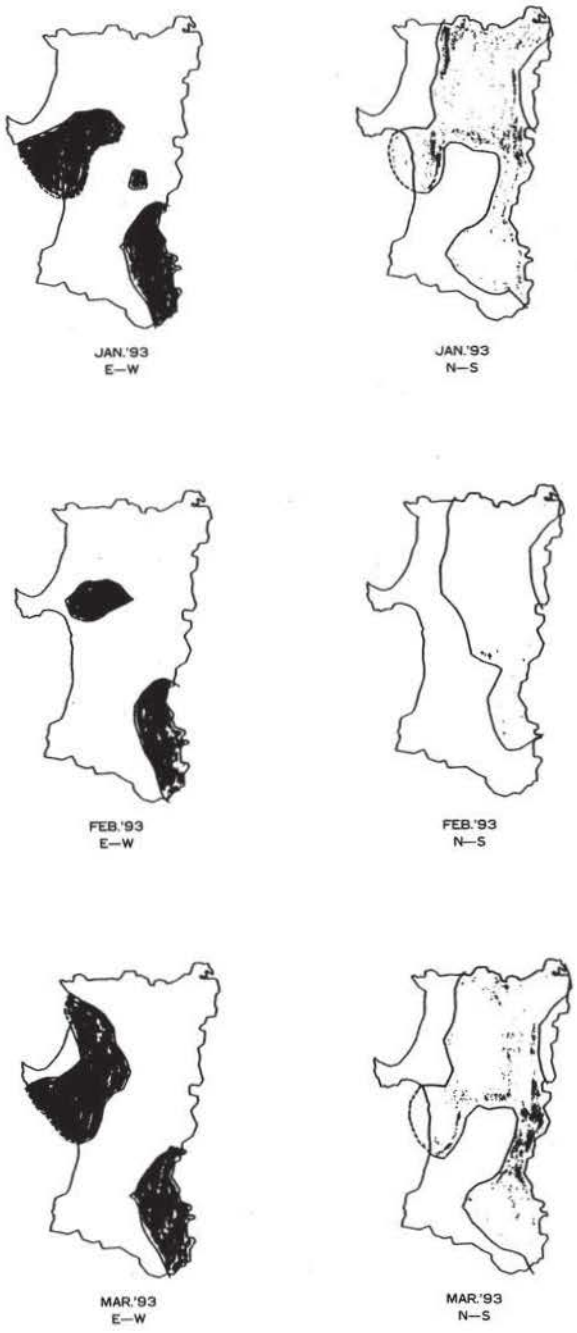

Fig. 4 Analysis of predominant wind in winter. Boundaries of painted area show the node where the wind dies down

force must be seen in winter. It is evident to the former discussion that a lot of thunder storms and some weak tornadoes occurred near the nodal line. Then chemical materials in the exhaust fumes will be raised from the ground.

Our probe has been extended to acid-rain spring through autumn in the same study area.

The average of pH-value and electrical conductivity through 1992 to 1994 were almost same as the results of falling snow in winter. Therefore, the acidified mechanics may be formed by a global environment of the air.

4. Conclusion

We have started to measure the pH-value and electrical conductivity for falling snow and deposited snow since February 1992. About five-sixth of the pH-values for falling snow were lower than 5.6 which is the critical value for acid-rain. The pH-values for deposited snow mainly observed in Akita city showed almost same trends as the falling snow.

In spite of the aggravation of water quality of precipitation including falling snow, there has been insufficient investigation to estimate the effect of acidity to the forest, farming land, lake and river. Then, we have to start gathering remote-sensing data on the forests and soils to study the change of environment.

REFERENCES

1) Haneda, M. and J. Matsumoto, Seasonal characteristics of water quality of precipitation and its pollutant load in Akita city, Proceeding of Japan Society of Civil Engineering, vol. 340, pp. 117-126, 1983
2) Study Group of Toyama's Snow, Study of Acid-snow in Toyama Prefecture, Report of Toyama's Snow, pp. 1-79, 1993