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Dew Chemistry

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Citation

DEW CHEMISTRY

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UAWRRC

Arkansas Water Resources Research Center

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Research Project Technical Completion Report

Project G-1549-06

ABSTRACT

DEW CHEMISTRY

From July, 1989 to July 1990 a total of 98 dews and 9 frosts
were collected at the University of Arkansas Agricultural Experiment
Station, Fayetteville. The total water flux from dews and frosts
per year is less than 2% of that from rains. Acid and nutrient
fluxes are also much lower in dew. In the following series of ions
the number in parenthesis gives the % of the yearly flux of the ion
in dew compared to rain for an average year: H^+(0.08), Ca^{2+}(23),
Mg^{2+}(9), K^+(20), Na^+(5), NH_4^+(12), Cl^-(7), SO_4^{2-}(5) and NO_3^-(6). A
typical dew has a pH of 6.25 compared to 4.9 for the average rain,
and is thus much less acidic. Acetate and formate ions in the
April-June period were, in equivalents, higher in dew than in the
rain and equal to about one half of the nitrate-sulfate total.

The steps governing dew composition are indicated to be (1)
nucleation on dry-deposition solids identified as illite, kaolinite,
quartz, feldspar, calcite, and dolomite (2) dissolving the soluble
portion of the dry deposition by dew water and (3) dissolving of
gaseous NH_3, acetic, and formic acids into the dew solution.

G. H. Wagner

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INTRODUCTION

A. Purpose and Objectives

No state effort and little national effort is being devoted to appraising the importance of dew in the research on acid rain and atmospheric pollutants. Dew involves dry deposition of dust directly onto plants followed by the condensation of moisture on the dust nuclei. Because dew forms directly on the plant and is perhaps more concentrated, especially during its evaporation, than rain, it may overshadow certain rain effects which work mainly through the soil. To understand rain effects, the magnitude and detail of dew effects must be separately understood. A beginning at understanding dew effects would be a knowledge of dew frequency, amount and composition. These are the main objectives of this study. It is hoped, that contributions can be made to the understanding of the dew-forming process.

B. Related Research and Activities

There is a sparse dew literature compared to rain. In more recent studies, General Motors had studied urban dew in a suburb of Detroit (Mulawa et al., 1986). Using a Teflon collector surface in the summer, these authors found: (1) dew to be comparable to rainwater composition except for much higher concentrations of Ca^{2+} and Cl^- and much lower acidity and (2) dew enhanced the deposition of water soluble gases and the retention of dry-deposited particles. In a study of one month's duration (August, 1983), dew chemistry was investigated at a rural site in Michigan, Allegheny Mountain, by Ford Motor Company (Pierson, et al., 1986; 1987). Using a Teflon collector, these authors found (1) dew

chemistry similar to rain chemistry, but more dilute and (2) ionic fluxes in dew were only a few percent of those in rain. Using a Teflon collector at a Claremont, California college campus (Pierson et al., 1988), dew acidity was found to be derived mostly from organic acids. Chameides (1987) by the use of models has studied the role of dew in the deposition of reactive atmospheric gases (SO_2, HNO_3, H_2O_2 and O_3). His article contains a good bibliography of the early dew literature. Our study differs from all the above in being for a much longer time, over all four seasons and involving many more individual dew observations, and, of course, it is for Northwest Arkansas.

METHODS AND PROCEDURES

All collections of dews, frosts and dry depositon were within the weather station compound at the Agricultural Experiment Station, University of Arkansas, Fayetteville. The location is 36 degrees 06' 02" latitude, 94 degrees 10' 24" longitude and an elevation of 391 m.

Initially (July, 1989), dews were collected on polyethylene (PE) sheets (38 cm x 35 cm) clamped to an aluminum sheet which was insulated on its bottom side by 1" of styrofoam encased in polyethylene film. There were two of these collectors located 1.35 m above ground level. All collectors were parallel to the ground and were deployed at all times.

Beginning September 10, 1989 a Teflon collector (96.5 cm x 96.5 cm) was used, mounted on an aluminum angle iron frame 1 m above the ground. This consisted of a 1 mm thick Teflon sheet on a sheet of aluminum. The aluminum sheet was insulated on its bottom side by 1"

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of styrofoam encased in a polyethylene bag. The Teflon sheet and the
insulation were held in place by long stainless steel C-clamps, two
to a side. On one side a gap in the C-clamp of about 0.3 m allowed a
5 cm overhang of Teflon sheet. During the morning collections, this
overhang fitted into the sawed-off top of a 1" polyethylene pipe.
The dew was squeegeed into the polyethylene pipe and ran by gravity
into a wide-mouth polyethylene collecting bottle. A 15 cm Teflon
squeegee was used. Frosts were removed by the Teflon squeegee into
a small sheet of polyethylene, thence into a sampling bottle. The
Teflon sheet on this collector was replaced by another Teflon sheet
of 92 x 92 cm size on April 9, 1990.

A routine was established for collecting. Samples were collected
early each morning shortly after daylight (6 a.m. - 7 a.m.). The
collecting surface was cleaned the preceeding evening usually just
before sundown. Many were done at 8 p.m - 10 p.m. at night early on,
as the dew forming process was believed to start after 10 p.m. In
one instance, frost was found to have already formed at 9 p.m. Other
difficulties like working by auto light led to cleaning just before
sundown. The later the cleaning can be postponed, the more the collec-
tion represents the chemical process during the actual dew formation.
Dry deposition, which is occurring at all times would preferably be
restricted to the time of the dew-forming process.

Cleaning was done by spraying the collector surface with 30 - 50 g
of deionized water and removing with a squeegee. This should be done
at least twice and sometimes more as when the rinse water could be seen

against the white background of the Teflon sheet to be still dirty. Conductivities and pH run on successive 37 g rinses on a particularly dirty collector were: 180, 50, 20, 16 micromhos/cm and in pH: 631, 6.23, 6.14, and 6.06 units. Deionized water of less than 1 micromhos /cm conductivity was used.

Each morning the collector should be cleaned, dew or not. Without this morning cleaning, particulate matter tends to "bake" into the collector. When no dew was present, the rinses were collected and retained as samples of the nightly dry deposition to be analyzed the same way as the dews, and to be compared to dews in composition and flux.

Dews, frosts and dry depositions were taken to the laboratory and conductivity and pH measurements were made within an hour using 10% of the sample. The remaining sample (90%) was filtered and stored at 4° C until shipped in 1-7 days to the Central Analytical Laboratory (CAL). All chemical analyses were made by CAL of the Illinois State Water Survey at Champaign, IL. Samples subsequent to 14A received 0.2% chloroform as a biocide to prevent the loss of acetate and formate ions (Bachman and Peden, 1986). Most samples shipped to CAL were composites of two or more dews. By always compositing the same percentage (90%) of the samples, the analyses became weight-averaged for the collection period. The relative standard deviation of all concentration measurements was less than 10% for all ions except K, acetate, and formate which was near 15% in the lower concentration ranges.

On some days dews were not collected for various reasons, but

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observations were made of the grass or the collector as to whether dew
had formed, and the size of the dew estimated as to being small, medium
or large. Such dews are referred to in the tables as observations to
differentiate them from actual collections. Altogether, there were 98
dews and 9 frosts collected and analyzed, and data from these collec-
tions are used in Figures 1 and 2.

A number of X-ray diffraction analyses were made on selected samples
of particulate matter. Particulate matter was recovered from dews and
frosts during the filtration step. A 1 cm x 2 cm piece of the filter
was placed on double-sticky tape on a glass slide for X-ray diffraction
analyses. A Diano X-ray diffraction unit was employed with Cu-K-alpha
radiation at a setting of 40 KV, 20 ma, time constant of 2.5 seconds,
range of 1 KV and scanning speed of 1 degree min^{-1}. Readings were taken
from 3 degrees to 35 degrees two theta. Identification of minerals was
made by comparing to the two-theta values of standard minerals in Chao
(1969).

PRINCIPAL FINDINGS AND SIGNIFICANCE

A. Frequency and Size of Dews

Fig. 1 gives a daily account for the year July, 1989 to July, 1990
of dews and frosts which were collected and analyzed (62% of the total).
Gaps in the data are the first 13 days of July, 1989 and March, 1990 when
no samples were collected. However, only 4 frosts are estimated for the
March, 1990 period based on 13 days of observation. As expected, most
dews are in the warm months (May, June, July, August), a lesser number
in September, but surprisingly a large number in October. Frosts were

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in the cold months, November to February.

The size of the dew or frost, the pH, and the electrical conductivity are shown in Fig. 1. More large dews occurred in May, June and July. As will be shown later, the PE collector was a somewhat less efficient collector. The PE-collector months, July and August, had no dews with conductivities below 20 micromhos/cm contrary to May and June. This is also believed to be due to the PE collector which will be shown later to collect more acidic dews than Teflon. (H^+ is the most conductive ion).

The pH of dews increased in winter months. Frosts tended to higher pH than dews. Based on the mean values in Fig. 1, the average dew formed 119g of water per square meter of surface, had a pH of 6.25 and a conductivity of 34 micromhos/cm (25° C). The average frost was 94 g/m^2, pH of 7.25 and conductivity of 37 micromhos/cm.

Table 1 summarizes by month the frequency and size of dews. Here, size estimates are made for those dews only observed, but not collected, and for periods when no observations were made. The mass of water contributed by dews per month is quite small and amounts to only 3.6 mm (0.14") in the highest month, June. For the year the total water contribution from dews and frosts was 21.2 mm (0.83"), 1.7% of the normal annual rainfall for the 5 years 1984-1988. The average dew noted above of 119g/m^2 per night is equivalent to only 0.119 mm (0.005") of rain.

For several nights in September and October of 1989, dews were collected at the same site on the polythylene (PE) and Teflon (T) collectors. As noted in the Methods and Procedures section, the PE

collector was smaller and one-third meter higher from the ground than the T collector. The collectors were only 3 m apart. The mass and acidity of dews from the two collectors are compared in Table 2. The T collector is more efficient and generally collected 30 - 50 g/m^2 more dew and occasionally still greater amounts. H$^+$ ion concentration in the PE-collected dew has a modal value of 2.5 times that of the T collector. This is equivalent to 0.30 lower pH in the PE-collected dew.

These differences may well be due to the slightly higher elevation and smaller size of the PE collector. However, it is more likely due in my estimation to the surface chemistry of PE and T and an indication of the types of differences that can be expected in nature on different plant surfaces. It was observed that the PE collector became less hydrophobic with age. Whereas water stood in small beads when the PE was first put into use, a month later dew was less beady and spreading more into an even film when squeegeed. Over the total use time of the T collector, the dew was non-wetting on its surface.

B. Composition and Flux of Dews

Table 3 lists the composition of the dew, frost, and dry deposition samples as determined and reported by CAL. Many of these samples were composites of two or more dews as explained in the Methods and Procedures section. The outstanding data in this table are the high pH values in column one, compared to the normal value of 4.9 for Fayetteville rain. Similarly high values are to be noted in Figures 1 and 2 for the individual dews, determined locally, and immediately after collection. The high pH is due to the alkalinity of the calcite and dolomite in the

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particulate matter in the dews.

It is of interest to compare ionic compositions of dews in Table 1 with an average rain. For 1988, the precipitation weighted means for the various ions in Fayetteville rain (NADP/NTN, 1989) in mg/L were: Ca^{2+}(.26), Mg^{2+}(.025), K^+(.02), Na^+(.115), NH_4^+(.28), NO_3^-(1.00), Cl^-(.17), and SO_4^{2-}(1.5). Dew tends to be 10-20 times more concentrated in Ca^{2+}, Mg^{2+}, NH_4^+, and K^+, but only 1-3 times more concentrated in Na^+, Cl^-, NO_3^-, and SO_4^{2-}. The high values for Ca^{2+}, Mg^{2+}, and K^+ are believed to reflect the much greater exposure of dew to partially soluble clay minerals, feldspar, calcite, and dolomite that were detected in the particulate matter of the dews. The same minerals, except calcite[*] and dolomite[*], have been detected in rain, but generally, in much smaller amounts. High NH_4^+ reflects probably the closeness of the collector to the main source of NH_3, the soil, and absorption of gaseous NH_3 by dew.

In Table 4, the samples have been more clearly identified as to dew, frost, dry deposition, type of collector, and the date collected. Concentration units in Table 4 are in microequivalents/L so that the stoichiometry can be examined. It will be noted in the last column of this table that there is an excess of cations. This excess diminished when analyses for acetate and formate ions were started with sample 17. Samples previous to this were not properly preserved with a biocide. From Sample 17 on, the cation/anion ratio averages 1.29 which is equivalent to 22% of the anions being unaccounted for. In previous work, (Wagner and Steele, 1987), rains were found to generally have a cation/

*Soluble in rain due to its acidity and excess of water,

anion ration of 0.85-1.15. It is believed that other unanalyzed-for organic anions, such as ions of glycolic acid, pyruvic acid, oxalic acid, lactic acid and larger monocarboxcyclic acids may account for the missing anions.

Knowing the water content of each sample, the collector area, and the number of nights involved, the nightly flux of the dews and frosts were calculated and summarized in Table 5. As the dew or frost evaporates from a plant or soil, the flux represents the ionic amount and composition left behind. This seems an important parameter. The samples are listed chronologically with dry deposition samples expunged. The nightly water flux for dews and frosts is about the same for the same time period. As noted previously with individual frost data, frosts tend to higher pH and lower conductivity than dews. There is a tendency to generally lower NO_3^- flux among the frosts which could be due to a lower uptake of nitrogen oxides.

In Table 6 the flux data have been collected by month and compared for the year to ionic fluxes for rain. Dews only observed but not collected are assumed to have compositions of collected dews of the same month. The acid flux (H^+) is only 0.08% of the yearly acid flux for rain averaged over 1981-1983. Ca^{2+} and K^+ have the highest ionic fluxes compared to rain. This is believed to be due to the availability of these ions in minerals in the dry deposition -- Ca in calcite and feldspar and K in clays and feldspar. Other ions have yearly fluxes in the 5-12% range of rain. It is interesting that the Na^+/Cl^- ratio in Table 6 for dew and frost is 0.74, near the 0.86 value of sea salt, aerosols

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of which permeate the troposphere and primarily govern the Na^+/Cl^-
ratio in rain. In the last line of Table 7 the yearly excess of
NH_4^+(12%) over SO_4^2(5%) in dew compared to rain would indicate some
absorption of NH_3 gas by dew to supplement the NH_4HSO_4 aerosol source
in rain (Wagner and Steele, 1987).

In Table 7 the fluxes of dew and dry depositions are compared.
One frost, 11bF-T1, is included. Dry depositions are samples collec-
ted by deionized water rinses of the collector when no dew had formed
on the collector overnight. In general, NH_4^+, acetate, and formate
fluxes are higher in the dews. This can be explained by the absorp-
tion of a gaseous NH_3, acetic acid, and formic acid into dews whose
composition is otherwise determined by the solubility of compounds in
the dry deposition. The deionized water rinses of the collector are
done in a matter of minutes compared to an overnight equilibration of
dew solution with the atmosphere and with the dry deposition.

When applying these results to plants it should be remembered
that all the daytime dry deposition, as well as that during the night
which has fallen since the last dew, is available to the new dew.
Thus, much higher ionic concentrations are exposed to the plant. This
points out the importance of understanding the total dry deposition,
not just that occurring the night of the dew.

The last column in Table 7 lists the minerals identified in var-
ious samples. The same minerals have been identified many times in
a dry deposition by exposing double-sticky-tape slides upwards to the
atmosphere. Also, over 300 rain filters from CAL from across the U.S.A.
have been analyzed by x-ray diffraction for these minerals and all the

same minerals found in Table 7 were identified (Wagner and Steele, 1990), except calcite and dolomite. These latter minerals are soluble in the acid and excess water of rain. In normal rains the amount of particulate matter is 10% or less of the usual concentration in dew.

C. Special Experiments

Sample AR-1A (Table 3 and 4) is condensate from an air conditioner in Building 273 only 75 m from the dew collector. The sample is a composite of samples taken over a 16 day period at 6:30 to 7:00 a.m., at least 12 hours since the last human activity in the building. Note the low Ca^{2+} concentration, high NH_4^+ and acetate concentrations compared to dew samples. This is interpreted as being due to the low availability of solid soil type aerosols (source of Ca^{2+}) in the indoor air, but ready availability of gaseous NH_3 and acetic acid.

Samples AR-41 are splits of the same master sample of dry deposition. The AR-41A moiety was aged without filtration in air for 12 hours inside a closed standard rain collection bucket (about 100 in^2) to simulate the overnight soaking of dry deposition in dew. In Tables 3 and 4 it will be noted that in the soaked sample the Ca^{2+} and HCO_3^- increased at the expense of H^+, acetate and NH_4^+. This indicated that calcareous particulate matter has been dissolved by acetic acid and some NH_3 lost by volatilization as the pH increased to near neutrality. Thus, all the other dry deposition samples in this report, which were filtered, should have the same differences compared to dew which soaks the dry deposition overnight.

A special experiment termed the "iced tea" experiment generated

sample AR-43. In this experiment, a 7 cm O.D. x 1 m Pyrex tube with a closed conical bottom end was mounted vertically next to the dew collector with the conical tip 10 cm from the ground. Ice water was placed inside the tube and condensate on the outside dripped into a widemouth PE collector bottle. Sample AR-43 was collected from 6:30 to 8:30 a.m. and filtered within 1 hour. In Tables 3 and 4 the low ionic content, except of Na^+ and Cl^-, of this sample is recorded. The collective surface is perpendicular to the ground and the time is short in contrast to the regimen of the main body of this report. Thus, conditions do not favor the collection and soaking of particulate matter.

High Na^+ and Cl^- of Sample AR-43 is due to contamination of NaCl from a previous experiment in which salt and ice were used in the Pyrex tube in a futile effort to speed up the collection of condensate. Instead, an icy coating formed on the tube and the process slowed down. The Na^+/Cl^- equivalents ratio of AR-43 of 0.98 rather than 0.86 of sea salt aerosol confirms its NaCl source.

CONCLUSIONS

The water flux and ionic fluxes of dew are small compared to rain. Measured over a year, the water flux from dew is less than 2% of that from rain. Ionic fluxes, compared to rain, are in the range of 5-23% with Ca^{2+}, K^+, and NH_4^+ being in the high end of the range. Dew composition is determined primarily by the water-soluble components of dry deposition (fallout) on which the dew forms: clays, feldspar, calcite and dolomite. This is augmented by absorption of gaseous compounds from the soil: NH_3, acetic acid, and formic acid, or formaldehyde,

which is oxidizable to formic acid.

As measured in this study, dew has access to only the dry deposition formed during the same night as the dew. In reality, all dry deposition since the last dew is available. Dry deposition flux and composition determine these same parameters in dew and are so central as to invite separate detailed study.

ACKNOWLEDGMENT

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Table 1.

FREQUENCY AND SIZE OF DEWS AND FROST

MONTH	DEWS[a]	FROSTS[a]	DAYS OF MISSING DATA[b]	TOTAL[c]			
				NUMBER	MASS (g/m^2)	RAIN EQ (mm)	%COLLECTED
July, 1989	4S,4M,4L	0	13	21	2628	2.60	48
August	9S,6M,6L	0	0	21	2250	2.30	76
September	3S,9M.13L	0	0	25	3473	3.50	45
October	11S,5M,2L	1S	0	19	2028	2.00	89
November	3S,2M	3S,1M	0	9	928	0.93	67
December	5S	6S	0	11	506	0.51	36
January, 1990	3L	2S,4M,1L	0	10	1065	1.10	10
February	0	1S,2M	8	4	496	0.50	50
March	0	1S,1L	18	5	200	0.20	0
April	5S,3M	2S	0	10	1090	1.10	80
May	7S,6M,3L	0	0	14	2969	3.00	88
June	9S,10M,2L	0	0	21	3582	3.60	95
Total for Year	134	25	39	172	21215	21.34	62

a. Total of collected and observed with S=small (0-100 g/m^2), M=medium (100-200 g/m^2), L=large (over 200 g/m^2).

b. No observations made on this number of days, but dew and frosts estimated for this period based on the rate for the rest of the month and added into the total.

c. Actual collections plus observations plus estimate for days of missing data. Observations are dews and frosts qualitatively observed, but not collected. Their mass estimated from average of S (50 g/m^2), M (150 g/m^2) and L (250 g/m^2).

Table 2.

COMPARISON OF THE MASS AND ACIDITY OF DEWS COLLECTED ON POLYETHYLENE (PE) AND TEFLON (T).

Date	pH		$\dfrac{C_H{+}(PE)}{C_H{+}(T)}$ [*]	MASS (g/m^2)	
	PE	T		PE	T
9-27-89	6.84	6.52	0.48	107	155
9-29-80	6.42	6.78	2.3	125	170
9-30-89	6.57	6.98	2.6	130	164
10-1-89	6.52	6.93	2.6	202	255
10-2-89	6.64	6.96	2.1	161	252
10-5-89	3.95	6.10	141.	40	76
10-7-89	6.02	6.68	4.6	218	340
10-8-89	6.57	6.78	1.6	100	151
10-9-89	6.28	6.67	2.5	83	181
10-10-89	-	-	-	21	25
10-11-89	-	-	-	19	52
10-13-89	-	-	-	19	54
10-14-89	-	-		20	67
10-15-89	-	-	-	0	30
10-16-89	-	-	-	0	29

[*]This ratio measures the concentration of H^+ of the dew collected on PE to that collected on Teflon on the same night, $C_H{+}(PE)/C_H{+}(T)=10^{(pH_T-pH_{PE})}$.

Table 3.

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Sample ID	pH (units)	H+ (ueq/L)	Cond. (uS/cm)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	NH4 (mg/L)	NO3 (mg/L)	Cl (mg/L)	SO4 (mg/L)	PO4 (mg/l)	Acetate (mg/L)	Formate (mg/L)
AR 1	6.95	0.112	42.1	2.903	0.168	0.422	0.433	2.96	3.67	0.79	3.05	-0.02	N.D.	N.D.
AR 1A	6.66	0.219	59.4	0.220	0.020	0.038	0.029	8.68	1.73	0.18	0.06	-0.02	22.30	N.D.
AR 2	6.41	0.389	46.9	3.572	0.202	0.329	0.234	2.47	5.05	0.64	8.40	-0.02	N.D.	N.D.
AR 3	7.01	0.098	29.7	2.469	0.073	0.267	0.165	2.08	1.43	0.35	1.30	-0.02	N.D.	N.D.
AR 4	7.02	0.095	43.6	5.750	0.200	0.430	0.167	1.30	2.23	0.40	2.44	0.11	N.D.	N.D.
AR 4B	6.79	0.162	22.7	2.599	0.141	0.289	0.410	0.57	1.79	0.84	1.07	0.03	N.D.	N.D.
AR 5	6.29	0.513	25.2	1.347	0.064	0.180	0.072	2.08	1.90	0.20	4.26	-0.02	N.D.	N.D.
AR 6	6.96	0.110	45.2	4.370	0.122	0.324	0.228	2.00	3.95	0.50	3.18	0.03	N.D.	N.D.
AR 7B	6.08	0.832	64.9	3.700	0.246	0.634	0.265	4.64	6.51	0.62	12.88	0.08	N.D.	N.D.
AR 8	6.34	0.457	28.4	2.316	0.127	0.213	0.085	1.99	1.18	0.18	2.28	0.04	N.D.	N.D.
AR 9A	6.84	0.144	36.9	2.995	0.129	0.409	0.149	2.40	2.11	0.33	3.19	-0.02	0.03	-0.02
AR 9B	6.40	0.398	24.6	1.961	0.118	0.272	0.061	1.52	1.59	0.19	2.12	-0.02	-0.02	-0.02
AR 10B	7.17	0.068	50.7	4.530	0.185	0.385	0.376	2.64	4.10	0.73	4.83	0.11	N.D.	N.D.
AR 10C	6.89	0.129	28.3	3.710	0.145	0.360	0.174	0.48	3.95	0.37	2.68	-0.02	N.D.	N.D.
AR 11	6.70	0.199	22.1	2.201	0.087	0.152	0.310	0.88	1.95	0.54	2.56	-0.02	N.D.	N.D.
AR 11A	6.64	0.229	22.5	2.339	0.117	0.292	0.265	0.56	3.52	0.46	2.13	0.36	N.D.	N.D.
AR 11B	6.67	0.214	12.5	1.058	0.036	0.186	0.143	0.64	0.59	0.24	1.08	-0.02	N.D.	N.D.
AR 12	6.88	0.132	27.7	1.639	0.079	0.133	0.145	2.40	2.24	0.26	2.96	-0.02	N.D.	N.D.
AR 12A	6.92	0.120	39.0	4.048	0.209	0.445	0.301	1.30	6.09	0.57	4.45	0.02	N.D.	N.D.
AR 13	7.27	0.054	64.3	4.830	0.142	0.403	0.253	5.08	7.07	0.46	5.80	-0.02	N.D.	N.D.
AR 13A	7.08	0.083	28.7	2.827	0.101	0.295	0.193	1.66	1.78	0.36	2.18	0.03	N.D.	N.D.
AR 14A	6.75	0.178	22.2	1.767	0.075	0.538	0.865	0.63	0.83	1.48	1.71	-0.02	N.D.	N.D.
AR 15	7.09	0.081	39.3	2.706	0.140	0.294	0.328	2.68	1.42	0.32	4.64	-0.02	-0.02	-0.02
AR 16	6.50	0.316	11.5	1.339	0.060	0.106	0.094	0.09	1.11	0.17	1.37	-0.02	-0.02	-0.02
AR 17	4.34	45.740	25.3	0.750	0.052	0.135	0.146	0.10	1.81	0.29	0.81	-0.02	7.76	0.03
AR 18	6.47	0.339	14.0	0.695	0.071	0.171	0.172	0.96	0.94	0.25	0.68	0.12	4.95	0.23
AR 19	5.68	2.090	18.4	0.593	0.121	0.513	0.255	1.11	1.60	0.57	1.53	0.32	0.56	0.68
AR 20	6.77	0.170	23.7	1.628	0.357	0.998	0.336	0.64	2.05	0.90	1.37	0.65	0.14	0.04
AR 21	6.95	0.112	41.6	2.764	0.717	3.220	0.595	0.86	3.37	1.90	1.68	0.51	0.31	0.39
AR 22	6.57	0.269	16.3	0.421	0.066	0.364	0.136	1.48	0.94	0.36	1.11	0.20	0.34	0.32
AR 23	6.23	0.589	24.6	1.075	0.367	2.420	0.167	0.70	3.40	0.53	1.23	1.48	0.14	0.12
AR 24	6.52	0.302	25.1	0.983	0.159	0.723	0.127	1.99	1.92	0.25	2.06	0.58	0.74	0.54
AR 25	6.29	0.513	21.4	1.066	0.101	0.433	0.109	1.86	1.03	0.31	1.24	0.21	0.46	0.37
AR 26	6.14	0.724	27.8	2.070	0.134	0.384	0.169	1.50	2.63	0.31	3.70	0.38	0.30	0.51
AR 27	6.35	0.447	17.5	0.814	0.108	0.469	0.126	1.27	1.22	0.26	1.26	0.36	0.41	0.39
AR 28	6.65	0.224	20.8	1.190	0.118	0.390	0.217	1.46	1.57	0.47	1.33	0.29	0.50	0.55
AR 29	6.87	0.135	42.1	2.538	0.174	0.446	0.365	3.16	3.88	0.58	2.95	0.31	1.56	1.40
AR 30	6.49	0.324	15.9	0.921	0.103	0.322	0.124	1.11	1.47	0.25	1.20	0.31	0.55	0.42
AR 31	6.57	0.269	17.6	1.200	0.100	0.392	0.101	1.13	0.90	0.29	1.41	0.34	0.58	0.56
AR 32	7.19	0.065	34.6	4.120	0.240	0.761	0.230	0.93	4.00	0.57	2.67	0.45	0.38	0.24
AR 33	5.03	9.336	42.8	2.635	0.336	0.876	0.433	1.65	5.31	0.89	5.97	0.65	0.68	0.84
AR 34	6.30	0.501	15.0	0.563	0.180	0.596	0.066	1.07	1.14	0.22	0.98	0.63	0.34	0.30
AR 35	6.71	0.195	24.6	1.343	0.170	0.475	0.147	1.69	2.64	0.47	1.80	0.42	0.46	0.46
AR 36	6.98	0.105	42.6	4.590	0.278	0.928	0.452	0.99	4.87	1.33	3.05	0.50	0.57	0.55
AR 37	6.83	0.148	21.1	1.144	0.119	0.372	0.109	1.73	1.16	0.29	0.77	0.34	0.81	0.70
AR 38	7.03	0.093	52.2	6.530	0.252	0.490	0.293	1.58	2.65	0.65	4.21	0.36	2.65	4.12
AR 39	6.75	0.178	23.2	1.199	0.105	0.280	0.345	1.59	1.41	0.50	1.41	0.20	0.86	0.91
AR 40	6.08	0.832	30.8	1.828	0.145	0.538	0.306	1.95	1.92	0.61	2.65	0.35	1.72	1.79
AR 41	5.59	2.571	19.5	1.079	0.138	0.698	0.253	0.84	1.97	0.58	1.41	0.41	0.60	0.65
AR 41A	6.48	0.331	18.8	1.644	0.160	0.701	0.311	0.43	1.73	0.64	1.30	0.25	0.50	0.19
AR 42	6.73	0.186	18.3	1.031	0.063	0.230	0.131	1.35	1.16	0.23	0.92	0.13	0.45	0.51
AR 43	5.37	4.267	38.8	0.100	0.010	0.097	6.130	0.21	0.15	9.68	0.20	-0.02	0.22	0.12

Negative values indicate detection limits (i.e. -0.009 means the concentration is less than the detection limit of 0.009).
N.D. = Not determined

Table 4.
COMPOSITIONS OF DEW, FROSTS, AND DRY DEPOSITIONS

Sample CAL	No. This Report*	Date Interval	pH UA Range	pH CAL	Ca++	Mg++	K+	H+	Na+	NH4+	NO3-	Cl-	SO4 2-	PO4 3-	HCO3- **	OH-	ACO-	HCOO-	Σ+	Σ-	Σ+/Σ-
AR-1	1D-PE	7/13-20/89	5/39-6.45	6.95	145	14	11	.112	18.8	164	59	22.2	64	-	46	.090	-	-	353	191	1.85
AR-1A	AC-Drip (Bld #273)	7/13-20/89	5.97-6.65	6.66	11	1.6	1.0	.219	1.3	482	28	5.1	1.3	-	24	.046	378	***	497	436	1.14
AR-2	2D-PE	7/21-27/89	4.62-5.86	6.41	179	17	8.4	.389	10.2	137	81	18	175	-	13	.026	-	-	351	287	1.22
AR-3	3D-PE	7/28-8/3/89	5.21-6.58	7.01	123	6.0	6.8	.098	7.2	116	23	9.9	27	-	53	.103	-	-	259	113	2.29
AR-4	4D-PE	8/4-14/89	4.50-6.76	7.02	288	16	11	.095	7.3	72	36	11.3	51	3.6	54	.106	-	-	394	156	2.53
AR-4B	4bDD-PE	8/2-7/89	5.01-5.78	6.79	130	12	7.4	.162	17.8	32	29	23.7	22	.9	32	.062	-	-	199	107	1.86
AR-5	5D-PE	8/15-23/89	4.77-6.23	6.29	67	5.2	4.6	.573	3.1	116	31	5.6	89	-	10	.020	-	-	196	136	1.44
AR-6	6D-PE	8/24-9/6/89	4.38-6.24	6.96	244	10	8.3	.110	9.9	111	64	14.1	66	.9	47	.092	-	-	383	191	2.00
AR-7B	7D-T1	9/7-9/28/89	3.55-6.66	6.08	185	20	16	.832	11.5	258	105	17.5	268	2.4	6	.012	-	-	492	397	1.24
AR-8	8D-T1	9/29-10/3/89	6.93-6.98	6.34	116	10	5.4	.457	3.7	111	19	5.1	48	1.2	11	.022	-	-	246	83	2.96
AR-9A	9aD-PE	10/4-10/89	3.95-6.57	6.84	150	11	10	.144	6.5	133	34	9.3	66	-	36	.070	.5+.4	.5+.4	311	145	2.14
AR-9B	9bD-T1	10/4-10/89	6.10-6.95	6.40	98	10	7.0	.398	2.7	84	26	5.4	44	-	13	.025	.0+.4	.0+.4	202	86	2.35
AR-10B	10bD-T1	10/11-23/89	6.41-7.27	7/17	227	15	10	.068	16.3	147	66	20.6	101	3.6	76	.149	-	-	414	264	1.57
AR-10C	10cDD-T1	10/12-22/89	6.35-7.34	6.89	186	12	9.2	.129	7.6	27	64	10.4	56	-	40	.078	-	-	242	170	1.42
AR-11	11D-T1	10/25/11/3/89	5.70-6.86	6.70	110	7.2	3.9	.199	3.5	49	31	15.2	53	-	26	.051	-	-	184	125	1.47
AR-11A	11aDD-T1	10/27-11/10/89	6.36-6.98	6.64	117	9.6	7.5	.229	11.5	31	57	13.0	44	11	23	.044	-	-	177	148	1.20
AR-11B	11bF-T1	10/27-11/19/89	6.50-6.86	6.67	53	3.0	4.8	.214	6.2	36	10	6.8	23	-	24	.047	-	-	103	64	1.61
AR-12	12D-T1	11/20-27/89	5.62-7.12	6.88	82	6.5	3.4	.132	6.3	133	36	7.3	62	-	40	.078	-	-	231	145	1.59
AR-12A	12aDD-T1	11/11-15/89	6.55-7.72	6.92	202	17	11	.120	13.1	72	98	16.0	93	.6	43	.084	-	-	315	250	1.26
AR-13	13D-T1	11/29-12/11/89	6.95	7.27	242	12	10	.054	11.0	282	114	13.0	121	-	103	.202	-	-	557	351	1.59
AR-13A	13aF-T1	11/29-12/11/89	7.38-7.77	7.08	141	8.3	7.5	,083	8.4	92	29	10.1	45	.9	64	.126	-	-	257	148	1.74
AR-14A	14F-T1	2/6-11/90	6.35-6.59	6.75	88	6.2	14	.178	37.6	35	13	41.6	36	-	29	.056	-	-	181	120	1.51
AR-15	15F-T2	4/10-11/90	7.39	7.09	135	12	7.5	.081	14.0	149	23	9.0	97	-	64	.125	-	-	318	193	1.65
AR-16	16D-T2	4/11-12/90	6.65	6.50	67	4.9	2.7	.316	4.1	5	18	4.8	29	-	16	.032	-	-	84	68	1.24
AR-17	17DD-T2	4/17-18/90	5.79	4.34	38	4.3	3.5	45.7	6.3	6	29	8.2	17	-	0.11	.0002	132		104	186	0.56
AR-18	18D-T2	5/21-22/90	6.08	6.47	35	5.8	4.4	.339	7.5	53	15	7.0	14	3.9	15	.030	84	5.1	106	144	0.74
AR-19	19D-T2	4/22-23/90	5.60	5.68	30	10	13	2.09	11.0	62	26	16.0	32	10	2.5	.005	9.5	13.0	128	109	1.17
AR20	20DD-T2	4/23-24/90	6.04	6.77	81	29	26	.17	15.0	36	33	25.4	29	20	30	.06	2.4	0.9	187	141	1.33
AR-21	21D-T2	4/24-25/90	6.48	5.95	138	59	82	.112	26.0	48	54	53.5	35	16	46	.09	5.3	8.7	353	219	1.61
AR-22	22D-T2	4/26-28/90	5.85-6.39	6.57	21	5.4	9.3	.269	5.9	82	15	10.1	23	6.3	19	.038	5.8	7.1	123	86	1.43
AR-23	23DD-T2	4/27-5/8/90	5.83-6.42	6.23	54	30	62	.589	7.3	39	55	14.9	26	48	8.8	.017	2.4	2.7	193	158	1.22
AR-24	24D-T2	4/29-5/7/90	6.72-6.77	6.52	49	13	18	.302	5.5	111	31	7.0	43	18	17	.033	13	12.0	197	141	1.40
AR-25	5/8-10/90	5/8-10/90	6.01-6.58	6.29	53	8.3	11	.513	4.7	103	17	8.7	26	6.6	10	.020	7.8	8.2	181	84	2.15
AR-26	26DD-T2	5/10-11/90	6.64	6.14	104	11	9.8	.724	7.3	83	42	8.7	77	12	7.1	.014	5.0	11.0	216	163	1.33
AR-27	27D-T2	5/12-14/90	5.83-6.33	6.35	41	8.9	12	.447	5.5	71	20	7.3	26	11	12	.023	6.9	8.7	139	92	1.51
AR-28	28D-T2	5/14-17/90	6.41-6.65	6.65	60	9.7	10	.224	9.4	81	25	13.2	28	9.3	23	.045	8.5	12.0	170	119	1.43
AR-29	29D-T2	5/17-18/90	6.67	6.87	127	14	11	.135	16.0	176	63	16.3	61	10	38	.075	26	31	344	245	1.40
AR-30	30D-T2	5/21-22/90	6.16	6.49	46	8.5	8.2	.324	5.4	62	24	7.0	25	10	16	.031	9.3	9.3	130	101	1.29
AR-31	31D-T2	5/22-24/90	6.24-6.43	6.57	60	8.2	10	.269	4.4	63	15	8.2	29	11	19	.038	9.8	12.0	146	104	1.40
AR-32	32DD-T2	5/24/31/90	5.01-7.68	7.19	206	20	19	.065	10.0	52	65	16.0	56	14	79	.16	6.4	5.3	307	242	1.27
AR-33	33D-T2	5/25-28/90	4.75-6.22	5.03	132	28	22	9.34	19.0	92	86	25.1	124	21	.55	.0011	12	19.0	302	288	1.05
AR-34	34D-T2	5/28-29/90	5.69	6.30	28	15	15	.501	2.9	59	18	6.2	20	20	10	.020	5.8	6.7	120	87	1.38
AR-35	35D-T2	5/31-6/3/90	5.61-6.08	6.71	67	14	12	.195	6.4	94	43	13.2	37	13	26	.052	7.8	10.0	194	150	1.29
AR-36	36DD-T2	6/2-13/90	6.58-6.89	6.98	230	23	24	.105	.105	55	79	37.5	64	16	49	.096	9.7	12	352	267	1.32
AR-37	37D-T2	6/3-5/90	6.21-6.52	6.83	57	9.8	9.5	.148	4.7	96	19	8.2	16	11	35	.068	14	16	177	119	1.49
AR-38	38D-T2	6/5-7/90	7.03-7.10	7.03	327	21	13	.093	12.7	88	43	18.3	88	11	55	.11	45	92	462	352	1.31
AR-39	39D-T2	6/8-10/90	6.35-6.41	6.75	60	8.6	7.2	.178	15	88	23	14.1	29	6.3	29	.057	14	20	179	135	1.33
AR-40	40D-T2	6/11-19/90	5.06-6.09	6.08	91	12	14	.832	13	108	31	17.2	55	11	6.1	.012	29	40	239	190	1.26
AR-41	41DD-T2	6/16-20/90	5.82-5.85	5.59	54	11	18	2.571	11	47	32	16.3	29	13	2.0	.004	10	14	144	116	1.24
AR-41A	41aDD-T2 4+	6/16-20/90	5.77-6.08	6.48	82	13	18	.331	14	24	28	18.0	27	7.8	16	.031	8.5	4.2	151	110	1.37
AR-42	42D-T2	6/22-27/90	5.67-6.62	6.73	52	5.2	5.9	.186	5.7	75	19	6.5	19	2.9	28	.054	7.6	11	144	94	1.53
AR-43	"ice tea" exp.	6/28/90	5.83	5.37	5	0.8	2.2	4.268	2.67	12	2.4	273.0	4.2	-	1.0	.002	3.7	2.7	291	287	1.01

*Collectors were polyethylene(PE)or Teflon (T1) (0.932 m^2); T2 (0.848 m^2) on which dew (D), frost (F) or dry deposition (DD) was collected. Sample AR - 1A is air conditioner drip from a nearby building.

** OH$^-$ and HCO$_3^-$ calculated as follows: OH$^-$ = 0.0101/H$^+$; HCO$_3^-$ = 511 (OH$^-$).

*** Acetate interfered.

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Table 5.

NIGHTLY FLUX OF VARIOUS IONS IN DEWS AND FROSTS

$\mu eq/m^2/night$

Sample[a]	H_2O[b]	Date	Ca^{2+}	Mg^{2+}	K^+	H^+	Na^+	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	HCO_3^-	OH^-	AcO^-	$HCOO^-$
1D-PE	110	7/13-20-89	16	1.5	1.2	0.012	2.1	18	6.6	2.4	7.0	-	5.0	0.001	-	-
2D-PE	231	7/21-27/89	41	4.0	1.9	0.090	2.4	32	19.0	4.2	40	-	3.0	0.006	-	-
3D-PE	159	7/28-8/3/89	20	1.0	1.1	0.016	1.1	19	3.6	1.6	4.4	-	8.4	0.016	-	-
4D-PE	128	8/4-14/89	37	2.0	1.4	0.012	0.94	9.2	4.5	1.4	6.5	0.46	6.8	0.014	-	-
5D-PE	352	8/15-23/89	24	1.8	1.6	0.180	1.1	41	11	2.0	31	-	3.6	0.007	-	-
6D-PE	110	8/24-9/6/89	27	1.1	0.92	0.012	1.1	12	7	1.6	7.3	0.10	5.1	0.010	-	-
7D-T1	95	9/7-28/89	18	1.9	1.5	0.080	1.1	25	10	1.7	25	0.14	0.58	0.001	-	-
8D-T1	189	9/29-10/3/89	22	1.9	1.0	0.086	0.70	21	3.6	0.96	9.0	0.22	2.0	0.004	-	-
9aD-PE	152	10/4-10/89	11	0.84	0.77	0.011	0.50	10	2.7	0.70	5.0	-	2.7	0.005	.04$\pm$.03	.0$\pm$.03
9bD-T1	130	10/4-10/89	13	1.3	0.92	0.052	0.35	11	3.3	0.70	5.7	-	1.7	0.003	-	-
10bD-T1	50	10/11-23/89	11	0.75	0.50	0.003	0.82	7.3	3.3	1.0	5.0	0.18	3.8	0.008	-	-
11D-T1	134	10/25-11/3/89	15	0.95	0.50	0.025	1.8	6.5	4.1	2.0	7.0	-	3.5	0.007	-	-
11bF-T1	127	11/1-3/89	7	0.39	0.60	0.025	0.80	4.6	1.3	0.85	2.9	-	3.0	0.006	-	-
12D-T1	192	11/20-27/89	14.3	1.1	0.60	0.023	1.1	23	6.3	1.3	11	-	7.0	0.014	-	-
13D-T1	40	12/5-6/89	9.7	0.48	0.40	0.002	0.44	11	4.6	0.52	4.8	-	4.1	0.008	-	-
13aF-T1	35	11/29-12/11/89	5.0	0.30	0.25	0.004	0.30	3.2	1.0	0.35	1.5	0.032	2.2	0.005	-	-
14F-T1	139	2/6-11/90	12	0.85	1.9	0.025	5.2	5.0	1.8	6.0	5.5	-	4.0	0.008	-	-
15F-T2	102	4/10-11/90	14	1.2	0.77	0.0083	1.4	15	2.3	0.92	9.9	-	6.5	0.013	-	-
16D-T2	168	4/11-12/90	11	0.82	0.45	0.053	0.69	0.84	3.0	0.81	4.9	-	2.7	0.005	-	-
18D-T2	248	4/21-22/90	8.7	1.4	1.1	0.034	1.9	13	3.7	1.7	3.5	0.97	3.7	0.007	21	1.3
19D-T2	153	4/22-23/90	4.6	1.5	2.0	0.32	1.7	9.5	4.0	2.4	4.9	1.5	0.38	0.0008	1.5	2.0
21D-T2	80	4/24-25/90	11	4.7	6.6	0.009	2.1	3.8	4.3	4.3	2.8	1.3	3.7	0.0072	0.42	0.7
22D-T2	187	4/26-28/90	3.9	1.0	1.7	0.050	1.1	16	2.8	1.9	4.3	1.2	3.6	0.0070	1.1	1.4
24D-T2	142	4/29-5/7/90	7.0	1.9	2.6	0.043	0.8	16	4.4	1.0	6.0	2.6	2.4	0.0045	1.9	1.7
25D-T2	137	5/8-10/90	7.5	1.6	1.5	0.070	0.65	14	2.3	1.2	3.6	0.90	2.7	0.0025	1.6	1.1
27D-T2	126	5/12-14/90	5.0	1.7	1.5	0.057	0.70	9.0	2.6	0.9	3.3	1.4	1.5	0.003	0.85	1.1
28D-T2	157	5/15-17/90	9.5	1.6	1.6	0.036	1.5	13	3.9	2.1	4.4	1.5	3.6	0.007	1.4	1.9
29D-T2	121	5/18-19/90	15	1.7	1.3	0.016	1.9	21	7.6	2.0	7.4	1.2	4.6	0.009	3.1	3.8
30D-T2	229	5/21-22/90	11	1.9	1.9	0.074	1.2	14	5.5	1.6	5.7	2.3	3.7	0.007	2.1	2.1
31D-T2	199	5/23-25/90	12	1.7	2.0	0.053	0.9	13	3.0	1.7	6.0	2.2	3.8	0.008	2.0	2.4
33D-T2	72	5/26-28/90	9.5	2.1	1.6	0.67	1.4	.6.5	6.0	1.8	9.0	1.5	0.04	0.0002	0.85	1.4
34D-T2	261	5/28-29/90	7.3	3.9	3.9	0.131	0.76	15	4.7	1.6	5.2	5.2	2.6	0.005	1.5	1.7
35D-T2	152	6/1-3/90	10	2.6	1.9	0.029	1.0	15	6.5	2.0	5.5	2.0	3.9	0.008	1.2	1.5
37D-T2	190	6/4-6/90	11	1.9	1.8	0.028	0.9	19	3.6	1.6	3.0	2.1	6.5	0.013	2.6	3.1
38D-T2	89	6/5-7/90	15	0.95	0.60	0.004	0.55	3.9	1.9	0.8	3.9	0.50	2.5	0.005	2.0	4.1
39D-T2	173	6/8-10/90	10	1.5	1.3	0.031	2.6	15	4.0	2.9	5.0	1.1	5.0	0.010	2.4	3.9
40D-T72	108	6/12-19/90	9.8	1.3	1.5	0.090	1.4	12	3.4	1.9	6.0	0.66	1.2	0.0012	3.2	4.4

a. D=Dew, F=Frost, PE=Polyethylene Collector (0.135m² area), T1=Teflon Collector (0.932m²), T2=Teflon Collector (0.85m²).
b. Average g/m²/night of D or F that formed on the collector. Exposure per night was 9-12 hours.

Table 6.

MONTHLY IONIC FLUXES IN DEW AND FROST

μ eq/m^2/month*

Month	Ca^{2+}	Mg^{2+}	K$^+$	H$^+$	Na$^+$	NH$_4^+$	NO$_3^-$	Cl$^-$	SO$_4^{2-}$	PO$_4^{3-}$	HCO$_3^-$	AcO$^-$	HCOO$^-$
July, 1989	602	51	33	0.918	44	535	227	64	405	-	128	NA	NA
August	688	38	30	1.39	25	215	172	39	324	4.5	124	NA	NA
September	436	42	29	1.83	20	502	150	29	378	4.8	29	NA	NA
October	270	21	16	0.50	16	205	72	21	121	1.2	63	NA	NA
November	76	5.6	4.0	0.16	6.5	105	29	7.3	52	-	36	NA	NA
December	72	4.0	3.4	0.043	4.1	58	21	4.6	26	0.31	31	NA	NA
January, 1990	67	4.7	11	0.135	29	28	9.9	33	31	-	22	NA	NA
February	31	2.2	5.0	0.063	13	13	4.6	16	14	-	10	NA	NA
March	21	1.5	3.4	0.042	9	8.6	3.1	10	9.5	-	6.9	NA	NA
April	69	14	17	0.69	12	88	28	17	41	7.4	29	30	12
May	151	30	32	2.35	18	216	70	25	93	32	41	25	30
June	187	22	25	0.844	23	215	65	30	86	23	52	43	61
Σ	2670	236	209	8.97	220	2188	851	296	1581	73	572	-	-
Rain**	11617	2657	1046	11670	4761	18728	14455	4544	29200	-	-	-	-
Σ/Rain(%)	23	9	20	0.08	5	12	6	7	5	-	-	-	-

*A blank indicates less than detection limit,
NA = not analyzed

**Yearly average for 1981-1983 rains (Wagner and Steele, 1987)

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Table 7.

COMPARISON OF DEW AND DRY DEPOSITION
NIGHTLY IONIC FLUX

Flux ($\mu eq/m^2$/night)

Sample*	Date Interval	Ca^{2+}	Mg^{2+}	K^+	H^+	Na^+	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	HCO_3^-	OH^-	ACO^-	$HCOO^-$	Minerals** Identified
4bDD-PE	8/2-7/89	19	1.8	1.1	0.024	0.03	5.0	4.4	3.6	3.2	0.14	5.0	0.009	-	-	not analyzed
3D-PE	7/28-8/3/89	39	2.0	2.2	0.032	2.2	37	7.2	3.2	8.6	-	17	0.032	-	-	not analyzed
4D-PE	8/4-14/89	74	4.0	2.8	0.025	1.8	18.8	9.2	2.8	13	0.46	14	0.027	-	-	not analyzed
10cDD-T1	10/12-22/89	14	0.90	0.72	0.010	0.60	2.1	5.0	0.80	4.2	-	3.0	0.006	-	-	I,K,Q,F,C
10bD-T1	10/11-23/89	11	0.75	0.50	0.003	0.82	7.3	3.3	1.0	5.0	0.18	3.8	0.008	-	-	I,Q,F,C
11aDD-T1	10/27-11/10/89	6.6	0.55	0.43	0.013	0.65	1.8	3.1	0.73	2.6	0.63	1.3	0.003	-	-	I,Q,F,C,D
11D-T1	10/25-11/3/89	15	0.95	0.50	0.025	1.8	6.5	4.2	2.1	7.0	-	3.5	0.007	-	-	I,K,Q,F,D
11bF-T1	11/1-3/89	7	0.38	0.60	0.025	0.80	4.6	1.3	0.9	2.9	-	3.1	0.006	-	-	I,Q
12aDD-T1	11/11-15/89	11	0.92	0.60	0.006	0.70	4.0	5.2	0.87	5.0	0.032	2.3	0.005	-	-	not analyzed
12D-T1	11/20-27/89	16	1.2	0.67	0.027	1.2	26	7.0	1.4	12	-	8.0	0.015	-	-	I,K,Q,F,C,D
17DD-T2	4/17-18/90	2.7	0.31	0.25	3.24	0.45	0.43	2.1	0.582	1.2	-	0.01	0.00002	9.4	0.06	not analyzed
16D-T2	4/11-12/90	11	0.82	0.45	0.053	0.69	0.84	3.0	0.81	4.9	-	2.7	0.005	-	-	not analyzed
18D-T2	4/21-22/90	8.7	1.4	1.10	0.084	1.9	13	3.7	1.7	3.5	0.97	3.7	0.007	21	1.3	not analyzed
20DD-T2	4/23-24/90	10.0	3.6	3.2	0.021	1.9	4.5	4.1	3.1	3.6	2.5	3.7	0.0074	0.30	0.11	I,Q,C
19D-T2	4/22-23/90	4.6	1.5	2.0	0.320	1.7	9.5	4.0	2.4	4.9	1.5	0.38	0.0008	1.5	2.0	not analyzed
21D-T2	4/24-25/90	11.0	4.7	6.6	0.009	2.1	3.8	4.3	4.3	2.8	1.3	3.7	0.0072	0.42	0.70	not analyzed
23DD-T2	4/27-5/8/90	4.9	2.7	5.5	0.053	0.65	3.5	5.0	1.3	2.4	4.4	0.80	0.0016	0.22	0.25	not analyzed
22D-T2	4/26-28/90	3.9	1.0	1.8	0.050	1.1	15	2.8	1.9	4.3	1.2	3.5	0.007	1.1	1.4	not analyzed
26DD-T2	5/10-11/90	9.6	1.0	0.9	0.067	0.67	7.6	3.9	0.80	7.1	1.1	0.65	0.0013	0.46	1.0	not analyzed
25D-T2	5/8-10/90	7.5	1.2	1.5	0.070	0.65	14	2.3	1.2	3.6	0.9	1.4	0.0025	1.6	1.1	not analyzed
27D-T2	5/12-14/90	5.0	1.2	1.5	0.056	0.70	9.0	2.6	0.90	3.3	1.4	1.5	0.003	0.85	1.1	not analyzed
32DD-T2	5/24-31/90	20	1.9	1.8	0.006	0.95	4.9	6.0	1.5	5.5	1.3	7.5	0.015	0.6	0.5	I,Q,F,C
31D-T2	5/22-24/90	12	1.7	2.0	0.053	0.90	13	3.0	1.6	6.0	2.2	3.8	0.008	1.9	2.4	not analyzed
33D-T2	5/26-28/90	9.5	2.1	1.6	0.670	1.4	6.5	6.0	1.8	9.0	1.5	0.04	0.0001	0.85	1.4	not analyzed
36DD-T2	6/2-13/90	17	1.7	1.8	0.008	1.5	4.0	6.0	2.8	4.7	1.2	3.6	0.007	0.70	0.90	not analyzed
37D-T2	6/3-5/90	11	1.9	1.8	0.028	0.90	18	3.6	1.6	3.0	2.1	6.5	0.013	2.6	3.1	I,Q,F
41DD-T2	6/16-20/90	3.2	0.65	1.1	.148	0.65	2.8	1.9	0.95	1.7	0.75	0.12	0.0002	0.60	0.85	not analyzed
41aDD-T2	6/16-20/90	4.8	0.75	1.1	.020	0.85	1.4	1.7	1.1	1.6	0.46	0.95	0.0018	0.50	0.25	not analyzed
42D-T2	6/22-27/90	11.4	1.1	1.3	.041	1.2	16	4.2	1.4	4.2	0.64	6.2	0.012	1.7	2.4	not analyzed

* D=dew, DD=dry depositon, F=frost

**By X-ray diffraction of particulate matter on 0.22μm pore size filter
 I=illite, K=kaolinite, Q=quartz, F=feldspar, C=calcite, D=dolomite
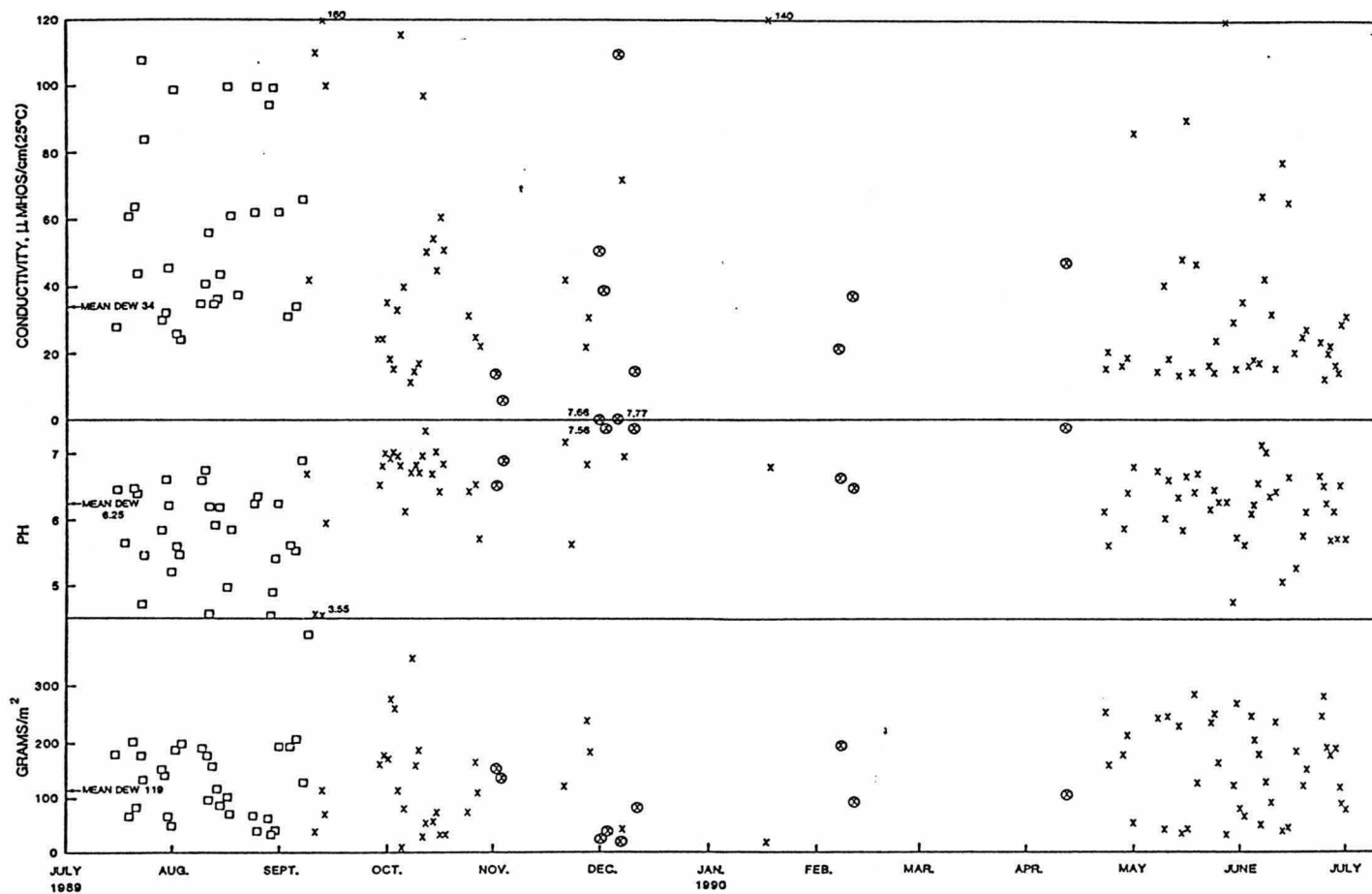
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Figure 1.

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Figure 2.