MONITORING FOR SALT EFFECTS AT THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP) currently under construction in southeastern New Mexico is a research and development facility to demonstrate the safe disposal of radioactive waste in a deep geological medium (bedded salt). The Ecological Monitoring Program at WIPP is designed to detect and measure changes in several ecosystem compartments. The primary factor which may affect the system prior to waste emplacement is the impact of windblown salt from discrete stockpiles on vegetation and surface soil processes. Control and experimental (potentially affected) plots have been established at the site and direct measurement of salt concentrations of surface soils are made quarterly in each plot. Deep soils have been sampled annually. To date, a pattern of accumulation and subsequent leaching of salts from the coarse-textured soils appears to be driven by annual rainfall patterns.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is a research and development facility operated for the Department of Energy by Westinghouse Electric Corporation to demonstrate the safe disposal of defense-generated transuranic (TRU) radioactive wastes in bedded salt 650 m below ground surface. The salt is mined and stockpiled at two locations on the surface at the facility, located 40 km southeast of Carlsbad, New Mexico. The site is on a sand-covered plain dominated by stabilized coppice dunes. Soils are typically deep (1.5 to 2.0 m) aeolian sands over a well-developed calcic horizon (caliche), are highly permeable (10-20 cm/hr) and have low water-holding capacities. The potential for wind erosion is very high if vegetation is removed. The dominant species in the area are shinnery oak (*Quercus havardii*), mesquite (*Prosopis glandulosa*) and sand sage (*Artemisia filifolia*).

The Ecological Monitoring Program at WIPP is designed to detect and measure changes in several ecosystem compartments which may signal that biotic function is being impacted by project activity. The primary factor which may affect the ecosystem prior to waste emplacement is the impact on vegetation and soil processes of windblown salt from discrete stockpiles. The design of the program is outlined in the annual Ecological Monitoring Program Reports (1,2). This paper will focus on salt impacts measured as ion concentrations in surface and subsurface soils sampled over three years.

METHODS

Permanent control and experimental (potentially affected) plots were established in 1984. Beginning in 1985, chemical parameters have been measured quarterly in surface soils from each plot. In addition, vegetative growth and reproduction in the plots are assessed twice annually to detect any inhibition of those parameters by changing soil salt concentrations. Subsurface soils are sampled annually at two depths (30-45 cm and 60-75 cm) to trace the movement of ions through the soil profile.

Four ecological monitoring plots are located in close proximity to the site to reveal construction related impacts and two plots are located approximately 2 km from the site to act as controls (Fig. 1). The four impacted plots are arranged in two pairs, one to the northwest (NW-1 and -2) of the north saltpile (near-field) and the other pair (SE-1 and -2) to the southeast of the east saltpile (far-field). The first plot of each pair is located adjacent to its nearest saltpile and the second is located approximately 150 m away. A seventh plot, east of the site and immediately northwest of the old (SE) saltpile, was added to the program in 1985, but data from that plot have not been included in this analysis.

This paper describes the results of quarterly analyses of surface soil samples and the annual analyses of subsurface soils. Although surface processes (litter decomposition, microbial activity levels and germination) are expected to exhibit effects of salt inhibition first, it is also important to monitor the deeper soil because the vegetative dominants at the site are deep-rooted species. Accumulation of ions in the deep soils could have a very negative impact on the system. To date, a pattern of accumulation and subsequent leaching of salts from the soil surface seems to be driven by annual rainfall patterns (Fig. 2), and the same pattern, somewhat muted, appears in the subsurface soils as well.

RESULTS AND DISCUSSION

Surface Soil (0-2 cm)

The surface soil samples collected quarterly are analyzed for soil parameters which may be indicative of the impacts under study. Patterns of interest include:

- Consistent increases in concentrations of specific ions over time
- Seasonal variation in soil parameters which are consistent in all plots
- Identification of patterns which may indicate interactions among components

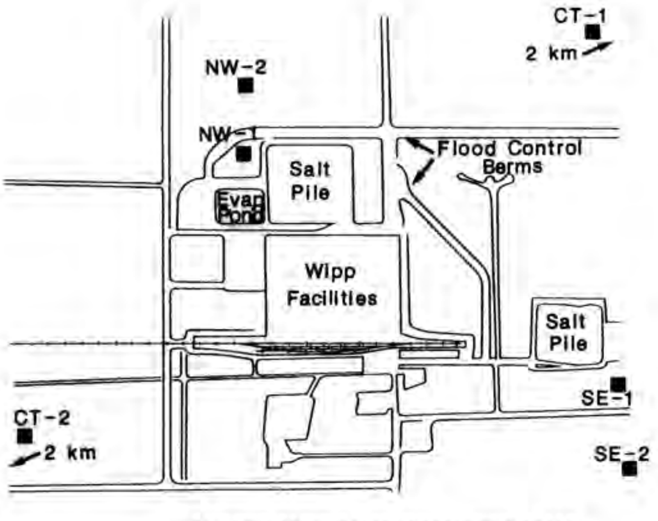

Fig. 1. The location of the Ecological Monitoring Plots at the Waste Isolation Pilot Plant.

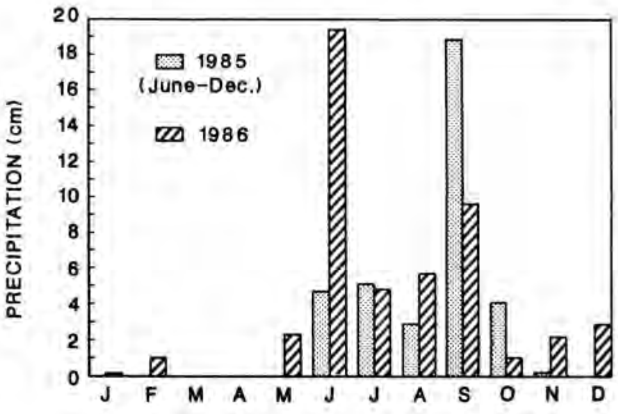

Fig. 2. Monthly precipitation recorded at the Waste Isolation Pilot Plant.

of the soil ecosystem, or the larger interacting system.

Six samples of surface soil are collected from each ecological monitoring plot every three months and are analyzed for the following parameters: chloride (mg/kg), pH, electrical conductivity (umho/cm), calcium (mg/l), magnesium (mg/l), potassium (mg/l) and sodium (mg/l). Cations, pH and electrical conductivity values are measured in a saturated soil paste. Chloride levels are measured in a water extract. Log transformed data are statistically evaluated using the Statgraphics software program for analysis of variance (anova). When the anova results indicate significant differences exist for a parameter among plots, a Student-Newman-Kuels test (3) is run to identify which plots differ. Cumulative data for the parameters measured in surface soil (except pH) are illustrated in Fig. 3 and discussed below.

Calcium. Calcium accumulates in the surface soil during dry periods and is leached slowly from the surface during periods of intense rainfall. Heavy rains (Fig. 2) occurred in the fall of 1985 and the summer of 1986. Calcium concentrations are similar in control and far-field plots, but are elevated in near-field plots.

Magnesium. Magnesium values follow a pattern similar to that of calcium although levels are so low that often only 3 or 4 mg/l separate the highest concentration from the lowest. A pattern similar to that of calcium is expected because both are double valence cations and will be retained by soil clays or organic material. Magnesium is typically present in the soil at much lower concentrations than calcium but, like calcium, is flushed from surface soils during periods of intense rains. Magnesium, like calcium, begins to accumulate in surface soils again quickly.

Potassium. Concentrations of potassium are generally highest in NW-1 and may originate from the active saltpile, the evaporation pond and the parking lot (refer to Fig. 1). However, the levels in the near-field and far-field plots do not differ significantly from one or the other control plots.

Sodium and Chloride. Sodium and chloride, both single valence ions, are leached more quickly from surface soil than the double valence ions calcium and magnesium. The highest concentrations of sodium and chloride are measured in NW-1, the plot directly downwind of the active saltpile, which consists primarily of halite (NaCl). NW-1 is also impacted by caliche dust generated by traffic on the adjacent parking lot.

Electrical Conductivity. Electrical conductivity is a measure of the concentration of soluble salts in the soil, and the levels are very low in the stabilized dune sand at WIPP. The pattern of conductivity values measured in the monitoring plots is similar to that of sodium. Levels are highest and most variable in NW-1, and fall in all plots during and immediately after the period of intense rains. For each data set, conductivity values are positively correlated with both calcium and sodium.

pH. pH measurements are not available for all data sets but some interesting differences are illustrated in Fig. 4. pH values are higher in the near-field plots than in the far-field and the control plots. Also, pH in the control plots is acidic most of the year, the exception being in winter (1/86). Soil acidity may be a result of the leaching of tannic and other organic acids from oak leaves. The input of carbonate salts from caliche into the near-field plots explains the higher soil pH in those sites. The elevation of soil pH in all plots in winter has not yet been explained.

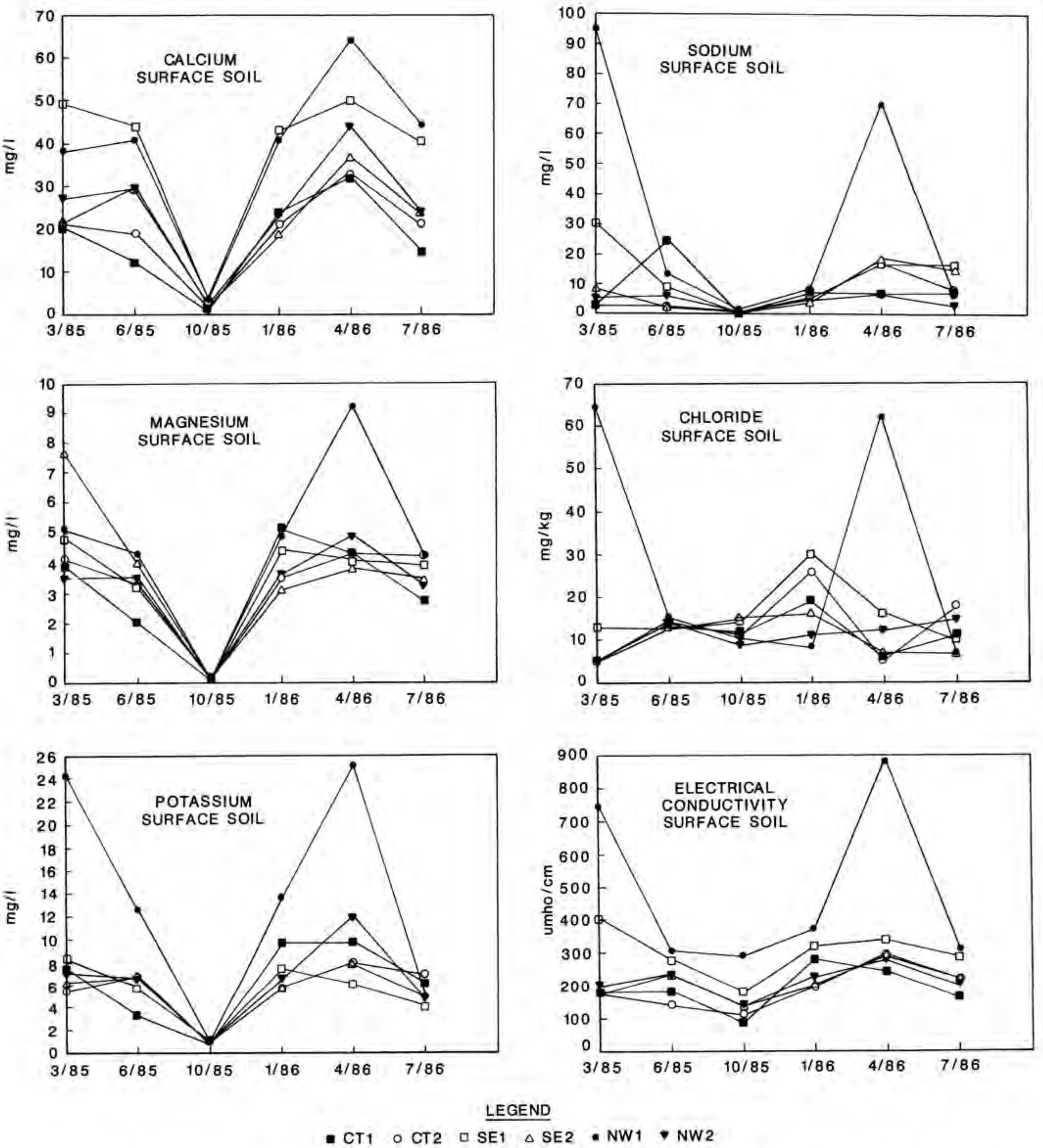

Fig. 3. Parameters measured in surface soils collected quarterly in the Ecological Monitoring Plots.

Soils in the near-field plots do exhibit higher cation concentrations than control and far-field plots, but the ions are removed from surface soils during periods of intense rains. Sodium and chloride ions which, at high concentrations are most likely to impede biological activity, are leached most easily from the soil. Construction activities, then, do have a measurable effect on soil ion concentrations, but concentrations of salts in the surface soils remain very low. It is possible that potentially inhibitive soil ion concentrations could accumulate over a period of several dry years, but that is not presently the case.

Intermediate Soils (30-45 cm)

Three samples are collected annually at intermediate depth from each ecological monitoring plot. Data are available for three years beginning in 1984. Samples are collected during the second quarter (June/July) which is normally at the beginning of the summer rainy season (see Fig. 2 for monthly precipitation data). Plot averages for each soil parameter are included in Table I.

Calcium. Calcium levels have decreased each year at this depth, but the differences between years and between plots are not significant. Concentrations at this depth are highest in SE-2 and lowest in NW-1, which indicates that there is no effect at this depth of the input of calcium ions at the soil surface.

Magnesium, Potassium and Electrical Conductivity. These parameters vary significantly over time but do not vary between sites at this depth. Each parameter was higher in 1985 than in 1984 or 1986, which probably reflects the late rainy season in 1985.

Sodium and pH. Sodium and pH vary significantly between plots but not over time. Sodium concentrations are lowest in CT-2 and highest in SE-1, but plot averages range from 2.4 to 11.7 mg/l, so values remain very low. Soil pH follows the same pattern, the highest average value is measured in SE-1 and the lowest in CT-2. The range of pH values is muted at this depth, varying between 6.9 and 7.4.

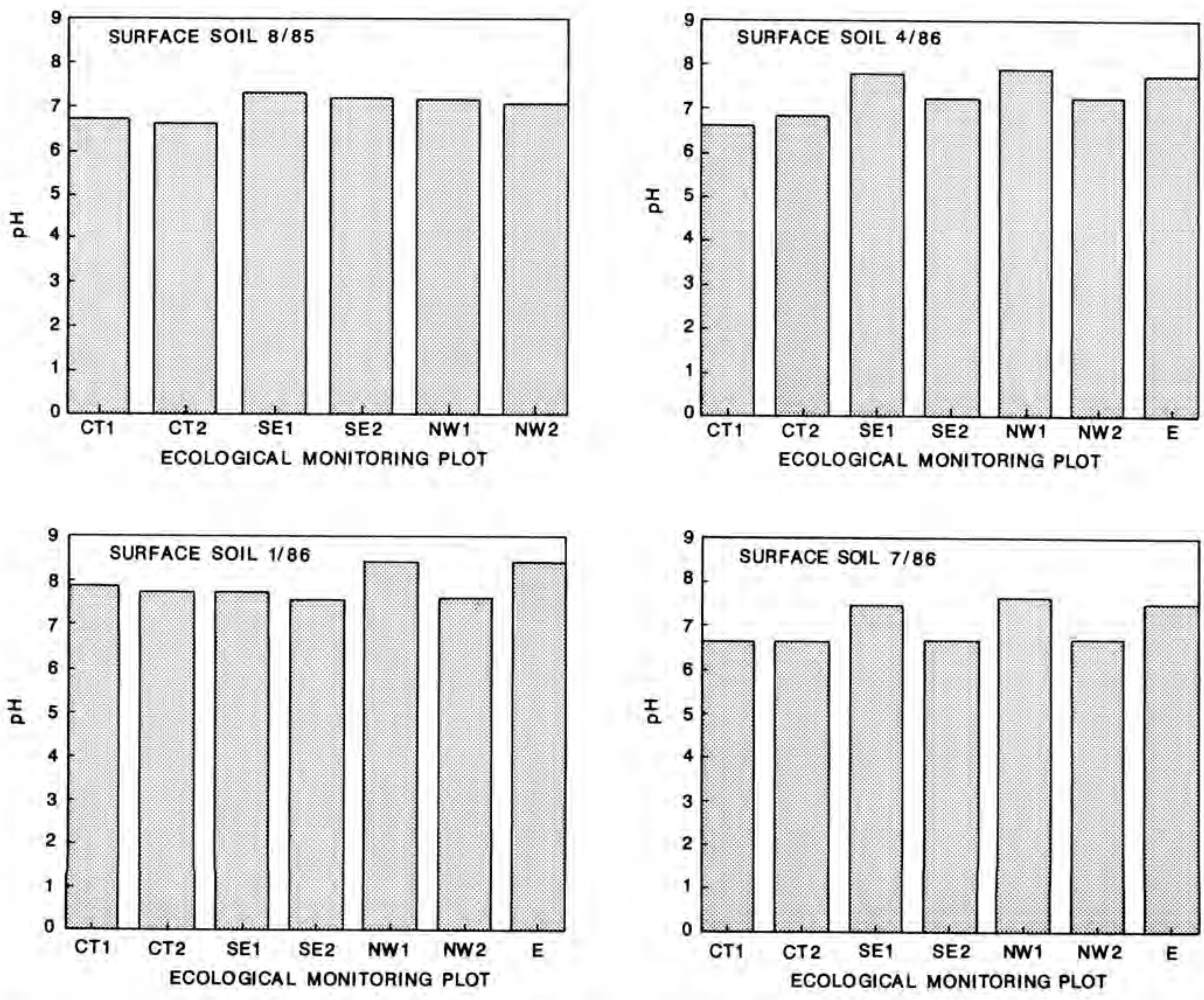

Fig. 4. Soil pH values measured in surface samples. Control soils are usually slightly acidic, while soils in near-field plots are above neutral.

TABLE I

Average Parameter Values and Pooled Standard Errors for Intermediate Soils

Values Computed by Statgraphics Software, Analysis of Variance Procedure

		Plot					
Parameter (Pooled Std. Err)	Year	CT-1	CT-2	SE-1	SE-2	NW-1	NW-2
Chloride	84	36.7	11.0	22.3	30.0	33.7	41.3
mg/kg	85	12.3	12.0	13.3	11.7	15.7	13.7
(5.09)	86	8.0	5.0	5.0	6.3	5.0	13.7
pH	84	7.0	6.7	7.6	7.2	7.0	7.2
(0.17)	85	7.0	6.8	7.3	7.3	6.9	7.1
	86	7.1	7.0	7.2	7.0	7.1	7.5
Conductivity	84	180	86	186	109	71	119
umho/cm	85	126	144	229	124	151	420
(55.09)	86	119	142	118	134	125	147
Calcium	84	11.1	15.4	16.8	10.8	6.3	15.1
mg/l	85	13.9	14.7	12.7	18.0	12.5	18.3
(3.92)	86	10.8	10.7	10.5	10.5	8.1	15.7
Magnesium	84	1.8	2.5	2.4	1.7	3.0	2.8
mg/l	85	2.5	3.0	2.8	2.8	2.9	3.2
(0.56)	86	2.3	1.7	2.7	2.2	1.2	1.9
Potassium	84	3.2	2.6	5.2	6.0	5.7	7.8
mg/l	85	7.1	5.9	5.9	6.9	5.6	6.3
(1.31)	86	4.3	4.8	5.7	3.5	3.8	3.2
Sodium	84	8.4	2.9	15.5	3.3	3.9	2.5
mg/l	85	9.1	2.8	15.1	2.3	8.7	15.2
(4.81)	86	2.7	1.6	4.5	3.8	8.4	2.8

Chloride. Chloride concentrations vary significantly between years, the highest values were measured in 1984. Average values have decreased since that time. Average concentrations are lowest in CT-2 and highest in NW-2.

Annual sampling of soils at an intermediate depth indicate no long-term zone of ion accumulation. Rather, leaching of soils at intermediate depths occurs at least during years of relatively high precipitation. Annual sampling has not allowed the tracking of variations in ion concentrations throughout the year, but our interest at this depth is whether long-term accumulation occurs.

Deep Soils (60-75 cm)

Deep soil samples are collected annually from the same sampling points as the intermediate soil samples. Plot averages for each soil parameter are included in Table II.

Calcium. Calcium concentrations in deep soils remain fairly constant from year to year and do not vary significantly among plots. Values are lowest in NW-1 and highest in CT-2, with no apparent pattern of change.

Magnesium. Magnesium concentrations tend to be higher in 1985 than for 1984 or 1986, but differences between plots and between years are not statistically significant.

Potassium. Concentrations of potassium do not differ between plots but were significantly higher in 1985 than in the other two years sampled. Plot averages are very low, ranging from 4.5 to 6.3 mg/l.

Conductivity. Conductivity values vary significantly between plots, but are not statistically different with time. Average values are highest in CT-1 and lowest in NW-1.

Sodium. Concentrations of sodium are highest in CT-1 and lowest in CT-2. Sodium does appear to accumulate over time in SE-1 and -2, peaking in 1986, while in the NW plots, sodium levels peaked in 1985.

pH. Values of pH do not vary significantly between sites or over time. In both the near-field plots, however, soil pHs were lowest in the 1985 samples collected prior to the rainy season, and before basic ions could be leached from the surface soils.

Chloride. Chloride concentrations in deep soils vary significantly between plots and between years. This anion appears to have been leached from deep soils since first measured in 1984. The highest average anion concentration was measured in NW-1, the lowest in SE-2.

There is no indication that ions deposited at the soil surface are accumulating in any zone of the soil profile to a depth of 75 cm (2.5 feet). It appears that ions are washed from the surface through the coarse-textured dune sand to accumulate, presumably, at the caliche layer which indicates the zone of maximum water percolation. Annual precipitation at the site exceeded the average in 1985 and 1986. It is possible that ion accumulation may occur on the surface or at some level in the soil profile during a series of dry years.

TABLE II

Average Parameter Values and Pooled Standard Errors for Deep Soils

Values Computed by Statgraphics Software, Analysis of Variance Procedure

Parameter (Pooled Std. Err)	Year	Plot CT-1	CT-2	SE-1	SE-2	NW-1	NW-2
Chloride	84	22.0	14.7	18.3	11.0	48.7	37.7
mg/kg	85	12.7	13.0	12.3	10.7	15.0	12.7
(2.00)	86	8.0	6.0	5.7	5.0	5.7	8.0
pH	84	7.3	6.7	7.6	7.1	7.0	7.3
(0.17)	85	7.1	7.1	6.5	7.3	6.7	7.3
	86	6.9	7.1	7.1	7.1	7.3	7.6
Conductivity	84	244	114	241	93	55	100
umho/cm	85	449	121	249	155	102	292
(79.85)	86	142	111	184	183	159	178
Calcium	84	22.8	33.5	16.3	7.0	6.5	6.8
mg/l	85	17.0	12.9	11.7	20.0	10.3	18.3
(8.25)	86	11.6	9.3	15.6	13.6	6.6	13.1
Magnesium	84	3.7	6.5	3.2	1.2	2.2	3.1
mg/l	85	3.2	2.5	3.1	4.2	3.4	3.5
(1.57)	86	2.4	2.0	2.3	3.1	1.4	2.5
Potassium	84	3.4	3.1	5.4	5.6	3.4	7.7
mg/l	85	6.8	5.2	5.7	8.7	7.2	6.2
(1.49)	86	4.8	5.5	2.3	4.6	3.2	3.8
Sodium	84	5.7	4.8	14.4	1.8	2.9	1.3
mg/l	85	68.5	3.6	17.0	2.1	10.0	10.5
(15.62)	86	3.7	2.1	23.2	23.1	6.1	3.3

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REFERENCES

1. C. C. REITH, ET AL., "Ecological Monitoring Program for the WIPP Project," First Semiannual Report, WTSD-TME-058, Carlsbad, NM (1985).

2. N. T. FISCHER, ET AL., "Ecological Monitoring Program Semiannual Report," January-June, 1985, DOE/WIPP-85-002, Carlsbad, NM (1985).

3. R. R. SOKAL and F. J. ROHLF, *BIOMETRY*, Freeman and Company, San Francisco, CA (1969).

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