STRONTIUM MOVEMENT INTO PROFILE OF MAURY SILT LOAM SOIL

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Abstract

Groundwater pollution due to chemcal application in agriculture activities has caused much public concerns. Based on the researches having been conducted, it was resulted that chemical leaching in soil frequently showed spatial pattern. Based on the fact, a field research was conducted in Maury silt loam soil (*fine, mesic, mixed, Typic Paleudalf*) to evaluate spatial variety of Sr movement into and below rooting zone. Chemical material SrCl2.6H2O was evenly distributed on soil surfacein a 18 x18 m plot. Soil samples were taken 4 times (after receiving rainfall 166, 3, 586, and 1085 mm) in 54 locations within the plot. At each sampling undisturbed soil was taken from surface until 100 cm depth, then the Sr element was analyzed from each 10 cm depth. The results showed that there was no spatial pattern found for Sr movement within a 100-cm soil depth in each sampling date. Therefore, based on the analysis of variance, it was about 95% of Sr2+ found on 0-20 cm soil depth even though after receiving 1085 mm rainfall.

Key Words: groundwater pollution, agricultural chemicals, spatial structure

INTRODUCTION

Agricultural chemicals such as fertilizers, pesticides, plant and animal regulators, have contributed to the enhancement of agricultural production. The promotion of conservation and/or no-tillage practices to eliminate soil and water loss by erosion has increased the use of some chemicals. In some soils, slightly larger amounts of pesticides and fertilizers are required to provide weed control and plant nutrients than for conventional tillage.

Conservation or no-tillage practices may increase the number of macropores open to soil surface. Water and solute can readily enter macropores open to soil surface, and the transport is much faster than that through micropores. Additionally, expansion of irrigation over the years also may have contributed to groundwater contamination. Irrigation can increase the concentration of salt, pesticide, and fertilizer chemical elements in groundwater recharge and return flow (Lee and Nielson, 1987). The impact of agricultural practices on water quality has been of concern to many scientists, especially in developed countries since approximately 1975 (Logan, 1990).

Many soil scientists have found that physical and chemical properties of some soils affect the behaviour of chemical and solute transport in undisturbed soil profile in the field of under laboratory conditions. They found that some of these soil properties were often spatially correlated.

To find out the fate of some plant nutrients, such as Ca^{2+}, in soil profile, strontium was chosen to replace Ca. Strontium, an alkaline-earth metal, has parallel biological cycle to that of calcium (Ca^{2+}) (Horr, 1963). In the soil profile, soluble Sr^{2+} that is added can remain highly mobile in the soil or can be adsorbed onto soil particles, undergo ion exchange, precipitate out of the solution, or form compounds with organic matter (Schulz, 1965). Based on the fact that the abundant amount of calcium is found in soil profile, the application of calcium to study the fate of it would be interfered. Therefore, Sr^{2+} was applied to soil surface on Maury silt loam soil having good drainage. The objective of this study was to identify spatial variability of Sr^{2+} movement in Maury silt loam soil and to evaluate the distribution of Sr^{2+} concentration in soil profile as as influenced by amount of precipitation received.

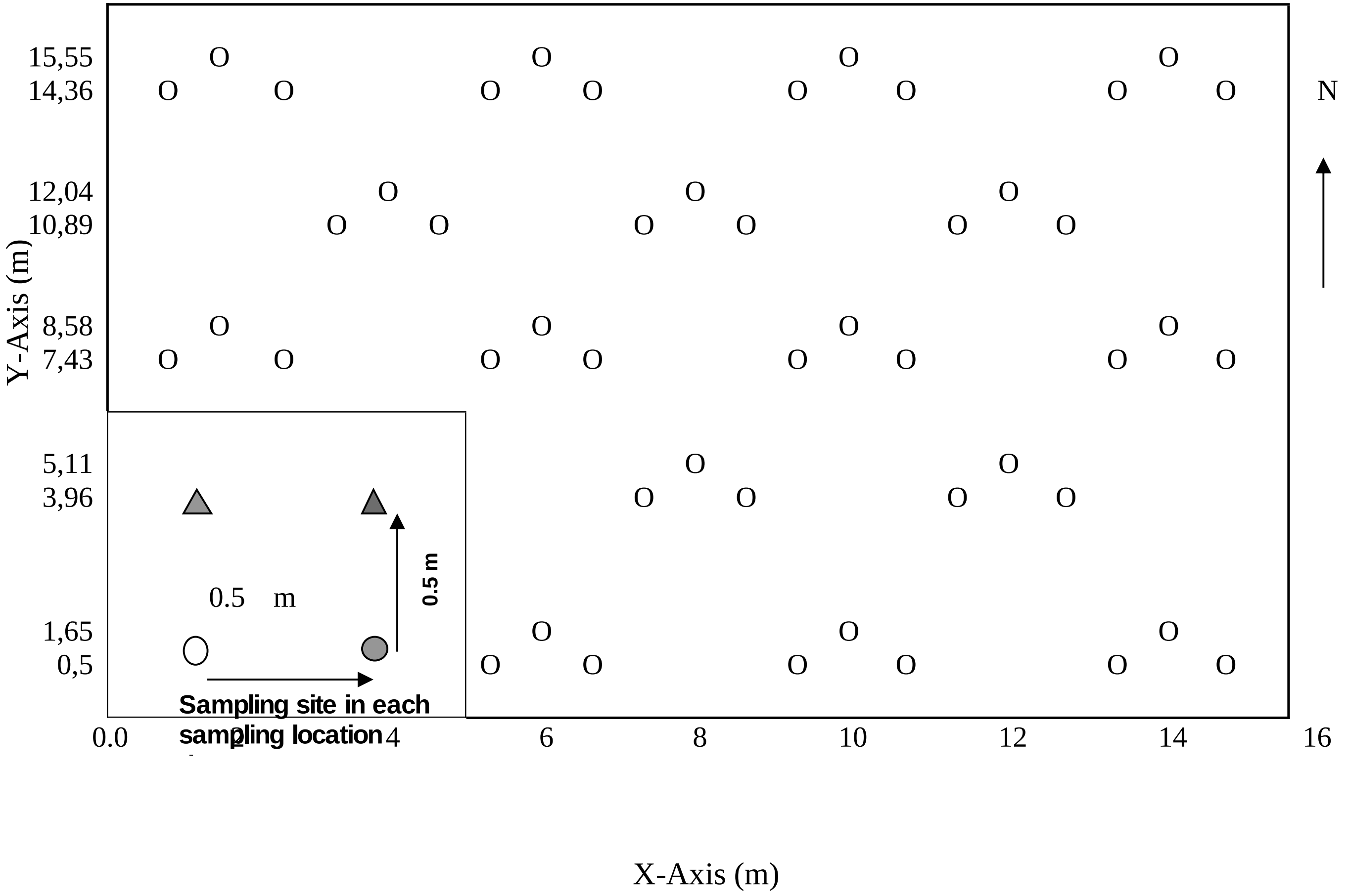

Figure 1. X-Y coordinates of each 54 sample sites in the field study and sampling location

MATERIALS AND METHODS

Table 1. Sampling dates and precipitation on the experimental site during the field study.

Sampling Date	Precipitation (mm)*	
	Between dates	Total to Each Date
Sept 27-1989 (I)	166**	166
Nov 20-1989 (II)	144	310
Jan 03-1990 (III)	276	586
July 25-1990 (IV)	499	1085

**) Precipitation distribution is attached*
***) Amount of precipitation received from application (August-1989) of SrCl2.6H2O to the first sampling date.*

This research was conducted at University of Kentucky Agricultural Experiment Station, at Lexington, USA. Strontium in form SrCl2.6H2O solution (with Sr^{2+} concentration 3367 ug cm-2) was sprayed on surface of Maury silt loam soil (fine, mixed, mesic, Typic Paleudalf). This soil has dark brown, very friable silt loam, and moderate, granular structure surface layer (which occurs to a depth of 35 cm), and reddish brown, friable silty clay loam that grades into silty clay in the lower part into 95 cm depth) as well as has high natural fertility, medium organic matter content, moderate plant moisture supplying capacity and moderate permeability. The site has not been cultivated for approximately 40-60 years. Grass and small weed covering the soil surface were killed using glyphosate a week prior to chemical application.

Samples were taken 4 times in approximately a one-year period corresponding to different amount of cumulative precipitation (as presented in Table 1) by using a soil core sizing 3.176 cm in diameter and 1 m in length. The geometry of each sample number was shown in Figure 1, while the position of soil sampling on each sample date was as in Figure 2Soil samples were separated in each 10 cm depth and saved in plastic bag. Ten (10) g of each sample was analysed for Sr^{2+} concentration by extracting it using 1 M NH4OAc adjusted to pH 7.0, then it was measured by using atomic Absorption (AA). Concentration of Sr obtained was analyzed using a geostatistical software program[1] to evaluate the spatial variability. Isotropic semivariogram and correlogram analyses were run the sum of the ten depth of each sampling date and each of the ten depths within each sampling date. If the data were not spatially correlated, analyses of variance using (ANOVA) using Fisher Statistics would be run. Mean separation value of Sr^{2+} concentration among depths within sample date was evaluated using the Least Significant difference (LSD).

RESULTS AND DISCUSSION

Figures 2,3,4 and 5 show the isotropic semivariograms of Sr^{2+} concentration among 54 sites at sampling date I, II, III, and IV, respectively. The four semivariograms represent the sum of all depths at each site sampled. There was no spatial structure in any of the four semivariograms, as well as for each each of the ten depths at each of the four sample dates (Figures not presented). Thus, the movement of Sr^{2+} at the field site at each sample date was spatially independent; in other words, the samples were randomly distributed. One would not expect the Sr^{2+} data to have spatial structure since Sr^{2+} is held on soil colloids about as tightly as is

[1] *GS+, Geosatistics for the biological sciences, version 1.01. Gamma Design Inc., P.O. Box 2.01, 457 East Bridge Street, Plainwell, MI 49080.*

Ca^{2+} and since the Sr^{2+} was applied uniformly to the soil surface.

Some soils exhibit a large degree of spatial structure and some less or no spatial structure. Under certain circumstances, geostatistical method failed to recognize significant relationship of the variability among soil properties. For example, Folorunso and Rolston (1984) found there was no correlation of field measure denitrification fluxes at 1-m sampling spacing. Semivariance analyses of infiltration data showed that areal variability was random at 2-m grid spacing Luxmoore et al., 1981).It was also found to be true for hydraulic conductivity, K, versus water content measurement at 60 and 90 cm depths at 5 cm intervals (Moutonnet et al., 1988).

Since the it was not spatially distributed, the average of Sr^{2+} data at each 10-cm depth increment for each sample date are presented in Table 2. While the distribution of Sr^{2+} concentration at four sample dates in soil profile is presented in Figure 6. Most of Sr^{2+} was found to be concentrated in the top 20-cm of the soil profile. It was 94-96% of sr^{2+} was found in these two 10-cm depths with about 0.6% in each of the other 8 depths. This was caused by the properties of Sr^{2+} which is adsorbed by the negative charge of soil colloids. Jansen and Radke (1988) found that divalent cations such as Sr^{2+} are much more strongly sorbed by montmorillonite than monovalent cations, even th ough Sr^{2+} exhibit significant surface diffusion during ion exchange against Na+ .

The same pattern of Sr^{2+} concentration was found for all four sampling date. The analyses of variance (not presented) shows that the overall mean of Sr^{2+} concentration is not significantly different among sample dates, but it does show significant differences among depths within date.

Table 2. Mean value of Sr^{2+} concentration (ug cm-3 soil) of each depth at four sampling dates after receiving 166, 310, 586, and 1095 mm precipitation, respectively.

Soil Depth	Sample Date			
	I	II	III	IV
	9-27-89	11-20-89	3-1-90	7-25-90
….. .cm …….	…………………………… ug cm-3 ……………………………….			
0-10	224 a*	231 a	252 a	221 a
10-20	111 b	128 b	123 b	161 b
20-30	4 c	5 c	5 c	3 c
30-40	3 c	5 c	4 c	5 c
40-50	3 c	4 c	3 c	3 c
50-60	3 c	3 c	2 c	2 c
60-70	2 c	2 c	1 c	1 c
70-80	1 c	2 c	1 c	0 c
80-90	1 c	1 c	3 c	0 c
90-100	1 c	1 c	1 c	0 c
% Recovery	105	113	117	118

**) Treatment mean followed by unlike letters are significantly different at(P<0.05)*

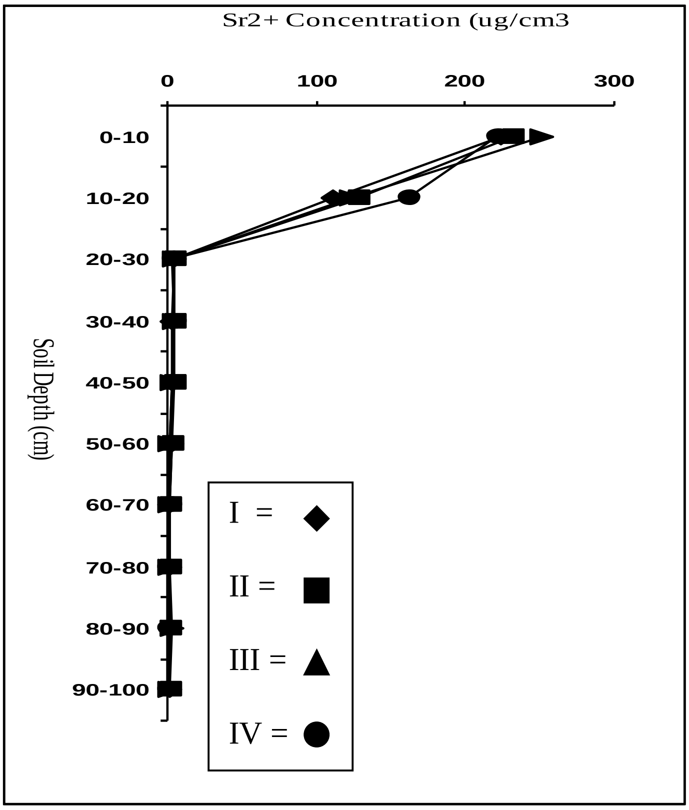

Figure 2. Mean value of Sr^{2+} concentration (ug cm-3 soil) of each depth at four sampling dates after receiving 166, 310, 586, and 1095 mm precipitation, respectively.

Based on the data presented in Table 2 and the analyses of variance, it can be interpretated that Sr^{2+} is strongly held by the negative charges of soil colloids in the surface 20 cm depth. After receiving up to 1085 mm precipitation, it did not move any deeper into the soil profile. Cline and Caldwell (1984) also found that 90Sr remained mostly in the upper soil layer with nearly all of the amount added.

CONCLUSIONS

Based on the above result, it can be concluded that Sr^{2+} content in the surface 1 m of soil was not spatially correlated at any of the four sample dates. Since there was no spatial structure found, ANOVA was employed to detect any statistical differences of Sr^{2+} concentration in the soil profile. It was about 94-96% of Sr^{2+} found in the surface two 10-cm depths at each sample date. It did not move deeper into soil profile even though after receiving 1085 mm precipitation.

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REFERENCES

Cline, J.F. and Caldwell, L.L. 1984. Movement of radiostrontium in the soil profile in an arid climate. Health Phys. 46:1136-1138.

Folorunso, O.A. and Rolston, D.E. 1984. Spatial variability of field-measure denitrification gas fluxes. Soil Sci. Soc. Am. J. 48:1214-1219.

GS+, Geosatistics for the biological sciences. 1990. Program Manual Geostatistics software, version 1.01. Gamma Design Inc., P.O. Box 2.01, 457 East Bridge Street, Plainwell, MI 49080.

Horr, C.A. 1963. A survey of analytical methods for the determination of strontium in natural water. In Chemistry of Strontium in Natural Water. U.S. Geological Survey. U.S. Govern. Print. Off., Washington.

Jensen, D.J. and Radke, C.J. 1988. Cesium and strontium diffusion through sodium montmorillonite at elevated temperature. J. Soil Sci. 39:53-64.

Lee, L.K. and Nielson, E.G. 1987. The extent and cost of groundwater contamination by agriculture. J. Soil Water Conserv. Jul-Aug.:243-248

Logan, T.J. 1990. Sustainable agriculture and water quality. In “Sustainable Agricultural Systems”, edited by C.A. Edwards, R.Lal, P.Madden, R.H.Miller, and G.House. Soil water Conserv. Soc. Ankeny, Iowa, p 582-613.

Luxmoore, R.J., Spalding, B.P., and Munro, I.M. 1981. Areal variation and chemical modification of weathered shale infiltration characteristics. Soil Sci. Soc. Am. J. 45:687-691.

Moutonnet, P., Pluyette, E., El Mourabit, N., and Couchat, P. 1988. Measuring the spatial variability of soil hydraulic conductivity using an automated neutron moisture gauge. Soil Sci. Soc. Am. J. 52:1521-1526

Schulz, R.K. 1965. Soil chemistry of radionuclides. Health Phys. 11:1317-1324