Bromide Addition to Test for Vertical Percolation and Plant Uptake

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INTRODUCTION

In 2019 we conducted a bromide tracer addition at the KBS LTER site to determine whether water infiltrating at the surface percolated vertically downward through the root zone. We wanted to verify whether suction lysimeters could be deployed beneath small subplots in our future LTER rainout shelter experiments. This experiment has also been called the “lysimeter spacing test.” Subsequently, we sampled grass that grew after the addition to see whether plants take up added bromide from the soil solution.

APPROACH

Three locations were selected along the northern edge of the lysimeter fetch field, in recently harvested wheat. At each of three locations we outlined a 5-m dia. circular area (19.63 m^2) using paint. Centered within that circle is a 1-m dia. (0.79 m^2) circular plot with garden edging on the perimeter.

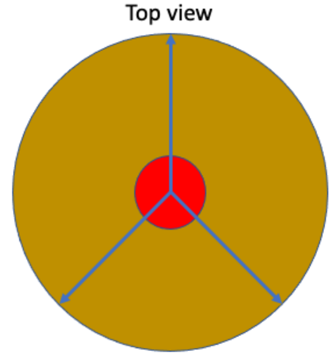
The coordinates of the centers of each plot were approximately (iphone GPS):

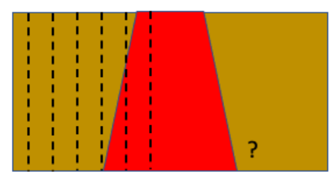
East: 42.410146 N, 85.373055 W
Center: 42.410144 N, 85.373765 W
West: 42.410104 N, 85.374056 W

Bromide additions and soil sampling:

We added 6 g Br/m^2 as NaBr dissolved in water (16.5 g NaBr/3 L) to the soil surface within each 1-m dia. Circular area on 24 July 2019 using a 1-gal portable garden sprayer. This is about the same addition amount that has been used earlier bromide tracer additions at KBS (Jin et al. 2008; Hess et al. 2018). On the day of Br addition and in each of the following four weeks, we watered the entire 5-m circle with pond water (KBS Pond Lab) from a tank on a truck to ensure at least 58 mm/week (290 mm total) over 5 weeks. That water source had very low Br concentrations.

After the fifth week, we took 4' soil cores in three transects from the center of each 5-m circle, as shown in the diagram on the right. The cores were located at 0.25, 0.75, 1.25, 1.75, and 2.25 m from the center point. A GeoProbe fitted with inserts of 48" length and 3" dia. Collected the 54 cores.





Cores were sliced open and sectioned in the field. Bromide was leached into pond water from three sections of each soil core (divided at 25 and 50 cm depths). The 25-cm core segments were mixed with 2 L of water and the deeper segment was mixed with 5 L using plastic bags that had been previously tested and shown to have no leachable bromide. The mixture was left on the soil surface until suspended soil settled out, then gently mixed and subsamples of the supernatant were collected for bromide analysis by ion chromatography after filtration. Samples were processed in order from expected low to high concentration to reduce the chance of cross-contamination. Remaining soil slurries were returned to the core holes in order of depth.

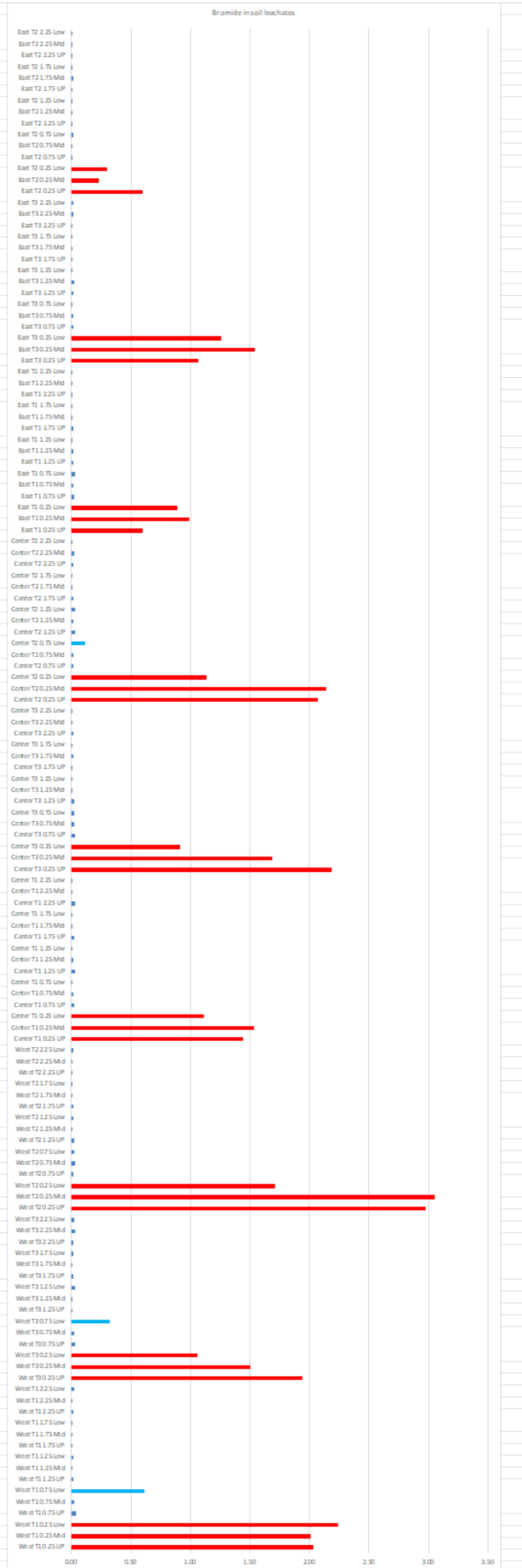
RESULTS

Vertical percolation of bromide:

The leachable bromide results show that the tracer was still present at all depths beneath the 1-m dia. Application area based on the cores taken at 0.25 m from the center point, and that the bromide had largely moved downward without much lateral outward spread (see table below). Three samples from outside the 1-m dia. Circle had detectable bromide, in each case in the cores taken at 0.75 m from the center (i.e., 0.25 m outside the 1-m dia. Circle), and only below 50 cm depth, and thus lateral movement was detected in 3 of the 9 cores collected at the 0.75 m distance. No bromide was found in cores taken at 1.25 m from the center (i.e., at 0.75 m outside the 1-m dia. Circle).

These results indicate that experimental treatments applied at the soil surface largely affect water directly beneath the application point, but in some cases can spread laterally at least 0.25 m but not more than 0.75 m in the lower part of the soil profile. Therefore, there should be uniform treatment within a circle of at least 0.5 m radius on the soil surface above a lysimeter.

West T1 0.25 UP	2.03
West T1 0.25 Mid	2.01
West T1 0.25 Low	2.24
West T1 0.75 UP	0.04
West T1 0.75 Mid	0.02
West T1 0.75 Low	0.61
West T1 1.25 UP	0.02
West T1 1.25 Mid	0.01
West T1 1.25 Low	0.02
West T1 1.75 UP	0.01
West T1 1.75 Mid	0.01
West T1 1.75 Low	0.01
West T1 2.25 UP	0.02
West T1 2.25 Mid	0.01
West T1 2.25 Low	0.03
West T3 0.25 UP	1.94
West T3 0.25 Mid	1.50
West T3 0.25 Low	1.06
West T3 0.75 UP	0.03
West T3 0.75 Mid	0.02
West T3 0.75 Low	0.32
West T3 1.25 UP	0.01
West T3 1.25 Mid	0.01
West T3 1.25 Low	0.03
West T3 1.75 UP	0.02
West T3 1.75 Mid	0.01
West T3 1.75 Low	0.02
West T3 2.25 UP	0.02
West T3 2.25 Mid	0.03
West T3 2.25 Low	0.02
West T2 0.25 UP	2.98
West T2 0.25 Mid	3.05
West T2 0.25 Low	1.71
West T2 0.75 UP	0.02
West T2 0.75 Mid	0.03
West T2 0.75 Low	0.03
West T2 1.25 UP	0.02
West T2 1.25 Mid	0.01
West T2 1.25 Low	0.02
West T2 1.75 UP	0.02
West T2 1.75 Mid	0.02
West T2 1.75 Low	0.01
West T2 2.25 UP	0.01
West T2 2.25 Mid	0.01
West T2 2.25 Low	0.02
Center T1 0.25 UP	1.44
Center T1 0.25 Mid	1.53
Center T1 0.25 Low	1.11
Center T1 0.75 UP	0.02
Center T1 0.75 Mid	0.02
Center T1 0.75 Low	0.01
Center T1 1.25 UP	0.03
Center T1 1.25 Mid	0.02
Center T1 1.25 Low	0.02
Center T1 1.75 UP	0.02
Center T1 1.75 Mid	0.01
Center T1 1.75 Low	0.01
Center T1 2.25 UP	0.03
Center T1 2.25 Mid	0.02
Center T1 2.25 Low	0.01
Center T3 0.25 UP	2.19
Center T3 0.25 Mid	1.69
Center T3 0.25 Low	0.91
Center T3 0.75 UP	0.04
Center T3 0.75 Mid	0.02
Center T3 0.75 Low	0.03
Center T3 1.25 UP	0.02
Center T3 1.25 Mid	0.01
Center T3 1.25 Low	0.01
Center T3 1.75 UP	0.01
Center T3 1.75 Mid	0.02
Center T3 1.75 Low	0.02
Center T3 2.25 UP	0.02
Center T3 2.25 Mid	0.01
Center T3 2.25 Low	0.01
Center T2 0.25 UP	2.07
Center T2 0.25 Mid	2.14
Center T2 0.25 Low	1.14
Center T2 0.75 UP	0.02
Center T2 0.75 Mid	0.02
Center T2 0.75 Low	0.12
Center T2 1.25 UP	0.03
Center T2 1.25 Mid	0.02
Center T2 1.25 Low	0.03
Center T2 1.75 UP	0.02
Center T2 1.75 Mid	0.01
Center T2 1.75 Low	0.02
Center T2 2.25 UP	0.02
Center T2 2.25 Mid	0.02
Center T2 2.25 Low	0.01
East T1 0.25 UP	0.60
East T1 0.25 Mid	0.99
East T1 0.25 Low	0.89
East T1 0.75 UP	0.02
East T1 0.75 Mid	0.02
East T1 0.75 Low	0.03
East T1 1.25 UP	0.02
East T1 1.25 Mid	0.02
East T1 1.25 Low	0.01
East T1 1.75 UP	0.02
East T1 1.75 Mid	0.01
East T1 1.75 Low	0.01
East T1 2.25 UP	0.01
East T1 2.25 Mid	0.01
East T1 2.25 Low	0.01
East T3 0.25 UP	1.07
East T3 0.25 Mid	1.54
East T3 0.25 Low	1.26
East T3 0.75 UP	0.02
East T3 0.75 Mid	0.02
East T3 0.75 Low	0.01
East T3 1.25 UP	0.02
East T3 1.25 Mid	0.02
East T3 1.25 Low	0.01
East T3 1.75 UP	0.01
East T3 1.75 Mid	0.01
East T3 1.75 Low	0.01
East T3 2.25 UP	0.01
East T3 2.25 Mid	0.02
East T3 2.25 Low	0.02
East T2 0.25 UP	0.60
East T2 0.25 Mid	0.23
East T2 0.25 Low	0.31
East T2 0.75 UP	0.01
East T2 0.75 Mid	0.01
East T2 0.75 Low	0.02
East T2 1.25 UP	0.01
East T2 1.25 Mid	0.01
East T2 1.25 Low	0.01
East T2 1.75 UP	0.02
East T2 1.75 Mid	0.02
East T2 1.75 Low	0.02
East T2 2.25 UP	0.01
East T2 2.25 Mid	0.01
East T2 2.25 Low	0.01
Pond Lab Extract Water 1	0.01
Pond Lab Extract Water 2	0.01
Pond Lab Extract Water 3	0.01
Pond Lab Extract Water 4	0.01
Pond Lab Extract Water 5	0.00



Plant uptake of bromide:

New green grass shoots had appeared over the experimental plots by the autumn. To see if bromide had been taken up by the grass, samples of the aboveground foliage were collected on 17 Oct 2019 from within the 1-m circle where bromide had been applied in July as well as outside (but not far from) the 5-m circle. Samples were oven-dried and ground, then bromide was extracted in boiling water (5 g sample in 100 mL water). Subsamples were analyzed by ion chromatography after filtration. Results showed readily measurable bromide in the grass within the addition area but not well outside of it (see table below). This shows that bromide added to soil solutions could be used to trace root water uptake.

Replicate plot	**Br in grass outside 5-m circle (mg/L)**	**Br in grass inside 1-m circle (mg/L)**
East	0.00	0.21
Central	0.00	0.29
West	0.00	0.23

REFERENCES

Jin, L., Williams, E., Szramek, K., Walter, L.M. and Hamilton, S.K. 2008. Silicate and carbonate mineral weathering in soil profiles developed on Pleistocene glacial drift (Michigan, USA): Mass balances based on soil water geochemistry. Geochimica et Cosmochimica Acta 72: 1027-1042.

Hess, L., E.-L. Hinckley, G.P. Robertson, S.K. Hamilton, and P.A. Matson. 2018. Rainfall intensification enhances deep percolation and soil water content in tilled and no-till cropping systems of the U.S. Midwest. Vadose Zone Journal 17:180128. doi:10.2136/vzj2018.07.0128

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