

DISPOSITION OF BROMIDE APPLIED TO GRASS AND FALLOW PLOTS

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When 300 kg Br/ha equivalent were applied to bermudagrass and fallow plots on Ruston sandy loam of 12% slope, less than 10% of the applied Br was found in the surface layers (0 to 15 cm) of application 15 months later. The remaining Br had moved laterally and vertically from the application zones. Laterally, movement both across the soil surface and through the soil profile occurred. Neither the amount of erosion nor the volume of rainfall runoff were useful factors in predicting Br movement over the plot surfaces. On both plots, some Br had reached the 2.5 m ground water table depth by 15 months. The grass cover, while effective in preventing soil erosion, was ineffective in minimizing Br movement. Both Br runoff and Br leaching depth were greater on the grass plot.

Present concern over environmental contaminants has created a need for more detailed information regarding the behavior of agricultural chemicals in soil. Of particular interest is the potential for soluble agricultural chemicals to be lost from the soil, either by surface runoff or by leaching to the ground water. Results of two recent studies (2, 7) indicate that bromide (Br) should have utility as a model chemical for studying the general pattern of movement of many soluble agricultural chemicals in soil. Several advantages seem to exist for using Br as a soluble model chemical. Natural occurrences are typically low (1, 8), and Br is not generally toxic to plants (3). Moreover, Br salts are fairly inexpensive and analytical determination of the ion is simple. In the present investigation, the fate of Br applied to grass and fallow plots has been determined. Both lateral and vertical movement of the Br was measured, and a balance sheet of Br distribution was constructed at the end of the study.

MATERIALS AND METHODS

The plots (Figure 1) were laid out on Ruston sandy loam (a Typic Paleudult soil) at the Water Quality Management Laboratory grounds. The Ruston soil series, a member of the Coastal Plains soils, is characterized by a sandy surface and a clay loam subsoil. Prior sampling of the soil had shown that it contained a very low background level of Br (<0.3 ppm). An area of approximately 12% slope was selected, in order to insure that runoff would occur. The area sloped downward, from north to south. Borders for the plots were made from 15-cm galvanized edging, and were driven to an 8-cm soil depth. The grass was removed on the east, fallow plot and the soil surface was leveled and tamped lightly. Herbicide (sodium salt of 2,2-dichloropropionic acid) was then applied to prevent grass regrowth. The thick cover of bermudagrass sod (*Cynodon dactylon*) was left intact on the west, grass plot. The upper edges of the plots were peaked to facilitate diversion of surface water from outside. The lower end of each plot was formed into a "V" and fitted with a spout to funnel the runoff to collecting containers. The containers, 80-liter plastic cans, were placed in holes under the spouts and both holes were covered with plastic sheeting to keep out

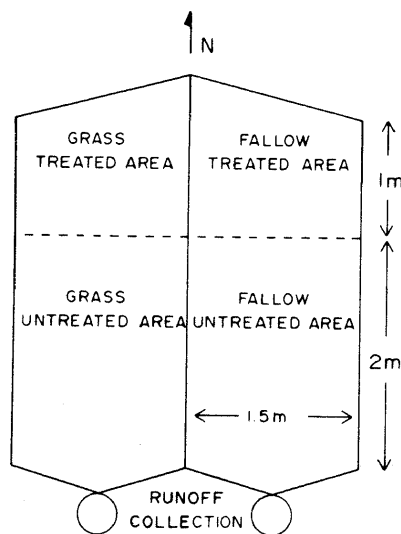


FIGURE 1. Layout of grass and fallow plots on Ruston sandy loam.

unwanted rainfall. The experiment began Mar 24, 1973, when the treated area of each plot (Figure 1) received 300 kg Br/ha equivalent applied as aqueous LiBr. On August 20, 1974, approximately 15 months later, the experiment was terminated.

Total volumes of runoff-sediment suspension were measured from each plot, and the suspensions were mixed thoroughly to obtain representative samples. The liquid was then evaporated to obtain sediment weights. Separate samples of both sediment and supernatant were taken for Br analysis. However, no evidence of Br sorption by sediment was ever detected.

At the end of the first summer the plots were sampled by hand to determine the maximum depth of Br movement. A few cores 2.5 cm in diameter in each treated and untreated area were taken. The cores were divided into 5-cm depth increments, appropriately composited cross-wise, and analyzed for Br. At the end of the experiment, single holes 30 cm in diameter were drilled down to the water table in the center of each treated and untreated area. The sides of the holes were then shaved to remove possible sidewall contamination during drilling. Soil samples were taken along the perimeter of each hole at 15-cm depth intervals. Concentrations of Br determined from these samples were assumed to be representative of the entire treated or untreated area in constructing subsequent Br balance sheets.

The grass plot, which exhibited no deleterious effects from the Br application throughout the experiment, was clipped whenever deemed necessary, and the clippings were left in place. Each summer during the experiment, representative portions of the clippings were sampled for Br content immediately after cutting and found to account for as much as 75% of the recovered Br in the 0-to-15-cm surface layers of the treated and untreated areas.

Analysis for Br was made with a specific ion electrode. Soil samples for Br analysis were extracted with 1 *N* calcium nitrate (20 g soil/100 ml). Plant samples for Br analysis were heated (550 C, 1 hr) with calcium oxide (1:1 weight ratio), and the residue was dissolved in water.

Jars placed around the edges of the plots were used to measure the rainfall. Air temperatures were obtained from the weather station at nearby Southeastern Oklahoma State University. Total rainfall received on the plots was 156 cm, and air temperatures averaged 19.9 C. Comparable long-term averages are 136 cm and 19.8 C. Therefore, during the study, rainfall averaged around 15% above normal whereas temperatures almost equalled the long-term average.

RESULTS

Runoff

Amounts of Br lost in runoff each month from the plots are shown in Figure 2. The largest monthly Br loss, 7.4 kg/ha, was from the grass plot soon after application. By comparison, the fallow plot only lost slightly more than 1 kg/ha the first month. Thereafter, monthly losses from both plots were less than 1 kg Br/ha until the following spring, when maximum losses were approximately 2.5 kg Br/ha. The pattern of Br concentrations in the runoff waters was similar to that observed on a kg Br/ha basis. Maximum concentrations were 100 and 17 ppm Br, observed in the initial runoff from the grass and fallow plots, respectively. Subsequent concentrations were generally <1 ppm Br (fallow plot) and <2 ppm Br (grass plot) until the following spring, when concentrations of 4 to 5 ppm Br were observed from both plots. Total amounts of rainfall runoff were 14 and 29 cm for the grass and fallow plots, respectively. Corresponding sediment losses were essentially zero, and 206 metric ton/ha. On neither plot was there a close association between Br loss in individual storms and rainfall runoff or sediment losses (r values <0.5).

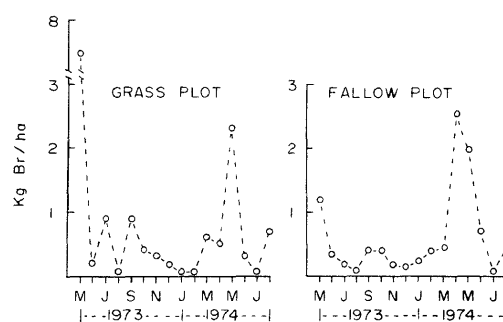


FIGURE 2. Amounts of bromide lost in runoff from grass and fallow plots from May 1973 through August 1974.

Profile Distribution

Distributions of bromide in the soil profiles down to the water table 15 months after application are shown in Figure 3. Mass flow of water is considered to be the dominant force involved and, in this regard, the Br can be considered to serve as a tracer for the infiltrating water (6). Most downward movement of Br occurred after the first 3 months of application. Both the grass and fallow plots were sampled at that time, and no Br had penetrated deeper than 20 cm in either the treated or the untreated areas. More than half the Br found in the treated surface layer of the grass plot was associated with the plants. Owing to Br uptake by the plants, at least 25% of the total Br found in the treated area of the grass plot remained in the 0-to-15-cm surface soil layer throughout the study period. By the end of the experiment, however, the main Br front had moved below the 1.5-m depth in all cases, and had already reached the 2.5-m groundwater table depth in the untreated grass area. The Br front in the untreated fallow area was also deeper (by ~ 0.5 m) than in the respective treated area.

Balance sheet

A balance sheet of Br distribution in the grass and fallow plots at the end of the experiment is shown in Table 1. Results are proportioned among the treated area, the untreated area, runoff, and unrecovered. Of the total applied Br 50 and 79% were accounted for in the grass and fallow plots, respectively. Not all of the Br was recovered because of Br movement into the ground water table, leakage of Br beyond the plot boundaries (verified by core sampling one meter outside the plots), and soil sampling variation. Moreover, in the case of the grass plot, Br differences in grass samples introduced another source of variation. Nevertheless, the results are considered adequate in giving a general, overall view of the fate of the applied Br. They show that most of the Br found in the grass plot was in the treated area, whereas most of the Br found in the fallow plot was in the untreated "run-on" area. Even so, the grass plot still yielded a larger portion of applied Br in the runoff than did the fallow plot (5 vs. 3%).

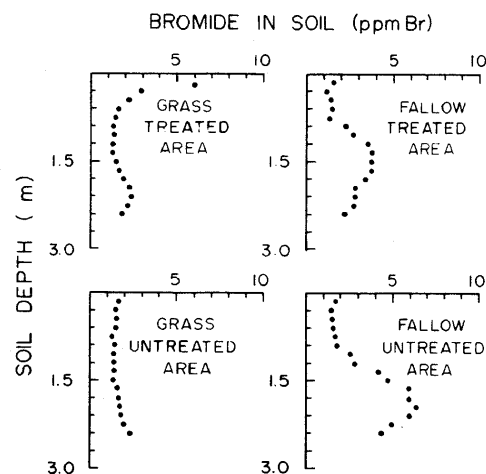


FIGURE 3. Vertical distribution of bromide in grass and fallow plots 15 months after application (The ground water table was at 2.5 m).

TABLE 1. Disposition of 300 kg Br/ha applications in grass and fallow plots after 15 months.

Plot	Location of applied Br			
	Treated area (%)	Untreated area (%)	Runoff (%)	Unrecovered (%)
Grass	26	19	5	50
Fallow	32	44	3	21

DISCUSSION

The results of this study clearly show that Br was a very mobile ion in the soil. On both the grass and fallow plots, less than 10% of the applied bromide was found in the surface layer (0 to 15 cm) of the treated areas at the end of the experiment. The remainder of the Br had moved laterally and vertically from the treated area. Laterally, movement both across the soil surface and through the soil profile occurred.

Neither the amount of erosion nor the volume of rainfall runoff were found to be useful factors in predicting Br movement over the plot surfaces. The grass plot, which yielded only 14 cm of rainfall runoff and essentially no erosion during the experiment, retained considerably less Br (on either an absolute or percentage basis) than did the highly erosive fallow plot. Such findings are generally consistent with recent observations by Olness *et al.* (4). In a study involving seven cropland watersheds in Central Oklahoma, they observed that while vegetable cover (alfalfa) minimized erosion, soluble nutrient losses in runoff tended to increase.

Evidently, infiltration (total rainfall minus runoff) of water into the soil was the most important factor influencing Br movement. The infiltrating water moved the Br both vertically and laterally from the zone of application. Since the effective infiltration was greater on the grass plot than on the fallow plot, the bromide front moved deeper (by ~ 0.5 m) down the soil profile of the grass plot. On the other hand, the nutrient cycling action of the grass also maintained an appreciable portion of bromide near the soil surface. Therefore, runoff which did occur on the grass plot tended to be more concentrated in Br. The net result was that both Br runoff and Br leaching depth were greater on the grass plot.

Lateral movement of subsurface water appeared to be an important factor in moving a large portion of the applied Br in this experiment. Similar movement in Coastal Plains soils has been reported by Rawls and Asmussen (5), and attributed to slowly permeable subsoils beneath sandy surfaces. The portions of applied Br found in the untreated areas were 19 and 44% for the grass and fallow plots, respectively. Such results are attributed mainly to lateral subsurface movement of Br from the upslope treated areas, rather than downward leaching of "run-on" Br. This view is supported by the fact that the grass untreated area did not contain a high Br concentration in the surface layer, whereas the grass treated area did. Additional support is provided by the fact that Br was found in the subsoil outside the plot boundaries.

The primary benefit of the grass cover was in preventing soil erosion. As a means of minimizing overall movement of Br from the zone of application, the results here show in a striking manner the ineffectiveness of the grass cover. Despite the fact that the grass grew approximately 8 months of the year, and appreciable plant uptake of Br occurred, both vertical movement and runoff losses of Br were enhanced on the grass plot. In fact, by 15 months after application, the Br front had already reached the ground water table on part of the grass plot. Consequently, these results emphasize the importance of application timing, placement, and avoiding excessive treatment rates with soluble agricultural chemicals on Typic Paleudult soils. Such recommendations are true even for land that has a growing plant cover most of the year. They cannot be ignored in minimizing the potential for impairment of surface and ground water quality.

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