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Ash Leachate Can Reduce Surface Erosion

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In laboratory analyses of the Larabee soil from northwestern California, ash leachate flocculated the clay fractions. As a result, the soil quickly settled out of suspension. To test the hypothesis that field plots on disturbed areas treated with ash leachate would be more resistant to erosion than nontreated plots, a study was done in July and August 1978, on two skid trails on the Humboldt State University Forest near Freshwater, in northwestern California. A rainfall simulator was used to measure differential erosion rates. Ash-leachate treated plots had 36 percent less erosion than nontreated plots. Differences in total sediment yield were statistically significant at the 97.5 percent level of confidence, as shown by a paired t-test of seven plots.

Retrieval Terms: fire, surface erosion, ash, rainfall simulator, soil structure, flocculation, skid trails

Surface erosion of soil is rare in undisturbed forests, but common in disturbed areas, particularly roads. Fires also disturb forests and accelerate erosion. One study of erosion after wildfire in northern California showed an increase of 2.3 times the normal amount of suspended sediment discharge.[1] A number of variables related to a specific fire, such as burn intensity, soil erodability, and percent bare soil help determine the surface erosion resulting from storms. These variables interact; for example, the intensity of a fire can modify the structure and erodability of a soil.

The few studies documenting the effects of fire and ash on soil structure have conflicting conclusions. Dymess and Youngberg[2] found that soil aggregation was reduced by 20.6 percent in a severely burned area, although aggregation was unaffected in a lightly burned area. Scott and Burgy[3] reported, however, that when columns of Hugo soil were heated to 250°C for 45 minutes, the percentage of soil aggregates increased and the infiltration rate doubled.

It has long been recognized that soil erodability is decreased by flocculation and accelerated by dispersion.[4] Natural leachates of ash and organic matter have the potential to influence clay structures[5] and, therefore, erosion rates.

Aggregation results from soil particles being held together by a material such as organic matter. Flocculation is the coagulation of clays resulting from electrical charges. Although the structure of surficial forest soils is determined by aggregation, the degree of flocculation of the clay fraction becomes more important in the subsurface.

Preliminary laboratory analyses of the Larabee soil demonstrated that ash leachate flocculated the clay fractions and caused a rapid settling of the soil in suspension. We then hypothesized that field plots on disturbed areas treated with ash leachate would be more resistant to erosion than untreated plots.

To test this hypothesis we focused on changes in soil structure induced by ash leachate after a burn. We confined our study site to poorly aggregated subsoils exposed in skid trails. A rainfall simulator applied distilled water to the ash-leachate treated and control plots. Runoff was collected and eroded sediment measured and compared.

This pilot study was specifically designed to (a) determine how ash leachate affects the structure of Larabee soil, particularly its degree of flocculation, and (b) compare differences of erosion rates on leachate-treated plots with those on control plots. Results showed that the treated plots had 36 percent less erosion than the controls.

MATERIALS AND METHODS

The field study was done in July and August 1978, and was restricted to two skid trails on the Humboldt State University Forest near the town of Freshwater in northwestern California. The skid trails were on 20 percent slopes at an elevation of 90 m. The climate of this redwood forest is characteristic of the coastal Pacific Northwest with foggy summers and heavy winter precipitation. The soil is a sandy loam of the Larabee series. The predominant clay is a magnesium-rich chlorite.

Rainfall simulators are reliable instruments in erosion research.[6] The simulator in this study (*fig. 1*) was modifed from the Meeuwig[7] type as follows:

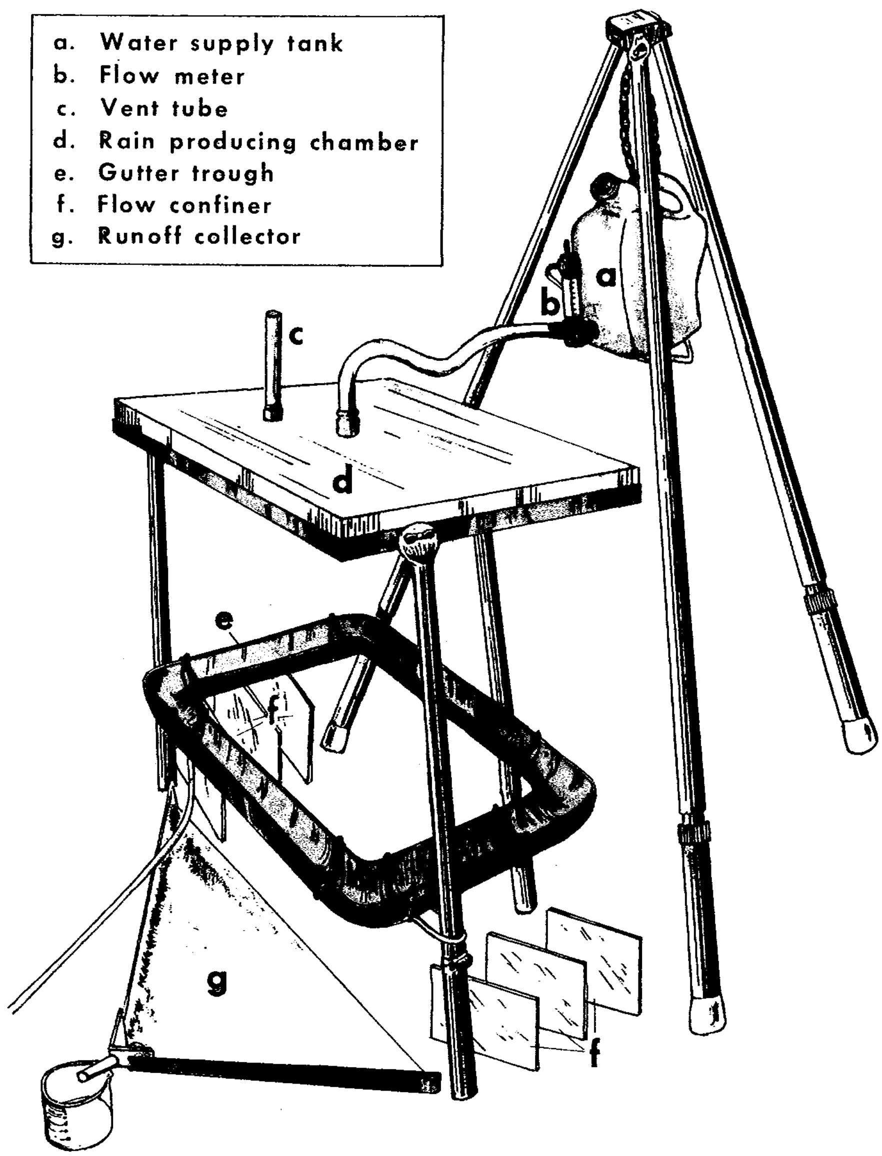

Figure 1—Rainfall simulator modified from the Meeuwig type with a separate tripod to accommodate water supply tank on rugged slopes and provide additional hydraulic head, and gutter trough to catch stray drops.

- A separate tripod was made to accommodate the water supply tank on rugged slopes and to provide additional hydraulic head for maximum operating efficiency.
- A gutter trough was mounted below the rain-producing chamber to catch stray drops (similar to a Tahoe Basin simulator[8]).
- Small steel plates (17.5 by 10.2 by 0.2 cm) were driven into the soil at a 45° angle to the edge of the plots to confine lateral flow.

The ash leachate was prepared by burning a pile of redwood litter collected from the study area. The resultant ash was placed in a muffle furnace at 450°C for 2 hours to create a homogeneous well-burned ash. Two grams ash were then mixed with 100 ml distilled water and, after 30 minutes drained through filter paper. The pH of the leachate was 10 and the conductivity values were approximately 1000 micromhos per cm. Analysis with an atomic absorption spectrophotometer indicated that potassium was the predominant cation (223 ppm), followed by sodium (24 ppm), calcium (22 ppm), and magnesium (0.7 ppm). Samples of this leachate added to soil suspensions from the study area flocculated the clay.

Preliminary testing indicated that the skid roads commonly had desiccation cracks that were not always exposed at the surface. As a result, the testing was limited to two stretches of skid roads having a north aspect. The paired plots were located in a grid pattern. The treatment and control plots of a pair were 1.3 m apart, perpendicular to the road direction. The plot to be treated was decided by the toss of a coin.

Soil plots were prepared for testing by removing the upper 5 cm of soil to expose the compacted fill. This was done to help pair the treatment and control plots by eliminating sites underlain by severe cracks or residual slash. Bulk density, water content, and texture were analyzed in the laboratory to validate similarity between plots. One liter distilled water was spread uniformly over the treated and control plots (0.6 by 0.6 m) to ensure that their moisture content would be similar. The treated plots were then sprayed with 450 ml ash leachate. Control plots were sprayed with 450 ml distilled water. Burlap cloth and plastic sheeting covered the plots for the next 24 hours to prevent evaporation and to allow sufficient time for the ash leachate to react with the soil.

The prepared plots then received rain falling from 1.2 m at a rate of 6.8 cm per hour for 36 minutes. This is a high but not unreasonable intensity. The artificial rain consisted of distilled water because it is chemically similar to natural rain—both have a conductivity of less than 10 micromhos per cm. Runoff from the soil plots was collected at 6-minute intervals. Eroded sediment was measured by oven-drying the runoff and weighing the remaining soil. Data were analyzed with a paired t-test to evaluate differences between treated and control plots.[9]

RESULTS AND DISCUSSION

Runoff from seven pairs of plots was collected for 36 minutes. The amount of sediment and water in the runoff was recorded at 6-minute intervals, and totaled after 36 minutes. Total sediment yields for paired plots after 36 minutes of rain were:

Pair	Control	Ash Leachate
	Grams	
1	45.63	25.00
2	71.23	37.43
3	58.98	27.41
4	22.73	33.00
5	36.18	24.48
6	23.75	19.06
7	28.20	17.47

The sediment collected for 36 minutes averaged 36.7 g for the control plots and 24.4 g from the ash-leachate plots, or 50 percent more sediment from the control than from the treated (*fig. 2*). This figure rises to 56 percent if the sediment remaining on the runoff collector at the end of 36 minutes is included.

A paired t-test showed that total sediment yield between the two groups was statistically significant at the 97.5 percent confidence level.

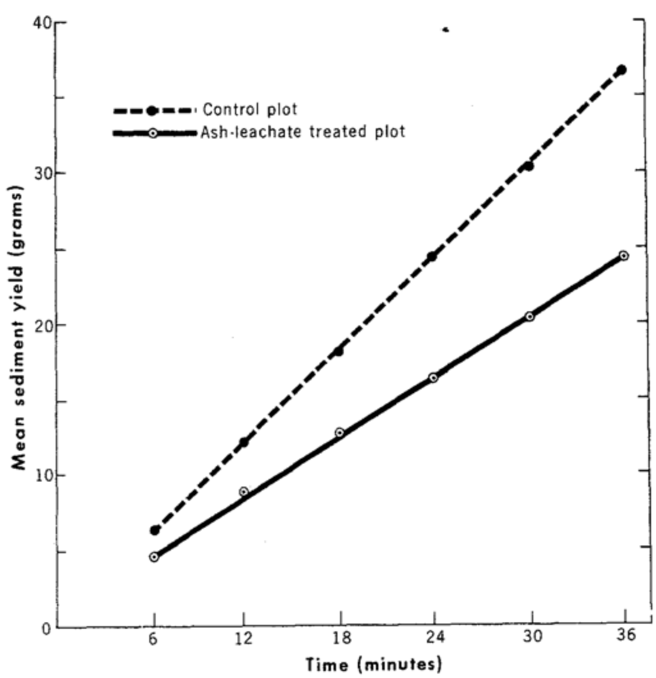

Figure 2—Average cumulative sediment collected in runoff from the paired plots. Control plots averaged 50 percent more sediment than leachate-treated plots.

The pairs showed no significant difference in volume of runoff water; consequently, infiltration was similar. This indicates that the difference in erosion rates should be attributed to different detachabilities, rather than to different transporting powers of the runoff.

The reduced erosion on the treated plots is most likely due to the flocculation of the clay fraction by electrolytes from the ash leachate. Fluids that disperse the soil are more erosive than those causing flocculation. Electrolytes, and cations in particular, allow the negatively-charged clays to form flocs, making the clay less detachable and more resistant to erosion.

The concentration and type of cation in the eroding fluid is a critical factor in erosion rates.[10] The type of clay is also critical because, although most clays are flocculated by ash leachate, kaolinite is commonly dispersed.

This study points out that ash leachate has the potential of reducing soil erosion. The investigation is limited to the physiochemical changes of one soil in response to one ash leachate. Several other changes associated with fire, such as loss of vegetation, litter removal, water repellancy and soil disturbance, however, can offset the influence that ash leachate may have on surface erosion.

Future research will focus on the elements in the leachate producing reduced erosion rates and the response of various soil types to ash leachate. It will also evaluate the relative importance of this mechanism under field conditions.

NOTES

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