

Factors influencing effectiveness of two surfactants on water-repellent soils

M. A. MUSTAFA • J. LETEY

WATER-REPELLENT SOILS are characterized by two undesirable physical properties: low water infiltration rate, and high runoff. Such soils have been reported in many parts of the world under various conditions, however, one of California's real practical problems involves soil-water repellency occurring on burned water-sheds. A high percentage of the many acres (primarily in southern California) burned over by wildfires every year includes soils which repel water. The combination of removing protective vegetation, and inducing water

repellency causes an extreme erosion hazard.

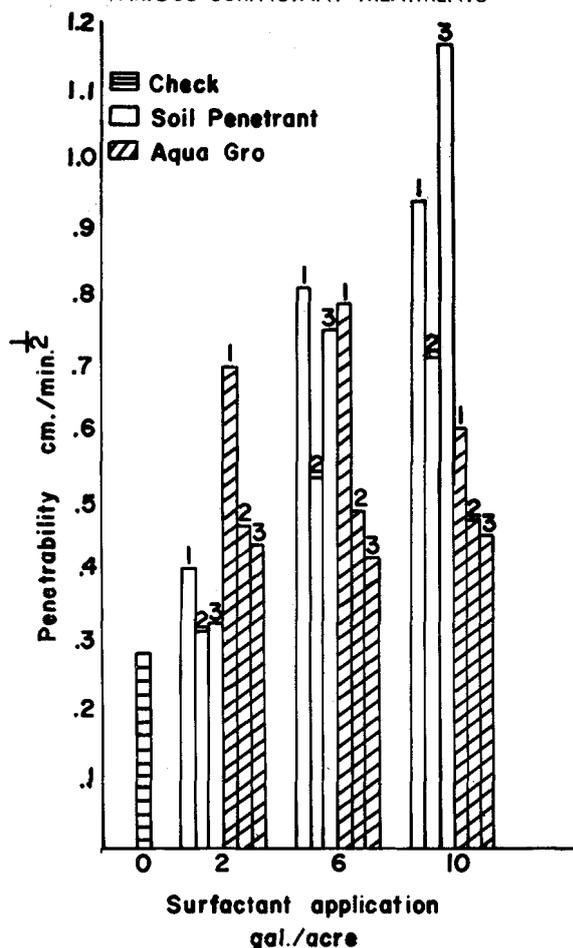
Surfactants (wetting agents) have already been demonstrated to allow water penetration into water-repellent soils. In one study at the San Dimas Experimental Forest, the application of surfactants greatly reduced erosion from the plots. However, in a later trial, the wetting agent treatment was not effective in erosion control. Several factors could influence the effectiveness of surfactant treatments. This report gives results of a study conducted to determine the effect of a few of these factors.

One factor considered was the *quantity* of surfactant applied per unit area—and

whether that quantity of surfactant was applied as a concentrate or whether it was diluted with water and the solution applied to the surface. Also considered were possible differences in results from applying water to the soil immediately after surfactant treatment, as compared with allowing the treatment to dry before water application. The *type* of surfactant was also investigated as a factor in the effectiveness.

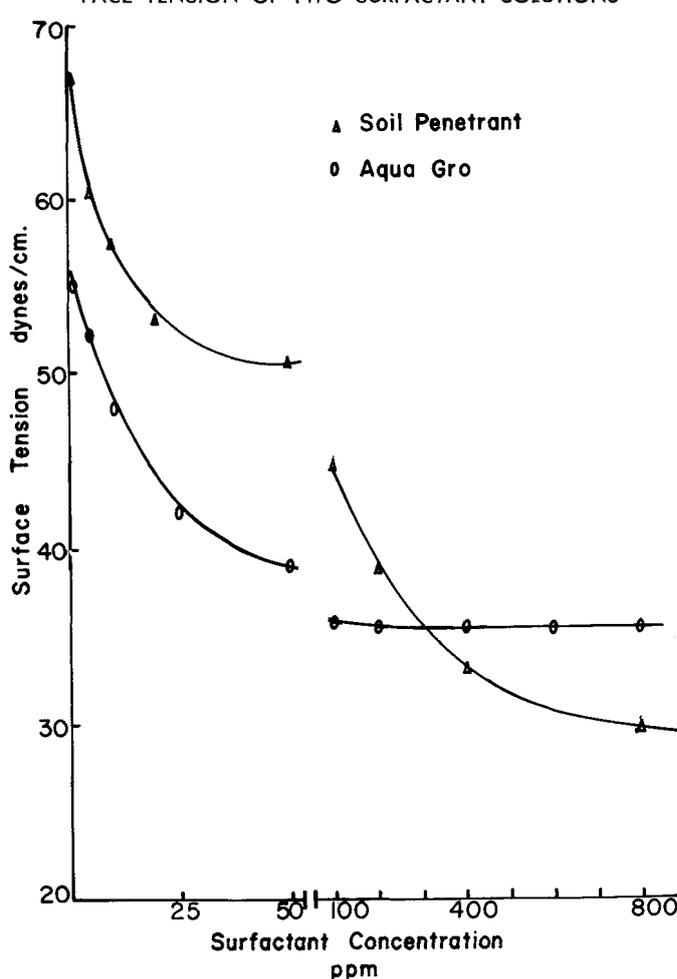
The study was conducted in the laboratory at Riverside on soils packed into glass columns. After a wildfire, soil-water repellency usually occurs in a layer at or just below the soil surface. The layer of water repellency varies in thickness. Be-

GRAPH 1. THE PENETRABILITY OF WATER FOLLOWING VARIOUS SURFACTANT TREATMENTS



Numbers at top of each bar represent: (1) surfactant applied as concentrate with no drying; (2) surfactant applied as concentrate with drying; (3) surfactant applied as solution with drying.

GRAPH 2. RELATIONSHIP BETWEEN CONCENTRATION AND SURFACE TENSION OF TWO SURFACTANT SOLUTIONS



low the water repellent layer, the soil is wettable. To simulate this condition, the glass column was packed with a wettable soil and then the top 1 inch was packed with a water-repellent soil taken from a site adjacent to the San Dimas Experimental Forest.

Two surfactants

Soil Penetrant and Aqua Gro were the two nonionic surfactants used in the study. Four rates of application (0, 2, 6 and 10 gallons/acre) were used for each surfactant. The following treatments were used for each surfactant and each rate of application: (1) The surfactant was applied as a concentrate by placing a drop of surfactant of sufficient weight to give the required treatment equivalent to gallons per acre in the center of the soil column. The infiltration study was then conducted immediately. (2) The surfactant concentrate was applied to the soil column as indicated before, however, the soil column was oven dried at 53°C overnight and cooled to room temperature before infiltration study. (3) The surfactant was added to 7 ml of water and the solution applied uniformly to the soil column. These soil columns were then dried at 53°C and allowed to cool before infiltration study.

The effectiveness of the treatments for water penetration was evaluated by horizontal infiltration of water into the column. Because the type of water used can also influence infiltration, calcium sulfate was added to the water to a concentration of .01 N in each infiltration study. The advance of the wetting front through the soil column was recorded. The position of the wetting front was plotted as a function of square root of time, producing a linear curve. The slope of the resultant curve was measured and is referred to as penetrability (graph 1). The higher the penetrability, the higher the infiltration rate. All surfactant treatments increased penetrability as compared with no treatment.

Soil Penetrant

Regardless of method of treatment, increasing the application rate of Soil Penetrant increased penetrability. When Soil Penetrant was added as a concentrate, penetrability was reduced by drying the soil prior to water application, as compared with watering immediately after surfactant application. In comparing solution application with concentrate application, it was possible to compare the two treatments only after drying. The experimental procedure did not allow the infil-

tration to be checked immediately after solution was applied to the soil without prior drying.

At the lowest application rate, there was no significant difference between applications of Soil Penetrant as a concentrate or solution. However, as the application rate increased, there was increased benefit from applying the surfactant as a solution rather than concentrate. It could be assumed that at the highest application concentrations, best effects would have been obtained by applying the surfactant as a solution, and then having water applied before the solution became dry.

Aqua Gro

Results with Aqua Gro showed almost no effect of application rate on penetrability. When the surfactant was applied as a concentrate, drying significantly reduced the penetrability as compared with no drying. There was almost no difference between the application as a concentrate or solution after the material was dried prior to infiltration.

Aqua Gro generally performed better than Soil Penetrant at the low application rates. However, at the highest application rate, Soil Penetrant gave higher penetrability than Aqua Gro for all treatments. Application of Soil Penetrant as a solution (particularly at the high application rate) seemed to give the best results.

In considering treatment of burned over watersheds, there is a conflict between practical application methods and expected results, however. Because of the rough terrain and difficulty of getting machinery on the area, watersheds have been treated by helicopter. It is therefore desirable to have low volume application to reduce helicopter time. This would dictate the use of concentrate rather than a dilute solution. Furthermore, it is not possible to program application rates so that one can be assured that rain will follow shortly after application. Therefore, the surface usually becomes dry before rain.

In every case, drying reduces the effectiveness of the surfactant treatment as compared with non drying. For Aqua Gro and low application rates of Soil Penetrant, there appears to be no significant difference between adding the material as a concentrate or as a solution. However, at high application rates there were definite benefits from applying Soil Penetrant as a solution rather than concentrate. The highest penetrability measured was for a solution application at the highest application rate of Soil Penetrant.

Another potential problem in applying the material as a concentrate to a watershed is that only the surface soil is exposed to the surfactant. Wind can easily blow the material away—again indicating the need for programming the application of surfactant prior to an expected rain.

If surfactants are to be applied to soils other than watersheds, there would be advantages to immediately applying water after treatment rather than allowing the surface to dry out. Soil Penetrant application as a solution rather than a concentrate would be preferred. There appears to be no significant difference, however, between solution, and concentrate applications for Aqua Gro.

Low rates

Of the two products tested, Aqua Gro was better than Soil Penetrant at low application rates. However, at higher application rates, Soil Penetrant was better than Aqua Gro. The difference in behavior between Soil Penetrant and Aqua Gro at different application rates might be associated with the surface tension-surfactant concentration relationships. Graph 2 presents curves representing the surface tension of the two products as a function of the concentration. Aqua Gro reduced the surface tension more than Soil Penetrant at low concentrations. However, at the higher concentrations, Soil Penetrant caused a lower surface tension as compared with Aqua Gro. In fact, Aqua Gro did not further reduce the surface tension even at concentrations greater than 100 ppm. Inasmuch as the surface tension of the solution was not affected by Aqua Gro concentration at higher concentrations, this could explain the effect of similar results for all application rates of Aqua Gro in these experiments. However, increasing the concentration of Soil Penetrant continues to cause a decrease in surface tension until rather high surfactant concentrations are obtained. This could explain the increased effectiveness of Soil Penetrant applications in these experiments. Furthermore, it could explain why Soil Penetrant was better than Aqua Gro at the high application rates, but less effective at the low application rate.

M. A. Mustafa was a graduate student (now at the University of Khartoum, Khartoum, Sudan), and J. Letey is Professor of Soil Physics, Department of Soils and Plant Nutrition, University of California, Riverside.