The Practical Use of the Energy Concept of Soil Moisture

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The introduction of the term pF into the literature on soil moisture by Schofield (5) has done much to make soil men conscious of the energy relations between soil and water. The pF, as we interpret Schofield’s definition, is the logarithm of the total soil moisture tension measured on a gravity scale, irrespective of the forms of energy involved.

It is the purpose of this paper to urge the popular acceptance of the pF concept as it is felt that it could serve to great advantage all persons dealing with the soil. Soil acidity has received the close attention of plant physiologists, agronomists, and farmers only after the pH concept had been accepted. Expressing the hydrogen-ion concentration in per cent of the soil weight could not be expected to result in an appreciation of its effect on soil solution and plant growth, but we continue to publish papers in which we express soil moisture in per cent of the soil weight.

It appears that two methods of recording soil moisture conditions are needed:

1. The amount of water per volume of soil, expressed as volume per cent, or as inches of water per inches of soil depth (analogous to total exchangeable hydrogen).
2. The energy with which the water is held by the soil, expressed as its logarithm, the pF (analogous to pH).

Knowledge of the interrelationships of these two items will permit the determination of the important hydrologic and plant physiologic facts that are dependent upon soil moisture.

The reasons that these methods are used so little are probably the relative inconvenience of determination and the lack of standardization of the important soil moisture constants on the pF scale. It seems that we need a new evaluation of the importance of the various soil moisture constants in line with the present knowledge of the energetics of soil moisture. If soil moisture constants are expressed on the weight or volume per cent scales, only a random interrelationship appears to exist among them.

It is fully realized that the relationship between the amount of soil water and the energy with which it is held is a continuous function without any sharp breaks. For reasons of practical use, however, and for the determination and tabulation of soil moisture data, it is necessary to select definite positions on the pF scale for those soil moisture “constants” that are reasonably equipotential in nature.

Table 1 has been prepared in which the more important soil moisture data are only considered, as normally the soil moisture constants are determined by drying. No claim is made for originality; an attempt is made to simplify soil moisture.

The purpose is merely to assemble the best information in a tangible form so that it is available at a glance to all practical soil men. It is hoped that the students of soil physics will offer suggestions for the improvement of this table.

In the main the table is self explanatory, however, a few remarks are in order to explain the position of several of the soil moisture constants on the pF scale.

Maximum moisture-holding capacity is expressed as 2.0, identical with total porosity or full saturation. Directly, this exists at zero tension, but as the logarithm of zero cannot be plotted on a finite graph, or a tension of 1 cm of water is used for the constant.

The term “Aeration Porosity Limit” is on the boundary between large, easily drained pores, which are of prime importance in the aeration of the medium sized pores that drain only slowly. Aeration porosity is taken to be delimited by pF 1.7. This latter value was selected on the basis of tests that showed only small differences between the pore space at pF 1.6 and pF 1.9; pF 1.7 lies between the values proposed for the limitation of the large pores. In their statement on Terminology of the Soil Science Society of America (7), Richards suggests 40 cm of water, Shaw 75 cm of water (pF 1.87), and Page pF 1.92, while Cummings urges that “measures should be taken to designate and name this unique point.”

The fact that many soils begin to become rate in texture (top of B horizon) at about 50 cm may be merely a coincidence. The most efficient drain tiles is frequently 3 feet. This means that they can remove the water from the “aeration pores” within approximately the upper 16 inches of soil or the main root zone of the majority of crops on tiled land. If tiles are placed at a depth of only the “aeration pores” of the upper 4 inches be freed from water. This seems to explain the general inadequacy of 2-foot tiling and at the same time substantiates the choice of pF 1.7 as the porosity limit.

The next important line of soil moisture determination is the field capacity at pF 2.7. While locally field capacity should obtain at 1 atmosphere.