Soil water potential

The retention and movement of water in soils, its uptake and translocation in plants and its loss to the atmosphere are all energy related phenomenon. The more strongly water is held in the soil the greater is the heat (energy) required to remove it. In other words, if water is to be removed from a moist soil, work has to be done against adsorptive forces. Conversely, when water is adsorbed by the soil, a negative amount of work is done. The movement is from a zone where the free energy of water is high (standing water table) to one where the free energy is low (a dry soil). This is called soil water energy concept.

Free energy of soil solids for water is affected by

i) **Matric (solid) force** i.e., the attraction of the soil solids for water (adsorption) which markedly reduces the free energy (movement) of the adsorbed water molecules.

ii) **Osmotic force** i.e., the attraction of ions and other solutes for water to reduce the free energy of the soil solution.

Matric and Osmotic potentials are negative and reduce the free energy level of the soil water. These negative potentials are referred to as suction or tension.

iii) **Force of gravity**: This acts on soil water and the attraction is towards the earth's center, which tends to pull the water downward. This force is always positive.

The difference between the energy states of soil water and pure free water is known as soil water potential. Total water potential (Pt) Ψt is the sum of the contributions of gravitational potential (Pg) Ψg, matric potential (Pm) Ψm and the Osmotic potential or solute potential (Po Ψo).

Pt Ψt = Pg Ψg + Pm Ψm + Po Ψo

Potential represents the difference in free energy levels of pure water and of soil water. The soil water is affected by the force of gravity, presence of soil solid (matric) and of solutes.

Earlier classification divided soil water into gravitational, capillary and hygroscopic water. The hygroscopic and capillary waters are in equilibrium with the soil under given conditions. The hygroscopic coefficient and the maximum capillary capacity are the two equilibrium points when the soil contains the maximum amount of hygroscopic and capillary waters, respectively. The amount of water that a soil contains at each of these equilibrium points is known as soil moisture constant.

The soil moisture constant, therefore, represents definite soil moisture relationship and retention of soil moisture in the field. The three classes of water (gravitational, capillary and hygroscopic) are however very broad and do not represent accurately the soil - water relationships that exist under field conditions.

Though the maximum capillary capacity represents the maximum amount of capillary water that a soil holds, the whole of capillary water is not available for the use of the plants. The plants can not utilize a part of it, at its lower limit approaching the hygroscopic coefficient. Similarly, a part of the capillary water at its upper limit is also not available for the use of plants. Hence, two more soil constants; viz., field capacity and wilting coefficient have been introduced to express the soil-plant-water relationships as found to exist under field conditions.

1. Field capacity: It is the capacity of the soil to retain water against the downward pull of the force of gravity. At this stage, only micropores or capillary pores are filled with water and plants absorb water for their use. At field capacity, water is held with a force of 1/3 atmosphere. Water at field capacity is readily available to plants and microorganisms.

2. Wilting coefficient: The stage at which plants start wilting for want of water is termed the Wilting Point and the percentage amount of water held by the soil at this stage is known as the Wilting Coefficient. It represents the point at which the soil is unable to supply water to the plant. Water at wilting coefficient is held with a force of 15 atmospheres.

3. Hygroscopic coefficient: The hygroscopic coefficient is the maximum amount of hygroscopic water absorbed by 100 g of dry soil under standard conditions of humidity (50% relative humidity) and temperature (15°C). This tension is equal to a force of 31 atmospheres. Water at this tension is not available to plant but may be available to microorganisms.

4. Available water capacity: The amount of water required to apply to a soil at the wilting point to reach the field capacity is called the "available" water. The water supplying power of soils is related to the amount of available water a soil can hold. The available water is the difference in the amount of water at Field Capacity (0.3 bar) and the amount of water at the Permanent Wilting Point (15 bars).

5. Maximum water holding capacity: It is also known as maximum retentive capacity. It is the amount of moisture in a soil when its pore spaces, both micro and macro-capillary, are completely filled with water. It is a rough measure of total pore space of soil. Soil moisture tension is very low between 1/100th to 1/1000th of an atmosphere or pF 1 to 0. Summary of the soil moisture constants, type of water and force with which it is held, is given in following table.

Soil moisture constants and range of tension and pF

S.No.	Moisture class	Tension (atm/bar)	pF
1	Chemically combined	Very high	---
2	Water vapour	Held at saturation point in the soil air	---
3	Hygroscopic	31 to 10,000	4.50 to 7.00
4	Hygroscopic coefficient	31	4.50
5	Wilting point	15	4.20
6	Capillary or available water	1/3 to -31	2.54 to 4.50

	Moisture equivalent	1/3 to 1	2.70 to 3.00
	Field capacity	1/3	2.54
	Sticky point	1/3 (more or less)	2.54
	Gravitational	Zero or less than -1/3	<2.54
	Maximum water holding capacity	Almost zero	---