Topic: Water Potential
B.Sc. Botany (Sub.) II
Group: C
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Water Potential

The water is a good solvent. The difference between the free energy of water molecules in pure water and the energy of water in any other system (e.g., water in a solution or in a plant cell or tissue) is termed the water potential. Water potential is a measure of the potential energy in water, specifically, water movement between two systems. Water potential is denoted by the Greek letter Ψ (*psi*) and is expressed in units of pressure (pressure is a form of energy) called megapascals (MPa). The potential of pure water ($\Psi^{pure\ H2O}$) is designated a value of zero (even though pure water contains plenty of potential energy, that energy is ignored). The water potential is measured in bars; a bar is a pressure unit, which equals 14.5 lb/in^2, 750 mm Hg or 0.987 atm. Water potential values for the water in a plant root, stem, or leaf are expressed relative to $\Psi^{pure\ H2O}$.

The water potential measurement combine the effects of solute concentration (s) and pressure (p) -

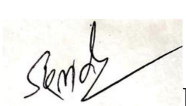
$\Psi system = \Psi s + \Psi p$

Where Ψs = solute potential, and Ψp = pressure potential.

Addition of more solutes will *decrease* the water potential, and removal of solutes will *increase* the water potential.

Addition of pressure will *increase* the water potential, and removal of pressure (creation of a vacuum) will *decrease* the water potential.

Water always moves from a region of high water potential to an area of low water potential, until it equilibrates the water potential of the system. At equilibrium, there is no difference in water potential on either side of the system (the difference in water potentials is zero). In order for water to move through the plant from the soil to the air (a process called transpiration), Ψ^{soil} must be $> \Psi^{root} > \Psi^{stem} > \Psi^{leaf} > \Psi^{atmosphere}$.



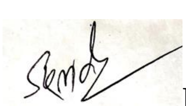
Let's consider solute and pressure potential in the context of plant cells:

Solute potential

It is (Ψ_s), also called osmotic potential, is negative in a plant cell and zero in distilled water, because solutes reduce water potential to a negative Ψ_s. The internal water potential of a plant cell is more negative than pure water because of the cytoplasm's high solute content. Because of this difference in water potential, water will move from the soil into a plant's root cells via the process of osmosis. This is why solute potential is sometimes called osmotic potential. Plant cells can metabolically manipulate Ψ_s by adding or removing solute molecules.

Pressure potential

It is (Ψ_p), also called turgor potential, may be positive or negative. Positive pressure (compression) increases Ψ_p, and negative pressure (vacuum) decreases Ψ_p. Positive pressure inside cells is contained by the rigid cell wall, producing turgor pressure. Pressure potentials can reach as high as 1.5 MPa in a well-watered plant. A Ψ_p of 1.5 MPa equates to 210 pounds per square inch (psi); for a comparison, most automobile tires are kept at a pressure of 30-34 psi. A plant can manipulate Ψ_p via its ability to manipulate Ψ_s and by the process of osmosis. If a plant cell increases the cytoplasmic solute concentration, Ψ_s will decline, water will move into the cell by osmosis, and Ψ_p will increase. Ψ_p is also under indirect plant control via the opening and closing of stomata. Stomatal openings allow water to evaporate from the leaf, reducing Ψ_p and Ψ_{total} of the leaf and increasing the water potential difference between the water in the leaf and the petiole, thereby allowing water to flow from the petiole into the leaf.



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