Soil water potential generally varies from –0.01 to –0.1 MPa. 1 MPa equals 10 bar or ~9.9 atm. The water potential is used to describe the direction of the movement of water. *Water molecules diffuse from the higher water potential to the lower water potential.* For example, if a plant cell is immersed in a solution that has a higher water potential than the cell, water will move into the cell.

Components of water potential

The water potential (ψ, the Greek letter *psi*) of a solution is the sum of four component potentials: gravitational (ψ_g), matric (ψ_m), osmotic (ψ_s) and pressure (ψ_p).

$$\psi = \psi_s + \psi_p + \psi_g + \psi_m$$

Osmotic potential: It is also called *solute potential*. It represents the effect of dissolved solutes on water potential. Pure water at atmospheric pressure has a solute potential of zero. Addition of solutes reduces the free energy of water. After addition, the solutes bind water molecules reducing the number of free water molecules and lowering the capacity of water to move and do work. Thus, adding solutes always lowers water potential. The solute potential depends on the concentration of dissolved solutes in the water and is independent of the specific nature of the solute.

Pressure potential: The pressure potential is the effect of hydrostatic pressure on the potential energy of a solution. If a pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases. It can be positive or negative relative to the atmospheric pressure. Positive pressures raise the water potential; negative pressures reduce it. The positive value of pressure potential within cells is referred to as *turgor pressure*. The value of pressure potential is usually positive, but can also be negative as is the case in the xylem under large tension (negative hydrostatic pressure). The value of pressure potential for pure water in an open beaker is 0 MPa.

Gravitational potential: *Gravitational potential* depends on the position of water in a gravitational field. It is the effect of height of a system above sea level. Its value is 0 MPa at sea level. Gravitational potential depends on the height of water above sea level and the acceleration due to gravity. Thus, raising a system vertically 10 metres will increase its water potential energy by 0.1 MPa. At the cell level, value of gravitational potential is negligible compared to pressure potential and solute potential, so it is generally omitted.

Matric potential: It depends on the adsorptive forces that bind water to a dry matrix. It manifests the tenacity with which water is held by the dry matrix.

As the matric potential is very much limited in living cells and also at cell level, value of gravitational potential is negligible, the water potential expression simplifies to:

$$\psi = \psi_s + \psi_p$$

Example

Let us take, a flaccid plant cell (i.e. a cell with no turgor pressure) which has an osmotic potential (ψ_s) of –0.5 MPa. Because the cell is flaccid, the internal pressure is the same as atmospheric pressure, so the pressure potential (ψ_p) is 0 MPa and the water potential of the cell is –0.5 MPa. Now suppose, this cell is placed in the beaker containing sucrose solution which has a water potential (ψ) of –0.2 MPa. This value is greater (less negative) than the water potential of the cell (ψ = –0.5 MPa), water will move from the sucrose solution in to the cell (from high to low water potential).

As water enters the cell, the protoplast beings to press against the cell wall. The wall resists pressure by applying an equal but opposite inward pressure on protoplast. This increases the pressure potential (ψ_p) of the cell. Consequently, the cell water potential increases, and the difference between inside and outside water potential is reduced. Eventually, cell pressure potential increases enough to raise the cell water potential to the same value as the water potential ... librium is reached ($\Delta\psi$ = 0 MPa), and net water transport ceases.

… known as **plasmolysis**. The cell is said to be *plasmolysed*. When water moves out; it is first losses from the cytoplasm and then from the vacuole. The stage of plasmolysis at which the first sign of shrinkage of protoplast from cell wall becomes detectable is called *incipient plasmolysis*. At incipient plasmolysis, the protoplast does not exert pressure against the wall, nor is it separated from the wall. Consequently, turgor pressure is zero. The process of plamolysis is usually reversible. When the cells are placed in a hypotonic solution (dilute solution as compared to the cytoplasm), water diffuses into the cell causing the protoplast to build up a pressure against the wall, that is called turgor pressure.

3.1.2 Chemical potential of water and water potential

The chemical potential of water is expressed in terms of free energy associated with one mole of water. The unit of chemical potential is the energy per mole of substance. In plant physiology, instead of chemical potential of water, we use a related parameter called *water potential*. Slatyer and Taylor introduced the concept of water potential, which is defined as the chemical potential of water divided by the partial molal volume of water (the volume of 1 mol of water). The word *potential* in the term *water potential* refers to water's potential energy. It is the measure of the free energy of water per unit volume. It is commonly expressed in terms of pressure units such as *Pascal*. By convention, the water potential of pure water at standard temperature and pressure is defined as 0 MPa. If some solute is dissolved in pure water, the solution has fewer free water and the concentration of water decreases, reducing its water potential. So, the water potential of an aqueous solution at atmospheric pressure will be less than zero.