Water Potential

Free Energy: It is the energy of the system available for doing some work at constant temp. It is usually stated in terms of energy per mole or per gram of the substance. Eg: Calorie / mole.

Chemical Potential: It is defined as the free energy per mole of a chemical substance. Eg. water in a solution. The larger the

chemical potential of a substance, the greater is its tendency to undergo chemical reaction and other forms such as diffusion and osmosis.

The chemical potential of water is referred to as water potential and is symbolised as Ψ. Thus, water potential can be taken as a measure of energy available for reaction or movement of water.

Water moves from the region of higher water potential to a lower water potential. Water potential while sometimes expresses as energy (calorie per mole), is usually expressed in terms of pressure. Eg: bar or Atmosphere.

Absolute values of water potential are not easily measured. But difference in water potential can be measured. If 2 sides of an aqueous medium have water potential Ψ_A and Ψ_B, then the difference in water potential is:

$$D\Psi = \Psi A - \Psi B$$

If ΨA is greater than ΨB, then ΨD (water potential) is +ve and water will move from A to B. However, if the values of water potential is -ve, water will move from B to A.

By definition, ΨD of pure water at atmospheric pressure is 0, hence, the water potential of water in cells and solutions is less than 0 i.e -ve. The water potential is affected by all factors which thins the chemical potential of water. For. eg. it is increased by

Turger or wall pressure and increase temperature. And it is decreased by additional, tension and decrease in temperature.

Osmotic Potential :

The osmosis of water primarily depends upon the conc of solute in diff. region of cells or tissues. The potential with which pure water will diffuse towards the solution is osmotic potential of that solution. Since, the potential of pure water is 0 and hence it has to move acc. to the conc gradient, the osmotic potential of a soln is less than 0 or it is -ve. Higher the conc of solutes in a soln, greater is its osmotic potential. Thus, O.P is a contribution made by dissolved solute to water potential.

Therefore, O.P can be considered as a component of water potential.

19.2.20.

Mechanism of Water Absorption (In Plants) :

Water is absorbed by the plants acc. to the potential gradient.

Pathway of Water In Root :

Water enters the roots principally through the walls of the root hairs & epidermal cells. From the epidermal cells the water passes through successive cells of thin walled cortical cells and then through the walls of endodermis. The presence of 2° thickening called casparian strips on the walls of endodermal cells restricts the movement of water through this cells. However, there are thin walled passage

cells in the endodermal layer which facilitates the movement of water. Water then moves to the xylem ducts & then it moves upward through them.

* That is water moves from soil to the roots when water potential of soil soln is more than that of cell sap. However, the gradient is generated differentially in slowly & rapidly transpiring plants. In slow transpiring plants the roots play an essential role in generating the gradient and the mechanism is called active absorption. In rapidly transpiring plants, the roots play a passive role, the water is just pulled into them, and the mechanism is called passive absorption. Active absorption of water by the roots occur by the process of osmosis ie. to the gradient in water or osmotic potential. The osmotic potential of the xylem sap is generally -2 bars or less whereas that of soil solution is in the order of -0.1 bar. In other words, the conc of solute in the cell sap is generally higher than that in the soil solution. As long as capillary water is available in the soil, the water will move from the soil soln to the cell sap. That is, from dilute soln to the concentrated soln. This inward flow of water will continue until the conc gradient is maintain. This is achieved by the development of an internal pressure in the roots called root pressure.

The natural visible phenomenon of with root pressure and exudation of sap is guttation. In this process, liquid water is

exudate by the leaves where it forms droplets. Active absorption, Root Pressure & guttation are considered to be diff. aspects of the same phenomenon.

It is not clearly understood how the root pressure develops. 3 theories have been proposed in explanation of the root pressure.

1) **Secretion Theory**: Some plant physiologist have suggested that root pressure is produced by the secretion of water into xylem. This secretion results from a higher permeability of water on the inner side, than on the outer side of the root cells. Alternatively, the secretion could also be achieved by spending some respiratory energy of the root cells.

2) **Electroosmotic Theory**: In this theory, it has been experimentally demonstrated that water can move across a membrane if any electric current is applied. However, attempts to cause water flow into roots by applying electric current have been unsuccessful.

3) **Osmotic Theory**: Acc. to this theory, root pressure develops as a result of osmotic process. The root functions as an osmometer because of accumulation of solute. Water moves from dilute soln (soil soln) to conc soln (xylem sap) through various tissues of roots & it causes the development of root pressure.

Active absorption	Passive absorption
1) Requires ATP	1) Doesnot require energy.
2) Active absorption creates root pressure.	2) Passive absorption doesnot create root pressure.
3) It requires O_2.	3) It doesnot require O_2.
4) Movement of water takes place from higher to lower conc against the conc gradient.	4) Movement of water takes place from lower to higher conc along the conc gradient.

Mechanism of Water Absorption :

According to Renner (1912 & 15), the mechanism of water absorption is of the following 2 types –

1) Active absorption – When roots are involved actively in water absorption and the absorbing forces in plants are developed primarily in roots, such type of absorption is called active absorption. It is found in plants where transpiration is less and water is present in sufficient amounts. Active absorption requires ATP during respiration. It is also of two types –

   (a) Osmotic absorption – In this type of absorption, the root acts like a osmometer and water is absorbed according to osmotic gradient. (b) Non osmotic absorption – Water absorption requires more ATP and takes place against osmotic gradient.

2) Passive absorption – When roots are inactive in water absorption and the water absorption forces develop primarily in leaves and stems and then reach to roots

through xylem, this type of water absorption is called passive absorption. It takes place mainly due to transpiration. Passive absorption is found in those plants where transpiration is very fast and doesnot require ATP.

Passive Absorption.

Water Absorption in rapidly transpiring plants can occur by passive mechanism. In this mechanism, root functions as passive absorption surface & water moves through them rather than by them. Indeed .... P.A can occur, even through dead or abnormal roots or even when no roots are present.

P.A results from the development of tension in xylem water as a consequence of water loss from leaves & other evaporating surfaces. The tension is then transmitted to the root surfaces through cells. This causes the mass flow of water from soil to the xylem of roots. As expected, the rate of passive absorption is well correlated to the rate of water loss or transpiration. However during some periods of the day (during noon) the rate of absorption doesn't cope with the rate of transpiration because of the resistance to water flow across the root cells. This caused the temporary wilting of the plant. The plants recover themselves from temporary wilting later in the day, when the rate of transpiration is lower.

Passive mechanism is more common means of water absorption than active absorption.

Some Sometimes roots are able to absorb water from the soil in vapour form when the soil is dry & when all liquid water in the vicinity of the root hair have dried up. In these case, the solutes don't move in size with this kind of water absorption as the water molecules can move through vapour phase and not the ~~molecules~~ solutes.

Factors Affecting Rate of Water Absorption :

1) Rate of Transpiration : Absorption of water increases with the increase in the rate of transpiration.

2) Root System : Absorption of water also depend on the extension of root system. Deep rooted plants can absorb more water than that of the shallow roots because of their better access to the available water. Further the permeability of water to root cells, depends upon the age and maturation. The rate of water absorption decreases with age as older tissue are suberized.

3) Low temp : Low temp. inhibits the rate of water absorption which is brought about by complex factors such as increase in the viscosity of water, decrease in the permeability of root cells etc.