

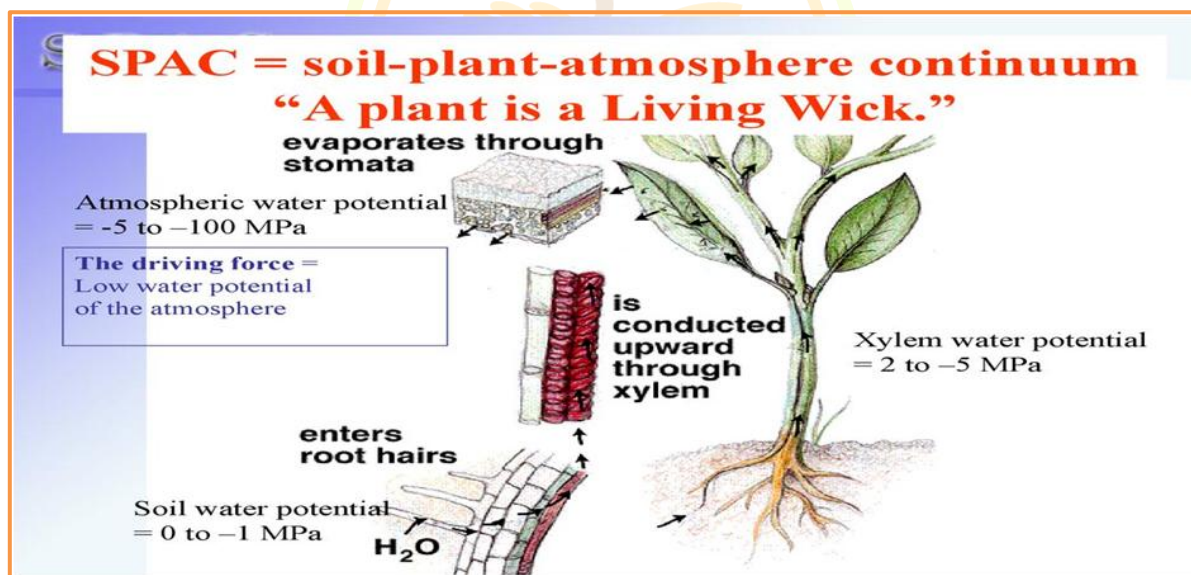
Soil-Plant-Atmosphere Continuum (SPAC): A Review

*Saikat Sarkar

Department of Agronomy, PGCA, Dr. Rajendra Prasad Central Agricultural University, Pusa-848125, India

*Corresponding Author's email: saikatsarkar.agro@gmail.com

The soil-plant-atmosphere continuum (SPAC) is the complete pathway for water moving from soil through plants to the atmosphere, forming a continuous system. Term SPAC was given by J.R Philip (1966). Continuum in description highlights the continuous nature of water connection through the pathway. The low water potential of the atmosphere, and relatively higher (i.e. less negative) water potential inside leaves, leads to a diffusion gradient across the stomatal pores of leaves, drawing water out of the leaves as vapour. As water vapour transpires out of the leaf, further water molecules evaporate off the surface of mesophyll cells to replace the lost molecules since water in the air inside leaves is maintained at saturation vapour pressure. Water lost at the surface of cells is replaced by water from the xylem, which due to the cohesion-tension properties of water in the xylem of plants pulls additional water molecules through the xylem from the roots toward the leaf. SPAC is a unified and a dynamic system. Flow of water through SPAC is a complex with series of resistance offered by different component of the system. Plants usually offer little resistance when soil has enough soil water and atmospheric conditions are moderate.



Water Potential in SPAC

Water potential is a measure of the potential energy in water, or the difference in potential energy between a given water sample and pure water and the rule is water always move from **higher** potential to **lower**. This is the vital concept for SPAC.

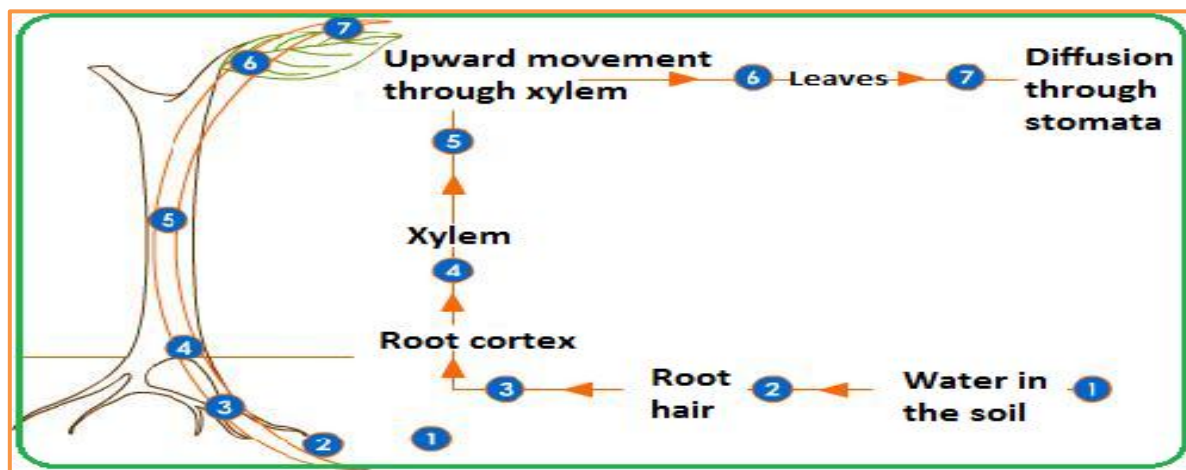
Soil: -0.1 to -20 bars

Plant: -5 to -50 bars

Atmosphere: -1000 to -2000 bars

- As soil is having greater water potential, water will move into the plant which is having lesser water potential than soil.

- From plant water moves to atmosphere which is having lesser water potential than plant.



Movement of water through various component of SPAC

Water Movement in the Soil

1. Saturated Flow:

- Occurs when all pores are completely filled with water either due to rain or irrigation water or under waterlogged situation.
- The flow of liquid water is due to a gradient in metric potential from one region to another.
- Water moves at a potential larger than -33kPa.
- The major force in driving water in saturated soil is gravity and naturally the major direction is downward movement.

2. Unsaturated Flow:

- Occurs when soil macropores filled with air and micropores with water and partly with air.
- It is a flow of water held at water potentials lower than 1/3 bar.
- Unsaturated flow caused by metric potential and the direction of flow is from higher to lower potential.

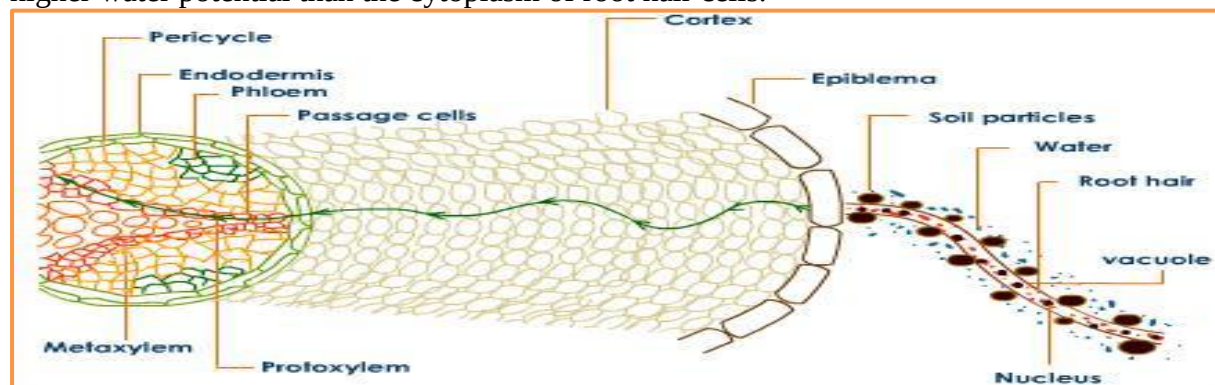
3. Water Vapour Movement:

The movement of water vapour from Soils takes place in two ways:

- Internal Movement – the change from liquid to vapour state takes place within the soil, that is, in the soil pores.
- External Movement – occurs at land surface and resulting vapours are lost to the atmosphere by diffusion and convection.

Water Uptake by Roots

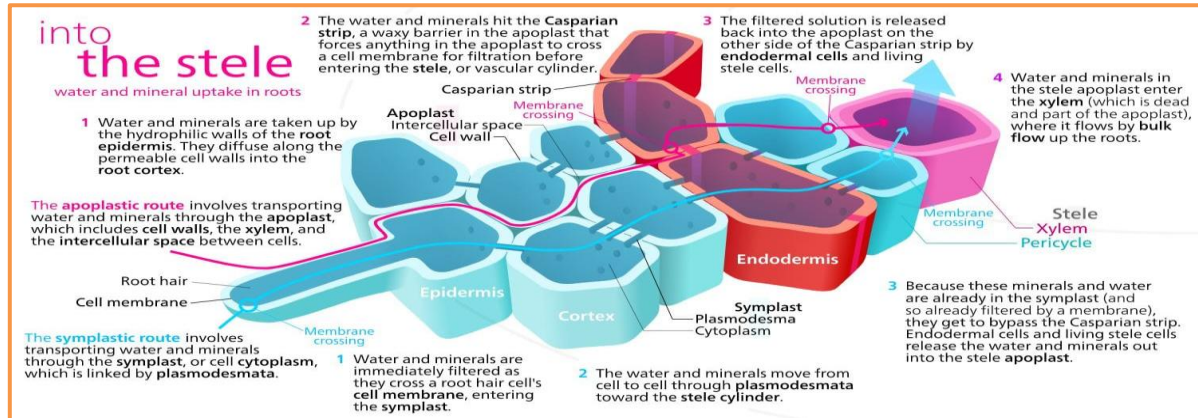
Water movement from soil to roots takes place single celled extension of epidermal cells i.e. Root hair. Water enters into roots hair cells mostly through osmosis, because soil water has a higher water potential than the cytoplasm of root hair cells.



Movement of water inside Roots

Mainly water movement inside roots takes place by 2 methods-

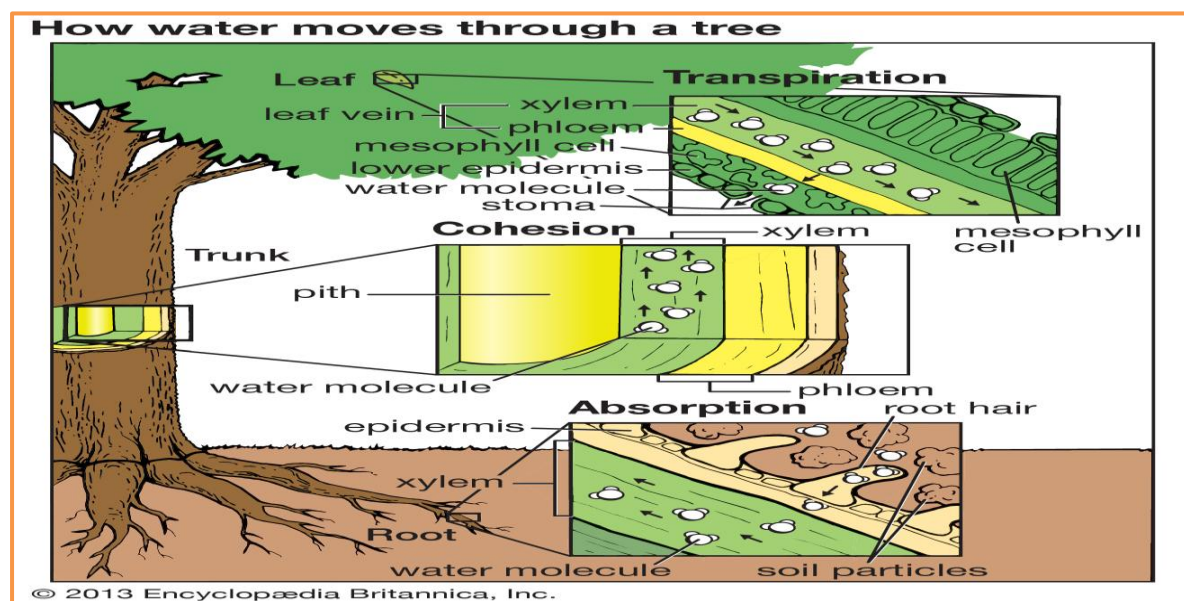
- 1) **Apoplastic pathway:** It is a route the water moves through cell walls and intercellular spaces of cortex.
- 2) **Symplastic pathway:** In this route, the water moves through protoplast of the roots cortex.



Movement of water inside Plant

Movement of water inside plants from one part of plant to other due to difference in water potential gradient.

- **Matrix potential** is involved in movement of water from soil to roots.
- **Pressure potential** is involved in water movement from roots to stem.
- **Osmotic potential** is involved in water movement from stem to cells.
- **Vapour potential** is involved in water movement from cells to stomata.



Water movement from Leaves to Atmosphere

- Transpiration is the loss of water from the plant through evaporation at the leaf surface.
- Water potential in leaves is -5 to -50 bar, while in atmosphere it is -1000 to -2000 bar.
- Due to this potential difference water molecules have a tendency to move towards atmosphere.
- Thus, water moves from stomatal opening to atmosphere in the form of vapours.
- Regulation of transpiration is done through opening and closing of stomata on leaf surface which are surrounded by guard cells.

Why to Study SPAC?

1. In irrigation agronomy SPAC is an important component.
2. Soil is the pool of nutrient and because of this movement in plant the nutrient and fertilizer we apply will move to all plant parts.
3. In Dry land agronomy SPAC is also important as it related to water movement and cooling effects on plant.
4. SPAC is crucial in plant physiology studies.
5. In remote sensing SPAC can be used to differentiate healthy plants from and stressed plants.